Zbornik 25. mednarodne multikonference

INFORMACIJSKA DRUŽBA

Proceedings of the 25th International Multiconference

INFORMATION SOCIETY

2022

Slovenska konferenca o umetni inteligenci
Slovenian Conference on Artificial Intelligence
Mitja Luštrek, Matjaž Gams, Rok Piltaver

Odkrivanje znanja in podatkovna skladišča - SiKDD
Data Mining and Data Warehouses - SiKDD
Dunja Mladenić, Marko Grobelnik

15. mednarodna konferenca o prenosu tehnologij
15th International Technology Transfer Conference
Špela Stres, Robert Blatnik

Vzgoja in izobraževanje v informacijski družbi
Education in Information Society
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Srednjeevropska konferenca o uporabnem teoretičnem računalništvu
Middle-European Conference on Applied Theoretical Computer Science
Andrej Brodnik, Gábor Galambos, Branko Kavšek

Kognitivna znanost
Cognitive Science
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Kognitonika
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Demografske in družinske analize
Demographic and Family Analyzes
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Vseprisotne zdravstvene storitve in pametni senzorji
Pervasive Health and Smart Sensing
Nina Reščič, Oscar Mayora, Daniel Denkovski

Legende računalništva in informatike
Legends of Computing and Informatics
Borut Žalik, Matjaž Gams

Ljubljana, Slovenija
10.-14. oktober
10-14 October
Ljubljana, Slovenia

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PREDGOVOR MULTIKONFERENCI INFORMACIJSKA DRUŽBA 2022

Petindvajseta multikonferenca *Informacijska družba* je preživela probleme zaradi korone. Zahvala za skoraj normalno delovanje konference gre predvsem tistim predsednikom konferenc, ki so kljub prvi pandemiji modernega sveta pogumno obdržali visok strokovni nivo.

Pandemija v letih 2020 do danes skoraj v ničemer ni omejila neverjetne rasti IKTja, informacijske družbe, umetne inteligence in znanosti nasploh, ampak nasprotno – rast znanja, računalništva in umetne inteligence se nadaljuje z že kar običajno nesluteno hitrostjo. Po drugi strani se nadaljuje razpadanje družbenih vrednot ter tragična vojna v Ukrajini, ki lahko pljuskne v Evropo. Se pa zavedanje večine ljudi, da je potrebno podpreti stroko, krepi. Konec koncev je v 2022 v veljavo stopil not raziskovalni zakon, ki bo izboljšal razmere, predvsem leto za letom povečeval sredstva za znanost.

Letos smo v multikonferenco povezali enajst odličnih neodvisnih konferenc, med njimi »Legende računalništva«, s katero postavljamo nov mehanizem promocije informacijske družbe. IS 2022 zajema okoli 200 predstavitev, povzetkov in referatov v okviru samostojnih konferenc in delavnic ter 400 obiskovalcev. Prireditev so spremljale okrogle mize in razprave ter posebni dogodki, kot je svečana podelitev nagrad. Izbrani prispevki bodo izšli tudi v posebni številki revije Informatica (http://www.informatica.si/), ki se ponaša s 46-letno tradicijo odlične znanstvene revije. Multikonferenco Informacijska družba 2022 sestavljajo naslednje samostojne konference:

- Slovenska konferenca o umetni inteligenci
- Izkopavanje znanja in podatkovna skladišča
- Demografske in družinske analize
- Kognitivna znanost
- Kognitonika
- Legende računalništva
- Vseprisotne zdravstvene storitve in pametni senzorji
- Mednarodna konferenca o prenosu tehnologij
- Vzgoja in izobraževanje v informacijski družbi
- Študentska konferenca o računalniškem raziskovanju
- Matcos 2022

Soorganizatorji in podporniki konference so različne raziskovalne institucije in združenja, med njimi ACM Slovenija, SLAIS, DKZ in druga slovenska nacionalna akademija, Inženirska akademija Slovenije (IAS). V imenu organizatorjev konference se zahvaljujemo združenjem in institucijam, še posebej pa udeležencem za njihove dragocene prispevke in priložnost, da z nami delijo svoje izkušnje o informacijski družbi. Zahvaljujemo se tudi recenzentom za njihovo pomoč pri recenziranju.

S podelitvijo nagrad, še posebej z nagrado Michie-Turing, se avtonomna stroka s področja opredeli do najbolj izstopajočih dosežkov. Nagrado Michie-Turing za izjemen življenjski prispevek k razvoju in promociji informacijske družbe je prejel prof. dr. Jadran Lenarčič. Priznanje za dosežek leta pripada ekipi NIJZ za portal zVEM. »Informacijsko limono« za najmanj primerno informacijsko potezo je prejela cenzura na socialnih omrežjih, »informacijsko jagodo« kot najboljšo potezo pa nova elektronska osebna izkaznica. Čestitke nagrajencem!

Mojca Ciglarič, predsednik programskega odbora
Matjaž Gams, predsednik organizacijskega odbora

FOREWORD - INFORMATION SOCIETY 2022

The 25th *Information Society Multiconference* (http://is.ijs.si) survived the COVID-19 problems. The multiconference survived due to the conference chairs who bravely decided to continue with their conferences despite the first pandemics in the modern era.

The COVID-19 pandemic from 2020 till now did not decrease the growth of ICT, information society, artificial intelligence and science overall, quite on the contrary – the progress of computers, knowledge and artificial intelligence continued with the fascinating growth rate. However, the downfall of societal norms and progress seems to slowly but surely continue along with the tragical war in Ukraine. On the other hand, the awareness of the majority, that science and development are the only perspective for prosperous future, substantially grows. In 2020, a new law regulating Slovenian research was accepted promoting increase of funding year by year.

The Multiconference is running parallel sessions with 200 presentations of scientific papers at eleven conferences, many round tables, workshops and award ceremonies, and 400 attendees. Among the conferences, "Legends of computing" introduce the "Hall of fame" concept for computer science and informatics. Selected papers will be published in the Informatica journal with its 46-years tradition of excellent research publishing.

The Information Society 2022 Multiconference consists of the following conferences:

- Slovenian Conference on Artificial Intelligence
- Data Mining and Data Warehouses
- Cognitive Science
- Demographic and family analyses
- Cognitonics
- Legends of computing
- Pervasive health and smart sensing
- International technology transfer conference
- Education in information society
- Student computer science research conference 2022
- Matcos 2022

The multiconference is co-organized and supported by several major research institutions and societies, among them ACM Slovenia, i.e. the Slovenian chapter of the ACM, SLAIS, DKZ and the second national academy, the Slovenian Engineering Academy. In the name of the conference organizers, we thank all the societies and institutions, and particularly all the participants for their valuable contribution and their interest in this event, and the reviewers for their thorough reviews.

The award for life-long outstanding contributions is presented in memory of Donald Michie and Alan Turing. The Michie-Turing award was given to Prof. Dr. Jadran Lenarčič for his life-long outstanding contribution to the development and promotion of information society in our country. In addition, the yearly recognition for current achievements was awarded to NIJZ for the zVEM platform. The information lemon goes to the censorship on social networks. The information strawberry as the best information service last year went to the electronic identity card. Congratulations!

Mojca Ciglarič, Programme Committee Chair
Matjaž Gams, Organizing Committee Chair

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PREDGOVOR

Umetna inteligenca še vedno hitro napreduje, so pa glavni dosežki lanskega leta na področjih, kjer smo jih že vajeni. Avtonomna vozila so vedno bolj avtonomna in se že uporabljajo za prevoz potnikov, čeravno v zelo omejenem obsegu. Jezikovni modeli, kot so izboljšani GPT-3, postajajo zreli za praktično uporabo, zato se njihovi stvaritelji začenjajo ukvarjati s tem, kako jih odvračati od tvorbe politično nekorektnih besedil. Po eni strani razumljivo, po drugi strani pa – ob problemu omejevanja svobode govora na spletu, ki si je letos prislužil nominacijo za informacijsko limono – tudi nekoliko skrb zbujajoče. Modeli za generiranje slik iz opisov, katerih prvi vidnejši predstavnik je bil DALL-E, so se letos namnožili, in videli smo več poizkusov njihove uporabe za izdelavo stripov. Potlej pa so tu še aplikacije v robotiki, medicini, računalniški varnosti in seveda zvitemu streženju spletnih reklam.

Ko umetna inteligenca postaja vedno zmožnejša in bolj razširjena, se pojavljalo pomisleki o njeni varnosti ter prizadevanja za uporabo, ki bo družbi v korist in ne v škodo. Ta škoda se začne z nepotrebnimi nakupi zaradi preveč zvitih reklam, ki nas spremljajo že dolgo in smo se z njimi sprijaznili, nadaljuje pa s še resnejšimi problemi, kot so denimo slabe medicinske in zaposlovalne odločitve. Zaradi tovrstnih problemov vse več držav sprejema zakonodajo o umetni inteligenci, ki bo raziskovalcem bržkone povzročila nekaj sivih las, a če bo dobra – in k temu skušajmo prispevati, kolikor lahko – bo tudi pomagala, da naše delo ne bo dobilo zloveščega pridiha. Vse več je tudi razmišljanja o splošni umetni inteligenci z zmožnostmi, ki presegajo človeške. Njen vpliv na človeško družbo utegne biti dramatičen. A če želimo zagotoviti, da bo dramatično dober, se bomo morali v prihodnjih letih resno lotiti raziskovalnega področja zagotavljanja, da kompleksni modeli umetne inteligence zares počno tisto, kar mislimo in želimo, da počno, ki je zaenkrat še precej v povojih.

Za konec pa poglejmo, kako je letos z našo konferenco. 11 prispevkov, ki smo jih prejeli, sicer ne opisuje tako visokoletečega dela, kot ga obravnavata prejšnja dva odstavka, so pa vseeno kakovosti in morda začetek česa pomembnega. Število je zmerno in Institut Jožef Stefan še malo bolj prevladujoč, kot običajno, za kar do neke mere krivimo COVID-19 – ne ker bi nas še vedno hudo pestil, ampak ker sta dve konferenčno klavrni leti raziskovalce konferenčenja malo odvadili. A upajmo, da bo tudi to minilo. Prirejamo pa letos v okviru konference Data Science Meetup – dogodek z lepo tradicijo in dobro udeležbo, kjer imajo strokovnjaki iz industrije kratke predstavitve svojega dela. Na to smo ponosni, saj rešuje težavo pomanjkanja prispevkov iz industrije, ki smo se je dotaknili že v preteklih predgovorih.

FOREWORD

Artificial intelligence is still making good progress, but the major achievements of the past year are in the areas where we have grown to expect them. Autonomous vehicles are increasingly autonomous and already being used to carry passengers, albeit in a very limited way. Language models, such as the improved GPT-3, are becoming ready for practical use. Because of that, their authors are starting to work on preventing them from generating politically incorrect texts. This is on one hand understandable, but on the other hand – considering the problem of censorship on the internet, which was nominated for the Information Lemon this year – somewhat concerning. Models that generate images from text descriptions, whose first prominent representative was DALL-E, are proliferating. We have seen several attempts of using them to generate comics. There are also applications in robotics, medicine, cybersecurity and of course cunning delivery of online ads.

With artificial intelligence becoming ever more capable and pervasive, concerns about its safety and use for the benefit of the society rather them harm are increasingly raised. The harm starts with unnecessary consumption due to insidious advertising, but these is old news we have become accustomed to. However, there are potentially more serious problems, such as bad medical or employment decisions. Because of these, a number of countries are drafting legislation about artificial intelligence. This will surely be a headache for researchers, but if the legislation is good – and we should help make it such if we can – it will benefit the reputation of our work. Superhuman general artificial intelligence is also increasingly entering professional and public debate. Its impact on the humanity could be dramatic. To ensure it is dramatically good, we will have to tackle the very much open research problem of ensuring that complex artificial-intelligence models indeed do what we think and want them to do.

Let us finally take a look at our conference. The 11 papers we received are not describing work as ambitious as that described in the previous paragraphs, but they are nevertheless good and perhaps the beginning of something important. The number is modest and Jožef Stefan Institute even more overrepresented than usual, which we partially blame on COVID-19. Not that it is still a major problem, but in the two years without truly good conference the researchers seem to have lost the habit of going to conferences to some degree. We hope that this, too, shall pass. On a brighter note, we are organizing Data Science Meetup as a part of our conference. This is an event with a longstanding tradition and good attendance in which experts from the industry give short talks on their work. We are quite proud of this achievement, since it addresses the lack of papers from the industry which we bemoaned in past forewords.

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Initial Results in Predicting High-Level Features of Constrained Multi-Objective Optimization Problems

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ABSTRACT

Trying numerous algorithms on an optimization problem that we encounter for the first time in order to find the best-performing algorithm is time-consuming and impractical. To narrow down the number of algorithm choices, high-level features describing important problem characteristics can be related with algorithm performance. However, characterizing optimization problems for this purpose is challenging, especially when they include multiple objectives and constraints. In this work, we use machine learning (ML) to automatically predict high-level features of constrained multi-objective optimization problems (CMOPs) from low-level, exploratory landscape analysis features. The results obtained on the MW benchmark show a significant difference in classification accuracy depending on the applied evaluation approach. The poor performance of the leave-one-problem-out strategy indicates the need for further investigation of the relevance of low-level features in CMOP characterization.

KEYWORDS

constrained multi-objective optimization, exploratory landscape analysis, sampling methods, problem characterization, machine learning

1 INTRODUCTION

Predicting high-level features of constrained multi-objective optimization problems (CMOPs) is important as it can help decide which algorithm to use when faced with a new (real-world) CMOP. The structure of the objective and constraint functions are usually unknown for such problems. Moreover, the evaluation of problem solutions might be very time-consuming. In such cases, it is beneficial to know certain high-level features of the CMOP, which eases the selection of an appropriate multi-objective optimization algorithm or constraint handling technique to solve the problem efficiently.

Two frequently considered high-level features of CMOPs are the problem type and connectivity of the feasible region. The problem type characterizes whether and how the constraints change the Pareto front of the problem. As pointed out by Tanabe et al. [8], this feature is useful as it indicates whether the problem needs to be treated as constrained or unconstrained. Moreover, Ma et al. [5] showed which constraint handling techniques are more successful in solving CMOPs, depending on the problem type. Similarly, the connectivity of the feasible region (or problem connectivity for short) defines the multimodality of the problem violation landscape and, therefore, crucially affects the choice of algorithms that can solve the problem efficiently [5].

High-level features of a new problem can be predicted using automatically calculated low-level problem features. The most widely known low-level features in evolutionary optimization are the exploratory landscape analysis (ELA) features. They were initially introduced to characterize single-objective optimization problems and implemented in the flacco package [2]. More recently, Liefooghe et al. [4] proposed a set of ELA features for multi-objective optimization problems, and Vodopija et al. [10] introduced additional ELA features for CMOPs.

In this work, we use the ELA features from [4] and some from [10] to investigate whether they are useful for predicting problem type and connectivity. To the best of our knowledge, this is the first attempt to predict the high-level features of CMOPs. A similar study was performed by Renau et al. [7] on single-objective optimization problems. They used ELA features to classify the optimization problem. When splitting the data into training and test sets, instances from the same problem were used for both training and testing. The first of our three experiments follows this setup. However, because this evaluation methodology is not useful in practice (the class of a new real-world problem is unknown), a second experiment is performed using the leave-one-problem-out methodology. Finally, the third experiment varies the number of target problem instances used for training to gain further insight in the difficult task of predicting high-level features from low-level ones.

The paper is further organized as follows. In Section 2, we introduce the theoretical background of constrained multi-objective optimization. In Section 3, we explain the features used in this study. In Section 4, we present the considered test problems, and in Section 5 the experimental setup. In Section 6, we report on the obtained results. Finally, in Section 7, we provide a conclusion and present the ideas for future work.

2 THEORETICAL BACKGROUND

A CMOP can be formulated as:

$$\begin{aligned} &\text{minimize} \quad f_m(x), \quad m = 1, \ldots, M \\ &\text{subject to} \quad g_k(x) \leq 0, \quad k = 1, \ldots, K, \end{aligned} \tag{1}$$

where $x = (x_1, \ldots, x_D)$ is a *search vector* of dimension D, $f_m : S \to \mathbb{R}$ are *objective functions*, $g_k : S \to \mathbb{R}$ *constraint functions*,

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$S \subseteq \mathbb{R}^D$ is the *search space*, and M and K are the numbers of objectives and constraints, respectively.

A solution x is *feasible*, if it satisfies all constraints $g_k(x) \leq 0$ for $k = 1, \ldots, K$. For each constraint g_k we can define the *constraint violation* as $v_k(x) = \max(0, g_k(x))$. The *overall constraint violation* is defined as

$$v(x) = \sum_{i}^{K} v_k(x). \tag{2}$$

A solution x is feasible iff $v(x) = 0$.

A feasible solution $x \in S$ is said to *dominate* another feasible solution $y \in S$ if $f_m(x) \leq f_m(y)$ for all $1 \leq m \leq M$, and $f_m(x) < f_m(y)$ for at least one $1 \leq m \leq M$. A feasible solution $x^* \in S$ is a *Pareto-optimal solution* if there exists no feasible solution $x \in S$ that dominates x^*. All feasible solutions constitute the *feasible region*, $F = \{x \in S \mid v(x) = 0\}$, and all nondominated feasible solutions form the *Pareto set*, S_o. The image of the Pareto set in the objective space is the *Pareto front*, $P_o = \{f(x) \mid x \in S_o\}$.

3 EXPLORATORY LANDSCAPE ANALYSIS

ELA is a selection of techniques able to analyze the search and objective space of a problem, their correlation and their characteristics with the goal of identifying the features important for the performance of optimization algorithms. To extract the ELA features, one needs to first generate a sample of solutions. The ELA features use statistical methods to characterize the problem landscape. Thus, one can use an arbitrary sample size. However, the ELA features are generally more accurate for large sample sizes. The ELA features proposed by Liefooghe et al. [4] and used also in this work can be divided into four categories: global, multimodality, evolvability, and ruggedness features.

The global features capture certain global problem properties, for example, the correlation between the objective values, average and maximum distance between solutions in the search space and the objective space, the proportion of non-dominated solutions, the average and maximum rank of solutions, etc.

The multimodality features assess the number of local optima in the objective space. They are computed for the bi-objective space and also for each objective separately, in both cases by analyzing the neighbourhood of each solution. If a solution dominates its neighbors (or has a better objective value than its neighbors), it is defined as a local optimum. The multimodality features comprise the proportion of solutions that are locally optimal, the average and maximum distances between local optima, etc.

The evolvability features describe how fast a local optimizer would converge towards an optimum. They are calculated by analyzing how many neighboring solutions are dominated by, dominating, or incomparable with a given solution.

The ruggedness features measure the correlation between the information and quality from neighboring solutions – larger correlation means a smoother landscape. The features are calculated by using Spearman's correlation coefficient on the evolvability features between each pair of neighboring solutions.

In addition, we include four ELA features from [10] that describe the violation landscape and its relation with the objective space. The first feature is the feasibility ratio. It is expressed as the proportion of feasible solutions in the sample and is one of the most frequently used features in categorizing violation landscapes. The second feature is the maximum value of overall constraint violation values in the sample. The last two features measure the relationship between the objectives and constraints. They are the minimum and maximum correlations between the objectives and the overall constraint violation.

Table 1: High-level features of the MW test problems.

Problem	Type	Connectivity
MW1	II	Disconnected
MW2	I	Disconnected
MW3	III	Connected
MW4	I	Connected
MW5	II	Connected
MW6	II	Disconnected
MW7	III	Connected
MW8	II	Disconnected
MW9	IV	Connected
MW10	III	Disconnected
MW11	IV	Disconnected
MW12	IV	Disconnected
MW13	III	Disconnected
MW14	I	Connected

4 TEST PROBLEMS

We base this study on 14 CMOPs proposed by Ma et al. [5] and called MW1–14. In addition to proposing the problems, the authors also describe them with high-level features, such as the problem type and connectivity of the feasible region. The values of these two high-level features for each MW problem are listed in Table 1.

Many of the ELA features proposed by Liefooghe et al. [4] can only be calculated for bi-objective optimization problems. Therefore, we investigate only the bi-objective versions of the MW problems although three of them are scalable in the number of objectives. All MW problems are also scalable in the number of variables. We use 5-dimensional problems to match the experimental setup from [7].

5 EXPERIMENTAL SETUP

In preliminary experiments, we used six sampling methods from the ghalton [1] and scipy [9] Python libraries: gHalton, Halton, Sobol, Latin hypercube sampling, optimized Latin hypercube sampling, and uniform sampling [3]. The results have shown that similar prediction accuracies are obtained when using data provided by any of these sampling methods. For this reason, we only present the results obtained using the Sobol sampling method in the rest of the paper.

The Sobol sampling method generates a sample set by partitioning the search space and filling each partition with a sample solution. We generate additional Sobol sample sets using the Cranley-Patterson rotation [3]. The solutions from the original sample set are rotated using a random shift of each dimension, thus creating new sample sets that preserve the properties of the Sobol sampling. The modulo operation keeps the shifted values within the unitary interval. This approach was also used by Renau et al. [7].

Following this approach, we generate 100 sets of samples, each with 512 solutions, which we then evaluate on all 14 MW benchmark problems. For each problem and sample set pair, we compute 46 ELA features, which represent a single instance in the data. As a result, by evaluating the 100 sample sets on each of the 14 test problems, we get 1400 data instances. We then use

these data instances and the corresponding high-level problem features (problem type and connectivity) to train a classifier for predicting the high-level problem features.

We use two widely used machine learning (ML) methods for classification: the Random Forest (RF) classifier and the k-Nearest Neighbors (KNN) classifier. The reason for choosing these classifiers instead of some others is that, usually, RF performs favorably compared to other ML classifiers. KNN, on the other hand, uses the distance between solutions as a performance metric, which is useful when analyzing the obtained classification results visually. For both RF and KNN, we apply the implementation from the scikit-learn library [6]. For KNN, we keep the default settings, while for RF we train 100 trees.

We perform three experiments that differ in the classifier evaluation methodology. In the first experiment, we base the evaluation methodology on the work by Renau et al. [7], where the data is split by using instances from the same problem for both training and testing. There, 50% of all instances are used for training, and the remaining 50% for testing. Furthermore, we take care of dividing the instances into training and test sets so that the proportion of instances from each problem is equal in both sets.

However, this methodology does not correspond to the real-world scenario where we want to learn the high-level features of a problem encountered for the first time. Therefore, we use the leave-one-problem-out evaluation methodology in the second experiment. Here, the instances from a single problem are used for testing, and the instances from all other problems for training. The procedure is repeated for all problems and the classification accuracy is calculated as the average over all train-test splits.

Finally, the third experiment is performed to see how adding target problem data to the training set influences the resulting classification accuracy. In this experiment, we vary the percentage of target problem data that is used for training between 0% and 99% with the step of 1%. When it equals 0%, no target problem data is used for training, which corresponds to the leave-one-problem-out methodology of the second experiment. Note that this setup never equals the one from the first experiment because here the data of all other (non-target) problems is always used for training. Again, this procedure is repeated for all problems and we report the average classification accuracy.

To better understand the task we are trying to solve, we visualize the classes by first reducing the dimensionality of the feature space from 46-D to 2-D using Pairwise Controlled Manifold Approximation Projection (PaCMAP) [11]. We use the Python package pacmap with default parameter values.

6 RESULTS

The results of the first experiment, where 50% of all data is used for training and 50% for testing, show that both RF and KNN achieve a classification accuracy above 98% (see Table 2). An explanation for such good results can be derived from the two leftmost plots in Figure 1. Here, we can see that PacMAP finds many clusters in the data. However, the clusters are highly correlated to the problems themselves. Thus, leaving some instances from the target problem in the training set results in a high classification accuracy because the classification task is now transformed into identifying to which cluster the new sample belongs, which is a much easier task to perform.

The more realistic scenario of having to predict the high-level feature of a yet unseen problem is tested in the second experiment. Here, the classification accuracy drops to only 7–19% for the problem type prediction, and to 41–57% for the problem connectivity prediction (see the leftmost points corresponding to 0% on the plots in Figure 2). This is comparable to the classification accuracy of the stratified classifier, which achieves 19% for the problem type prediction and 45% for the problem connectivity prediction. We can look at the results of the third experiment to help us understand this decline in classification accuracy. As seen from Figure 2, adding just a few instances of the target problem to the training set drastically increases the classification accuracy.

Table 2: Classification accuracy when 50% of all data is used for training and 50% for testing (first experiment).

Learning method	Problem type	Problem connectivity
RF	98%	99%
KNN	100%	100%

When the training data contains no instances from the target problem, the classifier is forced to find information about the high-level feature from other problems. However, this is a much harder task given that similar problems often have different high-level features (see the middle and right plots in Figure 1).

In the visualizations in Figure 1 the points indicating the correctly classified instances have black edges. As we can see, for many problems, RF has a 0% classification accuracy (top middle and top right plot). There are, however, some problems for which RF finds the correct class for a number of instances. Nonetheless, from these 2-D plots it is hard to understand why certain instances are misclassified by RF. This is because RF detects details in the data that the dimensionality reduction visualization method is unable to capture.

Similar behavior can be observed for KNN. Given that KNN classifies an instance depending on the classes of its most similar instances, the visualization from Figure 1 can help interpret its poor results on the leave-one-problem-out methodology. We can see that the clusters created by PacMAP are not well-aligned with the high-level features of problem type and connectivity. This makes predicting them a hard task for KNN. The clustering by PacMAP suggests that the applied ELA features are not descriptive enough for predicting problem type and connectivity.

7 CONCLUSION AND FUTURE WORK

In this work, we tried to predict high-level features of CMOPs. More specifically, using low-level ELA features, we constructed the classifiers to predict the problem type and connectivity. Two ML classifiers were utilized, RF and KNN.

We employed three evaluation methodologies. The first one follows the related work and splits the data into two halves, one serving as the training set and the other as the test set (instances from the same problem are used in both sets). The second evaluation methodology uses all instances from the target problem for testing, and none for training. The third method gradually adds the target problem data to the training set. We achieved excellent classification accuracy with the first evaluation methodology, but very poor ones with the second one. The drop in classification accuracy was checked by the third methodology, which has shown that already a small number of instances of the same problem increases the classification accuracy.

Visualizations of the data in the form of 2-D plots show that CMOP instances form clusters that are highly correlated to the problem instances, but not to the high-level problem features. For

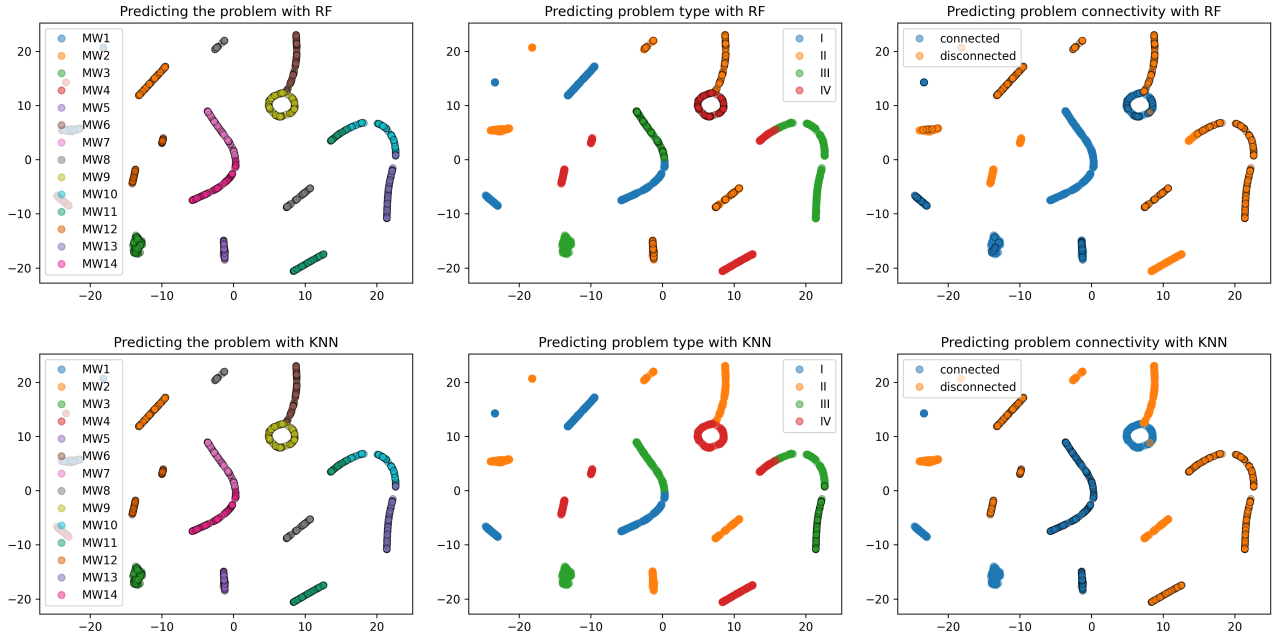

Figure 1: Dimensionality reduction of the ELA feature space using the PacMAP method. Points are colored based on their true values with correct classifications denoted by a black point edge. The top and bottom rows show the results for Random Forest and KNN, respectively, while the different classification targets are arranged in columns: the left column displays the results for the problem, the middle for problem type and the right for problem connectivity.

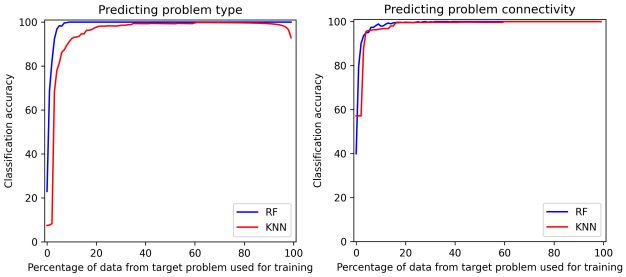

Figure 2: Classification accuracy for different proportions of data from the target problem used for training.

this reason, by including some instances from the target problem in the training set, the classification task becomes an easier task of recognizing to which cluster an instance belongs. Unfortunately, this is not a realistic scenario, since in the real world we have no information on the characteristics of the newly encountered problem. We therefore recommend to use the second evaluation methodology when addressing this task.

However, the initial results obtained using the second evaluation methodology are not so promising. A possible improvement could be considering more ELA features in the learning procedure, either additional ones from [10] or newly created ones. Moreover, using a more representative set of test problems from various benchmark suites may also improve classifier performance.

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REFERENCES

[1] François-Michel De Rainville, Christian Gagné, Olivier Teytaud, and Denis Laurendeau. 2012. Evolutionary optimization of low-discrepancy sequences. *ACM Transactions on Modeling and Computer Simulation*, 22, 2, 1–25.

[2] Christian Hanster and Pascal Kerschke. 2017. flaccogui: Exploratory landscape analysis for everyone. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO) Companion*. ACM, 1215–1222.

[3] Christiane Lemieux. 2009. *Monte Carlo and Quasi-Monte Carlo Sampling. Springer Series in Statistics*. Springer New York, NY.

[4] Arnaud Liefooghe, Sébastien Verel, Benjamin Lacroix, Alexandru-Ciprian Zăvoianu, and John McCall. 2021. Landscape features and automated algorithm selection for multi-objective interpolated continuous optimisation problems. In *Proceedings of the Genetic and Evolutionary Computation Conference (GECCO)*. ACM, 421–429.

[5] Zhongwei Ma and Yong Wang. 2019. Evolutionary constrained multiobjective optimization: Test suite construction and performance comparisons. *IEEE Transactions on Evolutionary Computation*, 23, 6, 972–986.

[6] F. Pedregosa et al. 2011. Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830.

[7] Quentin Renau, Carola Doerr, Johann Dreo, and Benjamin Doerr. 2020. Exploratory landscape analysis is strongly sensitive to the sampling strategy. In *International Conference on Parallel Problem Solving from Nature*. Springer, 139–153.

[8] Ryoji Tanabe and Akira Oyama. 2017. A note on constrained multi-objective optimization benchmark problems. In *IEEE Congress on Evolutionary Computation (CEC)*. IEEE, 1127–1134.

[9] Pauli Virtanen et al. 2020. SciPy 1.0: Fundamental Algorithms for Scientific Computing in Python. *Nature Methods*, 17, 261–272.

[10] Aljoša Vodopija, Tea Tušar, and Bogdan Filipič. 2022. Characterization of constrained continuous multiobjective optimization problems: A feature space perspective. *Information Sciences*, 607, 244–262.

[11] Yingfan Wang, Haiyang Huang, Cynthia Rudin, and Yaron Shaposhnik. 2021. Understanding how dimension reduction tools work: An empirical approach to deciphering t-sne, umap, trimap, and pacmap for data visualization. *Journal of Machine Learning Research*, 22, 201, 1–73.

Learning the Probabilities in Probabilistic Context-Free Grammars for Arithmetical Expressions from Equation Corpora

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ABSTRACT

A core challenge for both physics and artificial intelligence (AI) is symbolic regression: finding a symbolic expression that matches data from an unknown function. Symbolic regression approaches are largely data-driven and search an unconstrained space of mathematical expressions, often employing genetic algorithms. On the other hand, equation discovery approaches incorporate domain knowledge to constrain the structure space and search it using local or exhaustive search methods. In this paper, we adopt the use of probabilistic context-free grammars (PCFG) in equation discovery and propose a method for learning the probabilities of production rules in such PCFGs. We take a universal PCFG with an initial set of manually assigned probabilities for each production rule. We learn new probabilities by parsing each expressions in a given corpus of expression, such as the Feynman dataset.

KEYWORDS

equation discovery, grammar, probabilistic context-free grammar, parsing, learning probabilities, probability distribution

1 INTRODUCTION

Equation discovery is an area of machine learning that develops methods for automated discovery of quantitative laws, expressed in the form of equations, in collections of measured numeric data [5] [11]. More precisely, equation discovery methods seek to automate the identification of equation structure as well as parameters. Traditionally, domain experts derive equation structure based on the theory in the domain and use standard numerical optimization methods to estimate their parameters. Equation discovery methods often use domain knowledge to specify the space of equations they consider. The key questions in the field are how to best represent the symbolic language of mathematics, how to incorporate domain knowledge in the process of equation discovery, as well as how to perform the search for optimal equation structures. Symbolic regression methods are largely data-driven and search an unconstrained space of mathematical expressions, often employing evolutionary algorithms. On the other hand, equation discovery methods, such as process-based modeling [4], incorporate domain knowledge to constrain the structure space and search using greedy-local [12] or exhaustive search methods on the constrained space. The task of equation discovery is closely related to the task of supervised regression. Machine learning methods for supervised regression assume a fixed class of models, such as linear regression or neural networks with a particular architecture, and find the one that provides the best fit to the training data. Equation discovery methods typically consider broader classes of mathematical equations. These classes may be vast and many (often infinitely many) equations can be found that provide excellent fit to the training data. The challenge of symbolic regression is therefore twofold. On one hand, one can easily overfit the training data with an unnecessarily complex equation. On the other hand, the space of candidate equations is huge and grows exponentially as equation complexity increases, posing serious computational issues to equation discovery methods.

Equation Discovery systems explore the hypothesis space of all equations that can be constructed given a set of arithmetic operators, functions and variable. They search for equations that fit given input data best. The number of all possible candidate equations can be infinite.

Early equation discovery systems used parametric approaches to specify the space of polynomial equations considered. LAGRAMGE [13] uses context-free grammars (CFG) [9] to specify the language of equations considered. The recent system ProGED [2] uses probabilistic context-free grammars (PCFG), where a probability is associated with each production rule. In this paper, we propose a method for learning these probabilities for a given PCFG by using a given corpus of expressions.

2 GRAMMARS FOR EQUATION DISCOVERY

A grammar is a finite specification of a language. A language can contain an infinite number of strings, or even if it is finite, it can contain so many strings that it is not practical to list them all. Originating from computational linguistics, grammars are used as formal specifications of languages and use a set of production rules to derive valid strings in the language of interest. A grammar mainly consists of a set of production rules, rewriting rules for transforming strings. Each rule specifies a replacement of a particular string (its left-hand side) with another (its right-hand side). A rule can be applied to each string (equation) that contains its left-hand side and produces a string in which an occurrence of that left-hand side has been replaced with its right-hand side. A grammar further distinguishes between two kinds of symbols: non-terminal and terminal symbols; each left-hand side must contain at least one non-terminal symbol. It also distinguishes a special non-terminal symbol, called the start symbol. In equation discovery, we are interested in using grammars as generative models, as opposed to their common use for parsing, i.e., discriminating between legal and illegal strings in a language.

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2.1 Context-Free Grammar (CFG)

In formal language theory, a context-free grammar [9] is a formal grammar which is defined as a tuple G = (N, T, R, S). It is used to generate all possible patterns of strings in a given formal language. The syntax of the expression on the right-hand side of the equation is prescribed with a context-free grammar. The set T contains terminal symbols, i.e.,words for composing sentences in the language or variables in the arithmetical expressions. The terminals are primitive grammar symbols that can not be further rewritten, i.e., no productions are affiliated with them. Non-terminal symbols (syntactic categories) in the set N represent higher-order terms in the language, such as noun or verb phrases. Each of the non-terminals represents expressions or phrases in a language. The production rules in the set R are rewrite rules of the form A $\rightarrow \alpha$, where the left-hand side is a non-terminal, $A \in N$, while the right-hand side is a string of non-terminals and terminals, $\alpha \in (N \cup T)^*$. In natural language, a rule $NP \rightarrow AN$ specifies that a noun phrase NP has an adjective A and a noun N. A and N represent the subsets of adjectives and nouns, which are both terminals. No matter which symbols surround it, the single non-terminal on the left hand side can always be replaced by the right hand side. This is what distinguishes it from context-sensitive grammar. When deriving a sentence, a grammar starts with a string containing a single non-terminal $S \in N$ and recursively applies production rules to replace non-terminals in the current string with the strings on the right-hands sides of the rules. The final string contains only terminal symbols and belongs to the language defined by G.

In equation discovery, grammars represent sets of expressions that can appear in the right hand side of equations. These grammars use several symbols with special meanings. For example, the terminal $const \in T$ is used to denote a constant parameter in an equation that has to be fitted to the input data.

A simple context-free grammar $G_M = (N_M, T_M, R_M, S_M)$ deriving linear expressions from variables x, y, z is as follows:

$$\begin{aligned} N_M &= \{E, V\} \\ T_M &= \{x, y, z, +, *\} \\ R_M &= \{E \rightarrow E + V | E * V | V \\ &\quad V \rightarrow x | y | z\} \\ S_M &= E \end{aligned} \tag{1}$$

We write multiple production rules with the same non-terminal on the left hand side using a compact, single-line representation, e.g., $E \rightarrow E + V \mid E * V \mid V$ stands for the set of rules $\{E \rightarrow E + V, E \rightarrow E * V, E \rightarrow V\}$.

2.2 Probabilistic Context-Free Grammar (PCFG)

Grammar formalisms are not new to the field of equation discovery [4] [3] [13], but probabilistic grammars are. A probabilistic grammar assigns probabilities to productions and thereby allows one to use the grammar as a stochastic generator [10] [6] [15]. Probabilistic Context-Free Grammars (PCFGs), are a simple model of phrase-structure trees. They extend context-free grammars (CFGs) similarly to how hidden Markov models extend regular grammars. A grammar can be turned into a probabilistic grammar by assigning probabilities to each of its productions, such that for each $A \in N$:

$$\sum_{(A \rightarrow \alpha) \in R} P \rightarrow (A \rightarrow \alpha) = 1 \tag{2}$$

The probability of a derivation (parse) is defined as the product of the probabilities of all the production rules used to expand each node in the parse tree (derivation). These probabilities can be viewed as parameters of the model. The probabilities of all productions with the same non-terminal symbol on the left hand side sum up to one, i.e., we impose a probability distribution on the productions with the same symbol on the left hand side. As each parse tree, derived by a grammar G, is characterized by a sequence of productions, its probability is simply the product of the probabilities of all productions in the sequence [11].

We can extend the example context-free grammar G_M above to a PCFG by assigning a probability to each of the six productions, given below in brackets after each production:

$$\begin{aligned} E &\rightarrow E + V[p] | E * V[q] | V[1 - p - q] \\ V &\rightarrow x[p_v] | y[q_v] | z[1 - p_v - p_q] \end{aligned} \tag{3}$$

Here we have parameterized the probability distributions over productions for E and V with the parameters $0 < p < 1; 0 < q < 1; 0 < p_v < 1$; and $0 < q_v < 1$, respectively.

Context-free grammars are typically used to parse sentences. Probabilistic context-free grammars provide an estimate of the probability of a parse tree, in addition to the tree itself. Probabilistic context-free grammars also allow for another type of application — stochastic generation of sentences or, in our case, mathematical expressions. The probabilities, assigned to the productions, provide a great amount of control over the probability distribution of individual parse trees. In our example in Eq. 3, the parameters p and q control the probability of a larger number of terms in an expression, while the parameters p_v and q_v tune the ratio between the number of occurrences of variables x, y and z.

An important concept to consider when working with grammars is ambiguity. A grammar is formally ambiguous if there exist sentences (expressions) that can be described by more than one parse tree, generated by the grammar. Grammars for arithmetic expressions can express another type of ambiguity, called semantic ambiguity. All but the simplest arithmetic expressions can be written in many mathematically equivalent, but grammatically distinct ways. It is generally useful to adopt a canonical representation that each generated equation is converted into. This allows us to compare expressions to each other and check whether they are mathematically equivalent in addition to comparing their parse trees. In our work, we use the Python symbolic mathematics library SymPy [8] to simplify expressions, convert them into canonical form, and compare them symbolically.

3 LEARNING PROBABILITIES IN PCFGS FOR ARITHMETICAL EXPRESSIONS

Parameter learning approaches for PCFGs assume a fixed set of production rules and try to learn the probabilities assigned to them. Some approaches encourage sparsity and remove rules with very small probabilities. Parameter learning approaches are typically more scalable than structure search approaches, because parameter learning is a continuous optimization problem which is in general easier than the discrete optimization problem of structure search. Therefore, most of the state-of-the art algorithms for unsupervised learning of natural language grammars are parameter learning approaches.

3.1 The Approach

In this paper, we propose a parameter learning approach for PCFGs, based on parsing a corpus of expressions. We adopt the universal PCFG probabilistic context-free grammar for arithmetic expressions used by ProGED [2]. While ProGED uses manually assigned probabilities in this grammar, we use an initial set of randomly assigned probabilities to each production rule. The universal grammar is composed of production rules that include the four basic operations (+,-,*, /), basic functions (such as sin or log), constant parameters and variables.

Our method for learning probabilities from a given corpus of expressions is designed on the assumption that the probability of a production rule in the grammar is proportional to the incidence of the production in the parse trees for the expressions in the corpus. It uses a parser from the NLTK (Natural Language Toolkit) Python library [1] to parse the expressions in the given corpus using the universal PCFG. NLTK contains classes to work with PCFGs and there are different types of parsers implemented in the NLTK Python library. In particular, we use the InsideChartParser(), a bottom-up parser for PCFG grammars that tries edges in descending order of the inside probabilities of their trees. The "inside probability" of a tree is simply the probability of the entire tree, ignoring its context. In particular, the inside probability of a tree generated by production p with children $c[1], c[2], ..., c[n]$ is $P(p)P(c[1])P(c[2])...P(c[n])$; and the inside probability of a token is 1 if it is present in the text, and 0 if it is absent. For a given string (expression) and a grammar, the parser determines whether the string can be derived using the grammar and if yes, returns the appropriate parse tree. After parsing the equations we count the number of times each production rule appears in the set of parsing trees, for all parsed equations (except for rules directly resulting in terminal symbols (variables)). We then group production rules by left non-terminal symbol and derive the probabilities for each production rule as the number of appearances of a given production rule divided by the sum of such numbers for all production rules for the same non-terminal.

3.2 The Corpora

We apply the proposed approach to two corpora of expressions (that appear on the right hand side of equations). The first one is the Feynman Symbolic Regression Database, which includes a diverse sample of equations from the three-volume set of physics textbooks by Richard P. Feynman [7] and has been previously used as a benchmark for equation discovery [14]. It was constructed by Udrescu and Tegmark [3] to facilitate the development and testing of algorithms for symbolic regression. The equations from Feynman database contain between one and nine variables, the four basic operations ($+, -, /, *$), the functions exp, $\sqrt{}$, sin, cos, tanh, arcsin and ln, as well as a variety of constants – mostly rational, but also e and π. There are three components to an arithmetic expression: variables, constants and operators. Numerical values and constants are typically treated as free parameters (terminal symbols) to be optimized when evaluating an equation for its fit against given data. We replaced all constants, such as e, π and rational constants with the terminal 'C'(const), because we treat them as free parameters. The minimum number of constants ('C'), in the Feynman database is 0, which means that there are a some equations that have only variables as terminal symbols. On the other hand the maximum number of constants in the Feynman database is five constants in only one equation.

The second corpus consists of 4080 scientific expressions from Wikipedia. Those mathematical expressions are named after people and they are parsed from Wikipedia. Compared to the Feynman dataset, Wikipedia's corpus contains more functions such as: Abs, $factorial$, tan, $sinh$, $cosh$ and pow (which do not exist in the Feynman database) as well as irrational constants (e and π) and numerical constants, which have to be replaced by a constant 'C'(const) in the grammar. The equations in Wikipedia's dataset contain between one and fifteen variables, which is twice as much compared to the Feynman dataset and the maximum number of 'C' terminal symbols is 16 per equation.

3.3 The Learned Probabilities

By using the proposed approach on the two corpora of arithmetic expressions described above, we obtain two sets of probabilities, with each probability assigned to one of the production rules in the PCFG. More precisely, we now have three universal PCFGs: (1) with the initial probabilities, manually assigned by the authors of ProGED, (2) with probabilities fine-tuned (learned) on the Feynman dataset, and (3) with probabilities fine-tuned (learned) on the Wikipedia corpus of arithmetical expressions.

In this section, we first present the three sets of probabilities, for each of the above mentioned PCFs: these are given in Table 1. We then compare the probability distributions across the rules for each non-terminal symbol (S,F,T and R) in the PCFGs.

As compared to the initial grammar, the grammar learned on the Feynman database reduces the probabilities of the recursive production rules ($S \rightarrow S + F$ and $S \rightarrow S - F$) and increases the probability of the non-recursive rule ($S \rightarrow F$): This leads to simpler expressions with fewer additive terms. In contrast, the grammar learned on the Wikipedia corpus has a probability for the rule $S \rightarrow S + F$ very comparable with the probability in the initial grammar. It also decreases the probability of the recursive production rule $S \rightarrow S - F$ and increases the probability of the non-recursive rule $S \rightarrow F$ by approximately 0.1 in each case.

The probabilities of the recursive production rules for the F non-terminal symbol ($F \rightarrow F * T$ and $F \rightarrow F/T$) are mostly larger than the ones in the initial grammar. An exception is the rule $F \rightarrow F/T$ with the Wikipedia corpus. The probability of the non-recursive production rule ($F \rightarrow T$) is smaller, slightly for the Wikipedia corpus, more substantially for the Feynman dataset.

In the learned probability distributions over the production rules for the non-terminal T, the probability of the rule $T \rightarrow V$ is much higher (goes from 0.4 to 0.7). In both learned grammars, the probabilities of the $T \rightarrow R$ and $T \rightarrow$ 'C' production rules are substantially reduced. This is more noticeable for $T \rightarrow$ 'C', where the probability goes from 0.4 to slightly above 0.1.

We finally discuss the probability distributions over the production rules for the non-terminal symbol R in the initial grammar and the two learned grammars. A probability with value 0 for a production rule here means that that function for the particular production rule is not present either in the Feynman corpus or the Wikipedia corpus of mathematical expressions. For example, the functions ln and $arcsin$ are not present in the arithmetical expressions from the Wikipedia dataset, but are present in the Feynman database. On the other hand, the functions log, pow, Abs, $sinh$, $cosh$, $factorial$ and tan do not exist in the arithmetic expressions from the Feynman database, that's why their probability is 0. The grammar learned on the Feynman database increases the probabilities of the production rules $R \rightarrow (S)$, $R \rightarrow sin(S)$ and $R \rightarrow sqrt(S)$ as compared to the probabilities of the initial grammar. In contrast, the probabilities of the remaining production

Table 1: Probabilities of the production rules for the non-terminal symbols in the initial grammar, the grammar trained on the Feynman database and the grammar trained on the Wikipedia corpus of expressions.

Production rule	Initial	Feynman	Wikipedia
S -> S + F	0.2	0.1034	0.2004
S -> S - F	0.2	0.1552	0.1108
S -> F	0.6	0.7414	0.6888
F -> F * T	0.2	0.3635	0.3349
F -> F / T	0.2	0.2446	0.1098
F -> T	0.6	0.3919	0.5553
T -> R	0.2	0.1554	0.1746
T -> 'C'	0.4	0.1338	0.1174
T -> V	0.4	0.7108	0.7082
R →(S)	0.3	0.5391	0.6841
R → sin(S)	0.1	0.113	0.0249
R → arcsin (S)	0.1	0.0173	0
R → ln (S)	0.1	0.0087	0
R → tanh (S)	0.1	0.0087	0.0045
R → cos (S)	0.1	0.0956	0.0435
R → sqrt (S)	0.1	0.1304	0.0831
R → exp (S)	0.1	0.0872	0.0780
R → log(S)	0	0	0.0479
R → Abs(S)	0	0	0.0211
R → (S) '**' (S)	0	0	0.0032
R → sinh(S)	0	0	0.0032
R → cosh(S)	0	0	0.0026
R → factorial(S)	0	0	0.0019
R → tan(S)	0	0	0.0019

rules learned on the Feynman database have lower probabilities as compared to the initial grammar. The grammar learned on the Wikipedia corpus increases the probability of the $R \rightarrow (S)$ production rule and decreases the probabilities of the remaining rules as compared to the initial grammar.

4 CONCLUSIONS AND FURTHER WORK

In this paper, we have proposed an approach to learn the parameters, i.e., production rule probabilities, in probabilistic context-free grammars for arithmetic expressions. We demonstrated the proposed approach by learning the probabilities in a universal grammar for arithmetic expressions from two corpora of expressions. The learned probabilities differ substantially from their initial values. Most notably, the initial settings underestimated the frequency of variables in favor of numerical constants, overestimated the need for recursion with addition and subtraction, while setting the probability of recursion with multiplication too low. These observations show how difficult it is to set probabilities manually and highlight the utility of the learning algorithm.

The comparison of the learned probability values for the two corpora also hints towards differing properties of the two collections of equations. The Wikipedia corpus seems to favor multiplication over division to a greater extent than the Feynman dataset. In terms of expression complexity, we observed a preference for high-order terms in the Feynman dataset, in contrast to a preference for higher numbers of low-order terms in the Wikipedia corpus. The observed differences between the properties of the two corpora demonstrate that the universal grammar is expressive enough to encode these properties and that the learning algorithm is able to discover them. The results show a great deal of promise for the goals of inferring domain knowledge from equation corpora and improving the efficiency of grammar-based equation discovery through the fine-tuning of production probabilities.

As further work we would like to perform equation discovery experiments using the three universal grammars: the universal grammar with initial (default) probabilities, with probabilities learned on the Feynman dataset and probabilities learned on the Wikipedia corpus. For this purpose, we will use the equation discovery system ProGED, which uses a Monte-Carlo approach of sampling equation structures from a given PCFG and evaluating their fit to the given data. We expect that the number of successfully reconstructed equations from the Feynman dataset, when using the learned (fine-tuned) universal PCFGs, will be higher as the number of equations successfully reconstructed with the universal grammar with manually set probabilities.

REFERENCES

[1] Steven Bird, Ewan Klein, and Edward Loper. 2009. *Natural Language Processing with Python*. (1st ed.). O'Reilly Media, Inc.

[2] Jure Brence, Ljupčo Todorovski, and Sašo Džeroski. 2021. Probabilistic grammars for equation discovery. *Knowledge-Based Systems*, 224, (Apr. 2021), 1–12.

[3] Will Bridewell and Pat Langley. 2010. Two kinds of knowledge in scientific discovery. *Topics in Cognitive Science*, 21, 36–52.

[4] Will Bridewell, Pat Langley, Ljupčo Todorovski, and Sašo Džeroski. 2008. Inductive process modeling. *Machine Learning*, 71, 1, 1–32.

[5] Sašo Džeroski, Pat Langley, and Ljupco Todorovski. 2007. *Computational Discovery of Scientific Knowledge*. Vol. 4660. (Aug. 2007), 1–14.

[6] Brian C. Falkenhainer and Ryszard S. Michalski. 1990. Integrating quantitative and qualitative discovery: the abacus system. In *Machine Learning*. Yves Kodratoff and Ryszard S. Michalski, editors. Morgan Kaufmann, San Francisco (CA), 153–190.

[7] R.P. Feynman, R.B. Leighton, and M. Sands. 2015. *The Feynman Lectures on Physics, Vol. I: The New Millennium Edition: Mainly Mechanics, Radiation, and Heat*. Basic Books.

[8] Aaron Meurer et al. 2017. Sympy: symbolic computing in python. *PeerJ Computer Science*, 3, (Jan. 2017), e103.

[9] Alan P. Parkes. 2008. *A Concise Introduction to Languages and Machines*. (1st ed.). Springer Publishing Company, Incorporated.

[10] Cullen Schaffer. 1993. Bivariate scientific function finding in a sampled, real-data testbed. In *Machine Learning*, 167–183.

[11] Michael Schmidt and Hod Lipson. 2009. Distilling free-form natural laws from experimental data. *Science*, 324, 5923, 81–85.

[12] Jovan Tanevski, Ljupčo Todorovski, and Sašo Džeroski. 2020. Combinatorial search for selecting the structure of models of dynamical systems with equation discovery. *Engineering Applications of Artificial Intelligence*, 89, (Mar. 2020), 103423.

[13] Ljupčo Todorovski and Sašo Dzeroski. 1997. Declarative bias in equation discovery. In *Proceedings of the Fourteenth International Conference on Machine Learning* (ICML '97). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA, 376–384.

[14] Silviu-Marian Udrescu and Max Tegmark. 2020. Ai feynman: a physics-inspired method for symbolic regression. *Science Advances*, 6, 16, eaay2631.

[15] R. Zembowitz and J Zytkow. 1992. Discovery of equations: experimental evaluation of convergence. In *Proceedings of Tenth National Conference on Artificial Intelligence*. Morgan Kaufmann Publishers Inc., San Mateo, CA, USA, 101–117.

Prediction of the Inflow in Macedonian Hydropower Plants, Using Machine Learning

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ABSTRACT

As weather conditions become more complex and unpredictable as a consequence of global warming and air pollution, humans find it increasingly difficult to predict the amount of precipitation in the coming period, thus predicting the inflow into hydroelectric basins. Different types of hydropower plants (HPP), soil composition, how dry the soil is at the moment, the composition of precipitation, etc., also influence the inflow, making it even more difficult to be predicted. This research looks into the problem of predicting inflow in hydroelectric basins in Republic of North Macedonia and building machine learning models to do so. The main contribution of this research is the models for the largest five hydropower plants in Republic of North Macedonia (RM) that could optimize the loss and shortage of purchased electricity. Historical data from the closest meteorological station to each hydropower plant that we were working on, as well as historical data from the inflows at the hydropower plants, were used to build regression models that predict the inflow one day in advance for each hydropower plant separately. After deriving 19 new features, of which the majority are statistical, the predictive models' error was reduced. In the final step, we analyze the results empirically and qualitatively and comparing the models generated using different machine learning algorithms. For instance, one of the best models is the model for HPP Vrben, with the mean absolute error of around 8% of the average daily inflow. We built models using eight different regression algorithms for each hydropower plant, including linear regression and gradient boosting regression models as the models that make the smallest errors in predicting. These models could also help to prevent river and lake overflows in areas where hydropower facilities are located, with timely warnings minimizing the severity of natural disasters.

KEYWORDS

machine learning, regression models, hydropower plants, optimization of hydroelectric energy loss

1 INTRODUCTION

The global trend for producing electricity from renewable sources is increasing at an exponential rate. On the other hand, the world aims to reduce world's electricity losses, as there are more and more electrical devices and less and less non-renewable electricity sources. One of the solutions is to optimize electricity losses due to erroneous power consumption forecasts. First, from the standpoint of world non-renewable electricity savings consumption, as the coal or oil are, and then from the standpoint of public spending, because the later you purchase electricity, the more expensive it becomes. [3][5].

Hydropower now provides around 6.5% of the world's electricity needs. In Republic of North Macedonia the total installed capacity of hydropower is 556.8 MW, which is over 40% of the total capacity, ranking first among renewable energy sources. Hydroelectricity is used the most to meet daily variations in electricity consumption and to provide system services for regulation, allowing the power system to be more flexible and reliable. The peaks of electricity consumption are always regulated (i.e. supplemented) by hydroelectric energy while coal-fired power plants produce the majority of electricity. Predicting the quantity of electricity available from each hydropower plant in the future (the longer the period, the better) leads not only to the most efficient use of finances, but also to protection from natural disasters such as river and lake overflows. The amount of inflow in the foreseeable time to be predicted by humans becomes increasingly difficult, if not impossible, as meteorological conditions become more complex and unpredictable as a result of global warming and air pollution [4][1][9].

The inflow prediction in hydropower plants is mainly based on human judgement, however, it is not always accurate. Primarily, because it is about nature. There are two major issues with predicting future inflow accurately:

(1) Weather forecasting inaccuracy in the coming days. The issue is that the forecasting models get less accurate as the forecast gets further out in time [6].
(2) Different types of hydropower plants, especially the construction of pumped-storage hydropower plants, the complexity of geology, etc. In this research, we consider run-of-river and storage hydropower plants. Run-of-river hydropower plant includes a facility that channels flowing water from a river through a canal or pen-stock to spin a turbine, and rain influences the inflow almost immediately. Storage hydropower plants that include a dam and a reservoir to accumulate water, which is stored and released later when needed, providing flexibility to generate electricity on demand and reducing dependence on the variability of inflow. But whatever the hydropower plant type, the inflow is not directly related to weather conditions. For instance, the snow and hail do not accumulate straight away; it does require a time of melting, soil wetting, and for storage plants, additionally, conducting the water through the pipes to reach the basin, etc. [7].

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The inflow into hydroelectric basins can be predicted more easily when using machine learning than by analyzing geology, satellite monitoring, pollution monitoring, and changes in global warming. Developing a machine learning model that connects all of these features, allows the prediction to be made. Otherwise, it is quite difficult to perform it empirically, owing to a lack of resources for repeating the method for each existing hydroelectric plant. In this study, we built models using collected data from hydropower plants and the nearest meteorological stations with the aim of developing an application that would help to monitor the daily inflow one day in advance (Figure 1)[2].

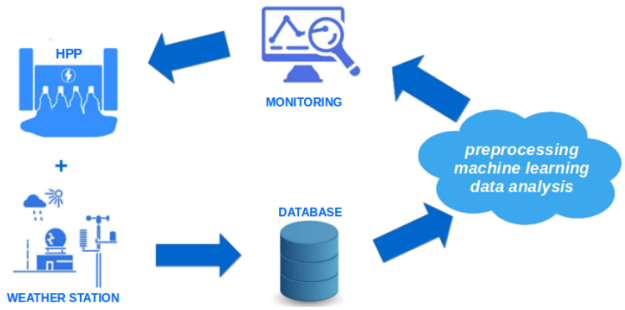

Figure 1: Graphical representation of the process: predicting inflow in the hydroelectric basins

2 METODOLOGY

2.1 Preprocessing

The daily inflow into the hydroelectric basins as labels and the amount of precipitation observed at the nearest meteorological station as descriptive features are merged by date. Then, because missing values represent less than 1% of the total data, they are filled using the average of each feature's values.

For most hydropower facilities, we could find only two descriptive features at first: the daily amount of precipitation [l] and the date. There were 11 additional available features in the data for HPP Tikvesh: time of moonrise and moonset (timestamp), intensity of precipitation $[l/m^2]$, duration of precipitation [min], time of sunrise and sunset (timestamp), the highest and lowest temperature of the day [K], absolute humidity $[g/m^3]$, cloud cover [oktas]. For HPP Tikvesh, missing values in the additional features are filled in with the average of the instances that have the same value in the most meteorologically related feature. For instance, 'humidity' and 'cloud cover'. The procedure is as follows: for a missing value in the feature 'cloud cover,' the corresponding value of 'air humidity' is X; find all the values from the feature 'cloud cover' that have the value X in the feature 'air humidity', calculate their average value and substitute for the missing value in the 'cloud cover' feature. In conjunction with the 'maximum temperature' feature, the same procedure is used to replace missing values in the 'lowest temperature' feature. Scaling the values in the descriptive features between 0 and 1 was the final step in the prepossessing process.

2.2 Feature Engineering

Using only the date and amount of precipitation as descriptive features, different regression models can be developed, but all of these predictive models have a low accuracy. Due to the computer's inability to understand the inflow pattern, including all the details that affect it, 19 new features were created from the original two. The 'date' feature was divided into three new features: day, month, and year, and they were added to the original features. Regarding the amount of precipitation and inflows into the hydroelectric basins, the derived features are the average, variance, p-variance, minimum and maximum values from the previous five days, and values from the previous day of both original features are also added as new features. Also, additional features are derived as sine and cosine functions of the days and months. The purpose of the trigonometric functions is to reduce the difference between December 31 and January 1, for instance.

Random Forest features ranking demonstrate that the features derived from the latest five days of both original features have the highest score. If we consider the correlation matrix, we can realize the same. The derived statistical features have the highest correlations with the inflow. Also it is interesting that while trigonometrically generated date features have the same correlation as the features from which they were derived, in terms of inflow, they do not correlate to each other with a degree of correlation of 1. For instance, HPP Vrben's sine function of the month, as well as the month itself (from which the sine function is derived), get a correlation index of -0.01 with the inflow, but a value of -0.04 with each other (Figure 2).

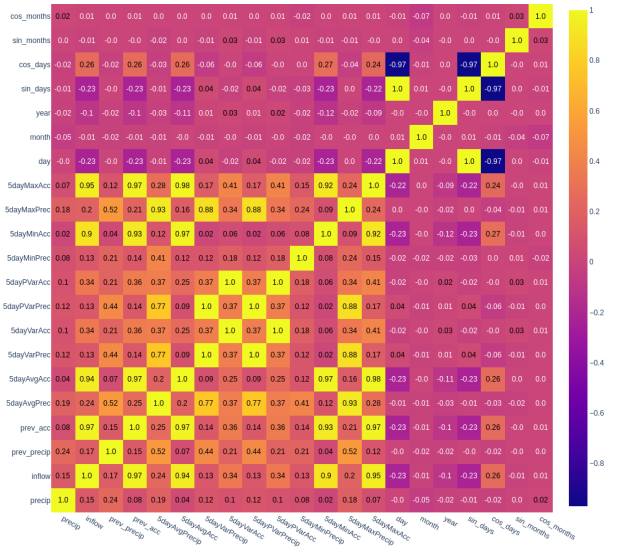

Figure 2: Correlation matrix after scaling for HPP Vrben

3 EXPERIMENTS AND RESULTS

3.1 Dataset Description

For each of the five hydropower plants in the Republic of North Macedonia that have been analyzed, the data processing and approach to the problem are the same. HPP Kozjak, HES Mavrovo power plants (consisting of HPP Vrutok and HPP Vrben), HPP Tikvesh, and HPP Shpilje are part of this study. The datasets are time-series, they were collected at daily intervals throughout an 11-year period (1/1/09 – 12/31/19) for each hydroelectric facility.

ESM[1] and UHMR[2] have collected the initial two variables, the amount of precipitation $[l/m^2]$ and inflows into the hydropower basin (Figure 3). The inflow is expressed as the maximum amount of electricity [MWh] it could be used to produce.

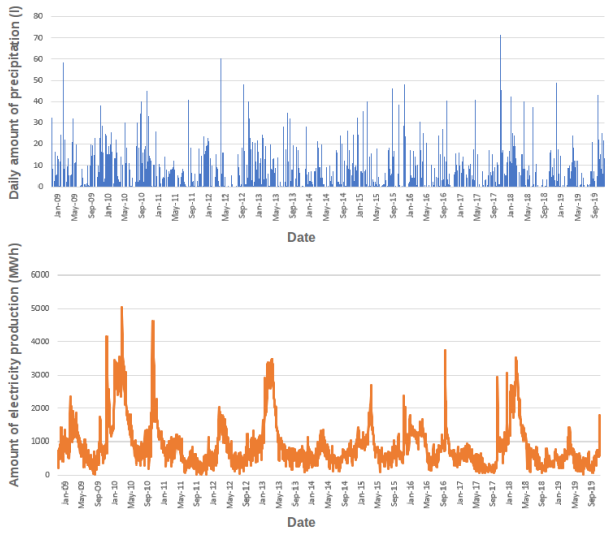

Figure 3: Top to bottom: (a) Amount of precipitation (meteorological station Debar) and (b) amount of electricity production (HPP Shpilje) during an 11-year period (2009 - 2019)

Equation 1 describes how to calculate the electricity that could be produced by hydropower plants, knowing that it is a product of power and working time [4].

$$E = \rho QgHt[Wh] \tag{1}$$

where, electricity is equal to water density ρ $[1000kg/m^3]$, multiplied by water flow (inflow) Q $[m^3/s]$, acceleration of gravity g $[m/s^2]$ and gross height drop H [m]. Inflow refers to water flowing into accumulation basins of hydropower plants. The inflow is measured in cubic meters per second $[m^3/s]$, but it can also be expressed as the quantity of electricity that the same amount of inflow could supply. When electricity is a projection of the inflow, the inflow is computed using Equation 1 and expressed in watt-hours [Wh].

3.2 Experimental Setup

To build models for one day in advance inflow prediction, we used eight different regression algorithms: Support Vector Machine, Random Forest, Linear Regression, Lasso, Gradient Boosting, Extreme Gradient Boosting, K-nearest neighbours, Decision Tree and Dummy that always predicts the mean of the training target values. Four evaluation metrics were used to evaluate the regression models for the prediction of inflow in hydropower plants: mean absolute error (MAE), mean squared error (MSE), root mean squared error (RMSE), and R-Squared (R2) as a standardized version of MSE.

Different numbers of selected features for each hydropower plant were considered using a class from sklearn library called SelectKBest, which selects the best features based on univariate statistical tests and the best numbers of features for each HPP were chosen based on the predictive models' errors. The experiment was divided into four parts: using all features, the best 15 features, the best 10 features, and the best 5 features, out of a total of 20 features.

Time-series can be troublesome for splits where with the shuffling process we get different train and test sets across different executions, for cross-validation, or when the test subset is before or somewhere in the middle of the train subset, etc. For instance, if a pattern appears in year 3 and persists for years 4-6, the model can detect it, even though it was not present in years 1 and 2. Because the datasets we use in this research are continuous time-series at the daily level, we split the evaluation datasets contentiously, without shuffling the subsets [8].

3.3 Results

For each of the four parts of the experiment for selecting the best n features, we calculated and plotted the mean absolute error [MWh] for each model (Figure 4, Figure 5). As we can see in Figure 4 and Figure 5, the differences in the errors are similar regardless of how many features the model is trained with. The best results are provided by different models developed using various algorithms and various number of features for each hydropower plant, but one thing that all of them have in common is that dummy regressor is the worst, while linear regression or gradient boosting produce the smallest errors. For example, if we choose HPP Vrben as one of the best outcomes, we can see that while the average daily input is 3.7 MWh, the error of the model developed using linear regression and selected 15 features is 0.34 [MWh]. Because the errors, with the exception of dummy and lasso, are not particularly big, ranging between [0.345, 0.40], all of the features listed after the five most influential features contribute a negligible percentage to improving or decreasing accuracy (Figure 5).

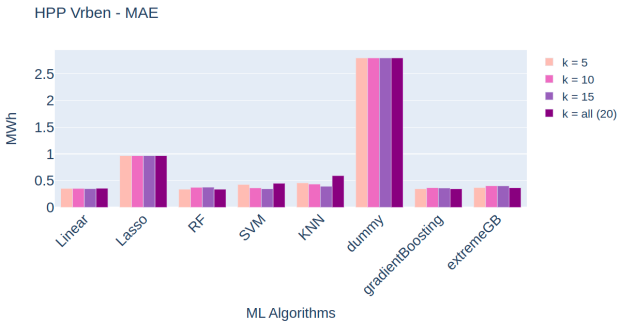

Figure 4: Graphical representation of the mean absolute error of the eight machine learning regressors used in the study, selecting different numbers of best features for HPP Vrben as a run-of-river diversion hydropower plant

4 CONCLUSIONS

Using eight different machine learning regressors, we built models for predicting inflow in Macedonian hydroelectric basins. A solution for predicting the daily inflow in hydropower plants has been proposed if the daily amount of precipitation and the amount of precipitation for the previous five days for the nearest meteorological stations are known.

[1]ESM - Elektrani na Severna Makedonija (litt. "Power plants of North Macedonia")
[2]UHMR - Uprava za Hidro-Meteoroloski raboti (National Hydrometeorological Service - Republic of North Macedonia)

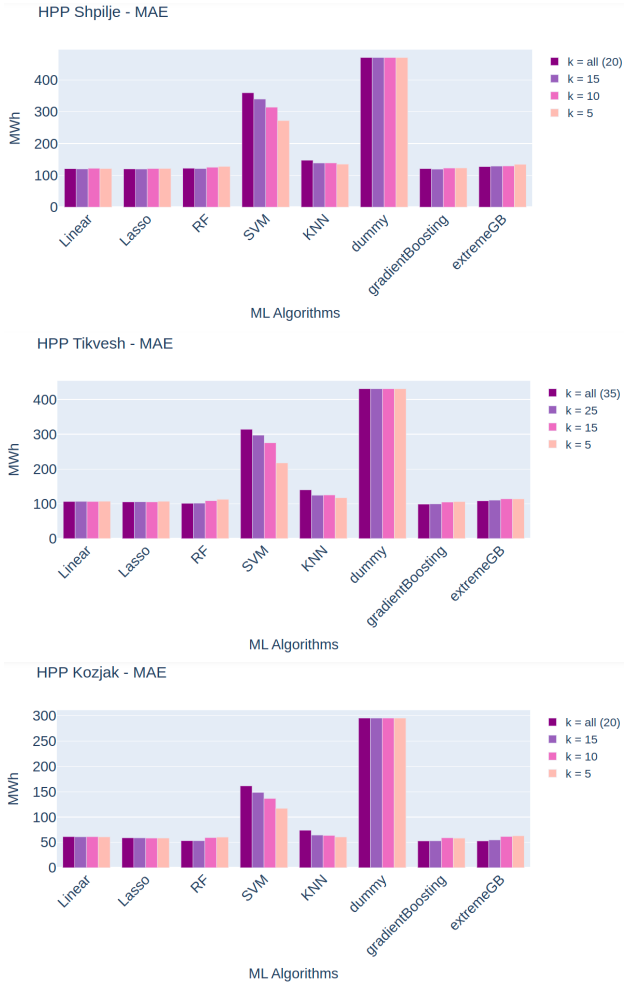

Figure 5: Top to bottom: Graphical representation of the mean absolute error of the eight machine learning regressors used in the study, selecting different numbers of best features for: HPP Shpilje, HPP Tikvesh, HPP Kozjak as storage hydropower plants

According to the results, the daily amount of precipitation and other inflow-related elements from the preceding days are the most important factors that explain inflows in hydroelectric basins. Of course, there are other variables to consider, such as temperature, cloud cover or humidity. Considering that the errors in prediction for HPP Tikvesh are not much smaller than the ones for the other HPPs where we have only the precipitation and inflow as original data and of course, the most important part - the derived features about last days, we may conclude that precipitation takes a certain amount of time to reach the basins as an inflow, depending on daily temperatures, the nature of the soil where the hydropower plant is located, and other factors.

Also, we can confirm hydrological and geological assumptions that continuity in the data is far more important in storage hydropower plants than in run-of-river diversion hydropower plants. For the first type of data, weather characteristics from previous days have no significant impact, but all original and derived attributes related to inflows and precipitation for the same day are crucial, because the rains are accumulated immediately. Otherwise, factors such as the period for melting the snow, temperature, soil moisture, and therefore the amount of inflow into the hydropower plant are significant for storage hydropower plants because it raises the river level, and thus the amount of inflow into the hydroelectric basins, but not immediately.

Because of the differences in the location, construction, and operation of hydropower plants, we can only build hydropower plant specific models. For some, the daily quantity of precipitation or the amount of precipitation from the previous day is the most essential factor, while for others, the amount of precipitation over a longer period is the most important factor. Based on this fact, which is also supported by our results for various hydropower facilities, we may conclude that we cannot build general model that can estimate the inflow for all hydropower plants. Because of the geological properties of the soil along the rivers and the temperature fluctuations in the past, we also cannot create a general model for hydropower plants of the same type.

Linear regression and gradient boosting models produce the best results. We can solve the inflow problem as a linear problem, because the relations between precipitation and inflow to the basins are simple. The precision of projected weather conditions is the key drawback for obtaining even lower errors. The more accurate the weather conditions are and the longer the time period of projected weather conditions is, the better the prediction of inflow in hydroelectric basins would be.

We built predictive models for the next day's inflow in this study. The next step is to create predictive models for as far in the future as possible, so that the model can assist in power management decisions. However, accurate projected meteorological conditions are required to develop such a model, and the further the time point, the greater the error. Hourly or minute time-series would predict more precisely in terms of time intervals.

REFERENCES

[1] Arsenov A. 2003. *Proizvodstvo na elektricna energija.* (1st. edition). ETF, Skopje.

[2] A. P. Verma A. Kusiak X. Wei and E. Roz. 2013. Modeling and prediction of rainfall using radar reflectivity data: a data-mining approach. *IEEE Transactions on Geoscience and Remote Sensing*, 2337–2342.

[3] Jianzhou Niu Tong Du Pei. ang Wendong Wang. 2019. A hybrid forecasting system based on a dual decomposition strategy and multi-objective optimization for electricity price forecasting. *Applied Energy*, 1205–1225.

[4] Djordjevic B. [n. d.] *Koriscenje vodnih snaga: Objekti hidroelektrana.* (1st. edition). Naucna knjiga, Beograd.

[5] Yazidi A. Goodwin M. 2014. A pattern recognition approach for peak prediction of electrical consumption. *IFIP Advances in Information and Communication Technology, Springer.*

[6] S. Makridakis. 2013. Accuracy measures: theoretical and practical concerns. *International Journal of Forecasting*, 9 (4), 1, 527–529.

[7] Joshua S. and Coblenz. 2015. Using machine learning techniques to improve precipitation forecasting. *PLoS One.*

[8] D. Fernando S. De Silva S. Perera S. Dissanayake and W. Rankothge. 2019. Supply and demand planning of electricity power: a comprehensive solution. *IEEE Conference on Information and Communication Technology.*

[9] Stoilkov V. 2015. *Predavanja po predmetot Osnovi na obnovlivi izvori na energija.* (2nd. edition). FEEIT, Skopje.

Peak Detection for Classification of Number of Axles

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ABSTRACT

A common requirement in scientific data processing is to detect peaks in a signal and to measure their positions, heights, widths, and/or areas. In this paper, the problem of peak detection from a raw signal is defined and presented. Providing the example, we showed how the problem of peak detection can be translated into detecting the number of axles in vehicles. Various algorithms for predicting the number of peaks (axles) were presented. Solution with derivatives, the solution with encoder and decoder and the solution with convolution neural network produced the best result, 99% accuracy with a certain percentage of skipped instances.

KEYWORDS

peak detection, neural networks, machine learning, signal, sensors, number of axles

1 INTRODUCTION

Identifying and analyzing peaks in a given time-series is important in many applications, because peaks are useful topological features of a time-series. In power distribution data, peaks indicate sudden high demands. In server CPU utilization data, peaks indicate sharp increase in workload. In network data, peaks correspond to bursts in traffic. In financial data, peaks indicate abrupt rise in price or volume. Troughs can be considered as inverted peaks and are equally important in many applications. Many other application areas – e.g., bioinformatics [2], mass spectrometry [4], signal processing [7, 8], image processing [10], astrophysics [13] – require peak detection.

Peak detection algorithms are also used for classification of the number of peaks or axles. For example, when a vehicle places one of its tyres on a weight sensor, a peak is detected in the signal. Each peak represents one vehicle axle. Therefore, the algorithm detecting how many peaks occur in a given signal in this way detects the number of axes. For the purpose of this study, 16 different signals for two driving lanes were provided by company Cestel. Sensors were placed under a bridge near Obrežje. Sensors 1 and 2 were placed at the beginning and end of measuring area for lane 1. Sensors 15 and 16 were placed on lane 2 in a similar fashion. The rest were placed perpendicular on the road between the pairs. The main goal of this paper is to predict the number of axles as accurately as possible with the use of mathematical models and machine learning algorithms given signals. We introduce the solution using deep neural networks (artificial neural network and convolution neural network), regular derivatives, predefined library find_peaks and a package $tsfresh$ for peak detection. In theory, peak detection is formally a trivial task, however, in reality the task can be performed only with some degree of accuracy.

The rest of the paper is organized as follows. Section 2 presents related work. Main methodology and algorithms are described in section 3. Finally, section 4 concludes the paper with summary and ideas for future work.

2 RELATED WORK

Peak detection is a common task in time-series analysis and signal processing. Standard approaches to peak detection include (i) using smoothing and then fitting a known function (e.g., a polynomial) to the time-series; and (ii) matching a known peak shape to the time-series. Another common approach to peak-trough detection is to detect zero-crossings (i.e., local maxima) in the

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differences (slope sign change) between a point and its neighbours. However, this detects all peaks-troughs, whether strong or not. To reduce the effects of noise, it is required that the local signal-to-noise ratio (SNR) should be over a certain threshold [8, 11]. The key question now is how to set the correct threshold so as to minimize false positives. Ma, van Genderen and Beukelman et al. [10] compute the threshold automatically by adapting it to the noise levels in the time-series as $h = \frac{max+abs_{avg}}{2} + K * abs_{dev}$, where max is the maximum value in the time-series, abs_{avg} is the average of the absolute values in the time-series, abs_{dev} is the mean absolute deviation and K is a user-specified constant. Azzini et al. [2] analyze peaks in gene expression microarray time-series data (for malaria parasite Plasmodium falciparum) using multiple methods; each method assigns a score to every point in the time-series. In one method, the score is the rate of change (i.e., the derivative) computed at each point. In another method, the score is computed as the fraction of the area under the candidate peak. Top 10 candidate peaks are selected for each method; peaks detected by multiple methods are chosen as true peaks. The detected peaks are used to identify genes; SVM are then used to assign a functional group to each identified gene. Key problems in peak detection are noise in the data and the fact that peaks occur with different amplitudes (strong and weak peaks) and at different scales, which result in a large number of false positives among detected peaks. Based on the observation that peaks in mass spectroscopy data have characteristic shapes, Du, Kibbe and Lin et al. [5] propose a continuous wavelet transform (CWT) based pattern-matching algorithm for peak detection. 2D array of CWT coefficients is computed (using a Mexican Hat mother wavelet which has the basic shape like a peak) for the time-series at multiple scales and ridges in this wavelet space representation are systematically examined to identify peaks. Coombes et al. [4] and Lange et al. [9] present other approaches for peak detection using wavelets and their applications to analyze spectroscopy data. Zhu and Shasha et al. [13] propose a wavelet-based burst (not peak) detection algorithm. The wavelet coefficients (as well as window statistics such as averages) for Haar wavelets are organized in a special data structure called the shifted wavelet tree (SWT). Each level in the tree corresponds to a resolution or time scale and each node corresponds to a window. By automatically scanning windows of different sizes and different time resolutions, the bursts can be elastically detected (appropriate window size is automatically decided). Zhu and Shasha et al. [13] apply their technique to detecting Gamma Ray bursts in real-time in the Milagro astronomical telescope, which vary widely in their strength and duration (from minutes to days). Harmer et al. [7] propose a momentum-based algorithm to detect peaks. The idea is compute velocity (i.e., rate of change) and momentum (i.e., product of value and velocity) at various points. A "ball" dropped from a previously detected peak will gain momentum as it climbs down and lose momentum as it climbs the next peak; the point where it comes to rest (loses all its momentum) is the next peak. Simple analogs of the laws in Newtonian mechanics are proposed (e.g., friction) to compute changes in momentum as the ball traverses the time-series.

3 METHODOLOGY

In this section, algorithms for peak detection are described. Each machine learning method uses 62076 samples (vehicles) and up to 16 signals for classification of number of axles. Typically, only the first signal was chosen for training the model. This is because the first signal had less noise than other signals. Each signal has different length. Therefore, the signals that had length less that maximum time had to be extended to maximum signal time in order to create features with the same length. To achieve this, additional zeros were filled to the positions up to the maximum signal time. Maximum time is 6113, which is equal to the number of features. Figure 1 shows a signal from Sensor 1 which has maximum sensor time.

Each method uses classification accuracy for evaluation of the model. Classification accuracy is a metric that summarizes the performance of a classification model as the number of correct predictions divided by the total number of predictions. In this study, correct predictions are correctly predicted peaks(number of axles).

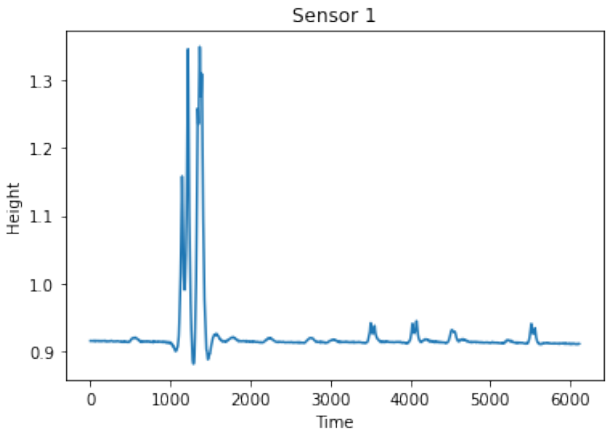

Figure 1: Signal with maximum sensor time.

3.1 Peak Detection with Derivatives

Since peaks are local maxima, we can use mathematical methods for finding them. But because we are not working with functions but rather noisy discrete signals, we need to modify them slightly.

Let us define s_i as i^{th} signal value. First we remove noise at the beginning and the end of the signal where there are no axes. To do so we find the horizontal line with maximum support, where support for line at height y is defined as the number of signal values s_i for which $|y - s_i| < margin$. For line height y we take n equally spaced values from interval $[min, max]$ and half the distance between consecutive y values is used as $margin$. Here min and max represent minimum and maximum value of the signal. To remove noise and normalize signal, we now define:

$$\hat{s}_i = \begin{cases} 0, & \text{if } s_i < y + 2 * margin. \\ \frac{s_i - min}{max - min}, & \text{otherwise.} \end{cases}$$

On signal $\hat{s}$ we calculate first and second derivative - $\dot{s}$ and $\ddot{s}$ - using finite difference, which is implemented using convolution with kernels $[-0.5, 0, 0.5]$ and $[1, -2, 1]$. Finally peaks can be acquired by finding indices i for which $\hat{s}_i > 0.25$, $|\dot{s}_i| < 0.01$ and $|\ddot{s}_i| < 0$ while only taking peaks which are local minima, i.e. $s_i > \max\{s_{i-1}, s_{i+1}\}$.

This procedure achieves accuracy $\approx 90\%$ when using sensor 1. When using other sensors, accuracy is lower, but it can be improved by choosing the correct sensor for every instance. We do this by training nine models: one regression model M_a for predicting number of axes and eight models M_k, $k = 1..8$, for

predicting whether prediction on sensor k is correct. We only use sensors from lane 1, since sensors on the other lane give poor accuracy.

First we define $p^{(i)}$ as correct number of peaks for instance i and $p_k^{(i)}$ as number of peaks detected by procedure described in this section for instance i using sensor k. Now we create matrix X and vector y on which we train gradient boosting regression. This model predicts number of axes from number of peaks detected on all sensors. Matrix X contains one row $x^{(i)} = [p_1^{(i)}, p_2^{(i)}, \ldots, p_8^{(i)}]$ for each instance i with one column for every sensor, while vector y contains ground truth values for number of axes:

$$X = \left[x^{(1)}, x^{(2)}, \ldots, x^{(m)}\right]^T, \quad y = \left[p^{(1)}, p^{(2)}, \ldots, p^{(m)}\right]^T.$$

Here m is number of all instances. Other eight models use the same matrix X, but different vector y. Model M_k which predicts whether detection using sensor k produces correct number of peaks uses:

$$y_k = \left[p_k^{(1)} = p^{(1)}, p_k^{(2)} = p^{(2)}, \ldots, p_k^{(m)} = p^{(m)}\right]^T,$$

where equality comparison evaluates to 1 when true and 0 when false. Gradient boosting classifiers are used for these models.

After all nine models are trained, peaks on a new instance $m+1$ can be detected by first using the described peak detection procedure on all eight sensors to obtain input vector $x^{(m+1)}$:

$$x^{(m+1)} = [p_1^{(m+1)}, p_2^{(m+1)}, \ldots, p_8^{(m+1)}].$$

This vector is then first fed into M_a model to predict number of axes and the result is rounded to closest integer value to get a. Furthermore models M_k are used to get confidence c_k for each sensor. Now valid sensors are the ones using which correct number of peaks were detected and have confidence higher than some threshold T:

$$sensors = \{k \mid 1 \leq k \leq 8 \wedge p_k^{(m+1)} = a \wedge c_k > T\}.$$

If $sensors = \emptyset$, instance $m+1$ is skipped, otherwise a axes are predicted and $\min\{sensors\}$is the best sensor for detection. For $T = 0.95$ this system has accuracy 99.5% while skipping 20% of instances.

3.2 Peak Detection with Encoder/Decoder

Since we know where peaks are located in every signal, we can train a model that will for every instance predict locations of peaks. Because we are working with time series data, we can use a one dimensional convolutional neural network with autoencoder architecture. This allows us to predict locations for variable number of peaks. Inputs and outputs have the same dimensions, while the model consists of two parts: encoder, to create low dimensional embedding in latent space, and decoder, to reconstruct output from it.

As inputs we use signals from sensor 1. On output we want to predict a vector of the same dimension, which has ones in time slots containing a peak and zeros everywhere else. Because CNNs take inputs of the same length, we pad all input and output vectors to maximum length. To make maximum length smaller, we use the noise removal method from section 3.1 to crop noise at the beginning and at the end from the signals.

Encoder is made of 3 convolutional layers. Each is followed by batch normalization and max pooling of size 2. Convolutional layers use ReLU activation, 8, 16 and 32 filters and sizes 5, 2 and 3 respectively. Decoder has the same structure with number of filters and sizes reversed and max pooling layers replaced with up sampling. This model is then trained using Adam optimizer and binary cross entropy loss function.

After model is trained, peaks on new instance can be detected by feeding sensor 1 signal s to it to obtain prediction vector p. Peaks are now located at indices for which prediction value is a strong enough local maximum and signal amplitude is high enough:

$$peaks = \{i \mid p_i \geq \max\{p_{i-5:i+5}\} \wedge \hat{p}_i > T_1 \wedge \hat{s}_i > 0.15\},$$

while skipping instances for which $\max\{p_i \mid i \in peaks\} < T_2$. Here $\hat{p}, \hat{s}$ are normalized to contain values in $[0, 1]$ and T_1, T_2 are thresholds that need to be selected. For $T_1 = 0.01$ and $T_2 = 0.5$ accuracy 99.6% is achieved with 20% skipped instances.

3.3 Peak Detection with Artificial Neural Network

Neural networks, also known as artificial neural networks (ANNs) or simulated neural networks (SNNs), are a subset of machine learning and are at the heart of deep learning algorithms. Their name and structure are inspired by the human brain, mimicking the way that biological neurons signal to one another [12].

Artificial neural networks (ANNs) are comprised of a node layers, containing an input layer, one or more hidden layers, and an output layer. Each node, or artificial neuron, connects to another and has an associated weight and threshold. If the output of any individual node is above the specified threshold value, that node is activated, sending data to the next layer of the network. Otherwise, no data is passed along to the next layer of the network [12].

In this method, artificial neural network was used to predict the number of peaks. Neural networks were a viable solution for this problem, because we had enough data at our disposal for deep learning. Whole signal from sensor 1 was provided as input layer. Architecture of the neural network contains two hidden layers, with 16 and 12 neurons, respectively. Output data (number of peaks) was one-hot encoded, therefore softmax activation function was used in the output layer. Model returned the probability for each class. In the end, an algorithm picked the column with the highest probability (i-th column depicts i number of peaks). This model achieved 91% accuracy for predicting the number of peaks.

3.4 Peak Detection with Convolution Neural Network

Convolutional neural networks are distinguished from other neural networks by their superior performance with image, speech, or audio signal inputs. They have three main types of layers, which are:

- Convolutional layers which convolve the input and pass its result to the next layer. This is similar to the response of a neuron in the visual cortex to a specific stimulus. Each convolutional neuron processes data only for its receptive field.
- Pooling layers which reduce the dimensions of data by combining the outputs of neuron clusters at one layer into a single neuron in the next layer.
- Fully-connected layers which connect every neuron in one layer to every neuron in another layer.

With each layer, the CNN increases in its complexity, identifying greater portions of the required information [1].

Convolutional neural network was utilized to predict the number of peaks. The motivation for the usage of this type of network comes from a fact that convolutional neural networks work well with time series data. Whole signal from sensor 1 was used as input layer. Architecture of the network contains three 1D convolution layers and three 1D pooling layers. At the end we used the fully connected layer with 100 neurons. Output layer has a softmax activation layer. Similarly than in subsection 3.3, the model returned the probability for each class and in the end, algorithm picked the column with the highest probability. This model achieved 97% accuracy. If we decide to skip 6.5% samples that are below the 99% probability threshold, we achieve the accuracy of 99.1%.

3.5 Peak Detection with Predefined Method Find_peaks

Another method for peak detection is by using the predefined function named $find_peaks$. This function takes a 1-D array and finds all local maxima by simple comparison of neighboring values. In the context of this function, a peak or local maximum is defined as any sample whose two direct neighbours have a smaller amplitude [6]. Because each signal has different maximum height, the parameter in function find_peaks named *height* differs from sample to sample. Height parameter is defined as minimal required height for peaks to be detected. Peaks below that threshold are not detected. Height was calculated by formula: height = | |max(sensorHeight)| - |min(sensorHeight)| | / 10. The above described method achieved 89% accuracy and also returned the position of every peak. An example can be seen on Figure 2 on which 2 peaks are detected. They are marked with 2 oranges crosses.

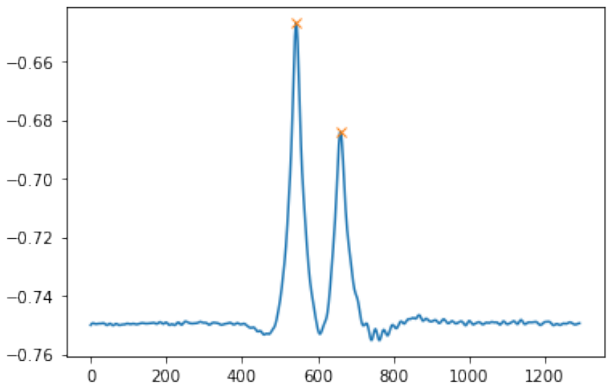

Figure 2: Signal with two peaks. Location of the peak is marked with an orange cross.

3.6 Peak Detection with Library Tsfresh

Another alternative approach for peak prediction is by using the python package named $tsfresh$. It automatically calculates a large number of time series characteristics, the so called features. Furthermore, the package contains methods to evaluate the explaining power and importance of such characteristics for regression or classification tasks. $tsfresh$ is used for systematic feature engineering from time-series and other sequential data. These data have in common that they are ordered by an independent variable. The most common independent variable is time (time series) [3]. After the features were extracted, they were used by gradient boost classifier for predicting the number of peaks. This approach produced 89% accuracy predicting the number of peaks.

4 CONCLUSION AND DISCUSSION

We defined and presented the problem of peak detection from a raw signal. Providing the example, we showed how the problem of peak detection can be translated into detecting the number of axles in vehicles. Various algorithms for predicting the number of peaks (axles) were presented. The solution with derivative, the solution with encoder and decoder and the solution with convolution neural network produced the best results, 99% accuracy with a certain percentage of skipped instances. In future work, the mentioned results can be tweaked and improved by using different learning parameters, e.g. different learning rate, different number of neurons, different activation function. Furthermore, better results can be achieved by changing the architecture of the neural network, e.g. different or more convolution or pooling layers. The results of peak detection can also be extended into determining the axle distances. Once the axle number is accurately predicted, a new set of algorithms can be implemented to solve this new task.

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REFERENCES

[1] Saad Albawi, Tareq Abed Mohammed, and Saad Al-Zawi. 2017. Understanding of a convolutional neural network. In *2017 international conference on engineering and technology (ICET)*. Ieee, 1–6.

[2] Ivano Azzini, Rossana Dell'Anna, Federica Ciocchetta, Francesca Demichelis, Andrea Sboner, Enrico Blanzieri, and A Malossini. 2004. Simple methods for peak detection in time series microarray data. *Proc. CAMDA'04 (Critical Assessment of Microarray Data)*.

[3] Maximilian Christ, Nils Braun, Julius Neuffer, and Andreas W Kempa-Liehr. 2018. Time series feature extraction on basis of scalable hypothesis tests (tsfresh–a python package). *Neurocomputing*, 307, 72–77.

[4] Kevin R Coombes, Spiridon Tsavachidis, Jeffrey S Morris, Keith A Baggerly, Mien-Chie Hung, and Henry M Kuerer. 2005. Improved peak detection and quantification of mass spectrometry data acquired from surface-enhanced laser desorption and ionization by denoising spectra with the undecimated discrete wavelet transform. *Proteomics*, 5, 16, 4107–4117.

[5] Pan Du, Warren A Kibbe, and Simon M Lin. 2006. Improved peak detection in mass spectrum by incorporating continuous wavelet transform-based pattern matching. *bioinformatics*, 22, 17, 2059–2065.

[6] 2022. Find peaks. https://docs.scipy.org/doc/scipy/reference/generated/scipy.signal.find_peaks.html. (2022).

[7] Karl Harmer, Gareth Howells, Weiguo Sheng, Michael Fairhurst, and Farzin Deravi. 2008. A peak-trough detection algorithm based on momentum. In *2008 Congress on Image and Signal Processing*. Vol. 4. IEEE, 454–458.

[8] Valentin T Jordanov and Dave L Hall. 2002. Digital peak detector with noise threshold. In *2002 IEEE Nuclear Science Symposium Conference Record*. Vol. 1. IEEE, 140–142.

[9] Eva Lange, Clemens Gröpl, Knut Reinert, Oliver Kohlbacher, and Andreas Hildebrandt. 2006. High-accuracy peak picking of proteomics data using wavelet techniques. In *Biocomputing 2006*. World Scientific, 243–254.

[10] Meng Ma, Arjan Van Genderen, and Peter Beukelman. 2005. Developing and implementing peak detection for real-time image registration. In *Proceedings of the 16th Annual Workshop on Circuits, Systems & Signal Processing (ProRISC2005)*. Citeseer, 641–652.

[11] GM Nijm, AV Sahakian, S Swiryn, and AC Larson. 2007. Comparison of signal peak detection algorithms for self-gated cardiac cine mri. In *2007 Computers in Cardiology*. IEEE, 407–410.

[12] Sun-Chong Wang. 2003. Artificial neural network. In *Interdisciplinary computing in java programming*. Springer, 81–100.

[13] Yunyue Zhu and Dennis Shasha. 2003. Efficient elastic burst detection in data streams. In *Proceedings of the ninth ACM SIGKDD international conference on Knowledge discovery and data mining*, 336–345.

Unified Question Answering in Slovene

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ABSTRACT

Question answering is one of the most challenging tasks in language understanding. Most approaches are developed for English, while less-resourced languages are much less researched. We adapt a successful English question-answering approach, called UnifiedQA, to the less-resourced Slovene language. Our adaptation uses the encoder-decoder transformer SloT5 and mT5 models to handle four question-answering formats: yes/no, multiple-choice, abstractive, and extractive. We use existing Slovene adaptations of four datasets, and machine translate the MCTest dataset. We show that a general model can answer questions in different formats at least as well as specialized models. The results are further improved using cross-lingual transfer from English. While we produce state-of-the-art results for Slovene, the performance still lags behind English.

KEYWORDS

question answering, Slovene language, deep neural networks, encoder-decoder models, natural language processing

1 INTRODUCTION

Most studies for the question answering (QA) task deal with the English language. This leaves many language specifics, not present in English, potentially inadequately addressed. E.g., some problematic language specifics in morphologically-rich Slovene language are noun and adverb declension, three different genders, three counts, the person or pronoun being hidden in a verb, etc. An additional problem for less-resourced languages is the lack of suitable datasets for QA.

Khashabi et al. [5] argue that building specialized models for each QA dataset or QA format is unnecessary, as they all require a similar inference capability. Therefore, it is possible to develop one model capable of answering questions in different formats. They call their approach UnifiedQA, and we adapted this approach to Slovene.

The number of QA datasets in Slovene is much lower than used in the original UnifiedQA. We found four partially human-translated but mostly machine-translated datasets. To improve that, we first machine translate the additional MCTest dataset [9] into Slovene and fix translation errors.

Our method is based on the pretrained Slovene encoder-decoder transformer model SloT5 [11]. We finetune the model on the five QA datasets and analyze its performance. We also test the role of uppercase and lowercase letters, the impact of unanswerable questions, and the contribution of each dataset to the performance of the unified model. Next, we test the cross-lingual transfer and train a multilingual question answering model based on the multilingual mT5 model [13], using English and Slovene datasets. Finally, we perform a qualitative analysis of the obtained models. The results show that our system is currently the best performing QA system for Slovene. We make its source code freely accessible[1].

The paper is split into four further sections. In Section 2, we outline the related work on QA in Slovene. Section 3 presents our adaptation of UnifiedQA methodology and the applied Slovene QA datasets, and Section 4 discusses different evaluation settings and their results. In Section 5, we present the findings and ideas for further improvements.

2 RELATED WORK

The QA in Slovene is relatively unexplored. In the pre-neural setting, Čeh et al. [1] developed a closed-domain QA system for answering common questions that arise during students' studies at the University of Maribor, Faculty of Electrical Engineering, Computer Science and Informatics. The translation of the SuperGLUE benchmark suite to Slovene in 2021 [14] provided four partially human, partially machine translated QA datasets (BoolQ, COPA, MultiRC, and ReCoRD) and evaluation of Slovene BERT models. Ulčar et al. [11] adapted the SloT5 model for the yes-no and multiple-choice questions. Finally, Zupanič et al. [15] translated the SQuAD 2.0 dataset from English and adapted different multilingual models. They achieved the best result with the SloBERTa 2.0 model [12]. In contrast to the above works, we apply the transfer learning paradigm within the encoder-decoder SloT5 and mT5 models and provide a unified approach to different QA formats, obtaining the best results so far.

3 METHODOLOGY

Our methodology follows Khashabi et al. [5] UnifiedQA methodology. The authors define four QA formats (extractive, abstractive, multiple-choice, and yes/no) and unify the learning approach to these formats. The extractive format requires that the answer is directly stated in the supplied context as a substring. The abstractive format requires paraphrasing of the given context and the answer may require linking information from several sentences. The multiple-choice datasets have possible answers listed and the aim is to select the given option correctly. Finally, the yes/no questions require only yes or no as an answer.

The datasets with different QA formats are converted to text format, with parts of the input separated by the `"\n"` separator. Extractive, abstractive and yes/no questions are coded as `"question \n context"` and multiple-choice questions as `"question \n possible choices \n context"`. Here, the possible choices are indicated in capital letters from A onwards `(A) choice 1 (B) choice 2...`.

We initially considered four QA datasets. Three stem from the translation of the SuperGLUE benchmark to Slovene [14]: MultiRC [4] (abstractive), COPA [10] (multiple-choice) and BoolQ [2] (yes/no). We also used the SQuAD 2.0 [8] (extractive) Slovene

[1] https://github.com/klogar/QAslovene

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translation [15]. SQuAD 2.0 contains unanswerable questions, and some are also present in MultiRC. As we focus on the reading comprehension task, all selected datasets have a context. COPA is a commonsense reasoning dataset, which is not our primary focus, but we included it due to being human translated into Slovene. BoolQ, MultiRC, and SQuAD 2.0 are partially human translated [14, 15].

To have a non-commonsense multiple-choice dataset, we machine translated the MCTest dataset [9] and fixed some translation errors. To reduce the cost of translation, we partially used the commercial solution DeepL [3] and partially an internal neural machine translator of a bit lesser quality. Later, we translated the entire MCTest dataset with the DeepL translator and made it publicly available in our repository. However, the reported results are obtained using the initial mixed translation setting.

As the starting training model for monolingual Slovene UnifiedQA models, we used the monolingual Slovene variant of the T5 transformer encoder-decoder model [7], called SloT5 [11]. For the cross-lingual transfer experiments, we applied the multilingual variant of T5, called mT5 [13]. Due to computational time and GPU memory limitations, we used the SloT5 and mT5 models of the smallest size (60M and 300M parameters, respectively). Originally, Khashabi et al. used the T5 model [7] of the largest possible size (11B parameters) and the $\text{BART}_{\text{large}}$ model [6] as a starting point for the UnifiedQA model. However, they also report results for the T5_{small} model, which we report for comparison, so all models are of comparable sizes. Table 1 lists the parameters used to finetune our models.

Table 1: Parameters for finetuning UnifiedQA models.

Parameter	Value
Maximum input size [tokens]	512
Maximum output size [tokens]	100
Number of epochs	25
Batch size	8
Number of beams	4
Learning rate	5e-5

4 EXPERIMENTS AND RESULTS

In this section, we report our work on empirical evaluation. We present the evaluation metrics, original English results, experiments and results in the monolingual Slovene setting, and in the cross-lingual transfer setting.

4.1 Evaluation Metrics

For each dataset, we use a different evaluation metric. For BoolQ, we report the classification accuracy; for SQuAD 2.0, the F_1 score; for MultiRC, we use ROUGE-L; and for the multiple-choice datasets (MCTest and COPA), we calculate the best match between the generated text and the offered options and compute the classification accuracy. In all cases, the answers are first normalized (removing punctuation and unnecessary spaces and converting the text to lowercase).

4.2 English UnifiedQA Results Using T5_{small}

First, we replicated the results of the original English UnifiedQA [5] and also obtained the results for the datasets not originally used, i.e. COPA and MultiRC (the latter was only used as a yes/no dataset in [5]). The results are presented in Table 2. The results for BoolQ and MCTest are slightly worse than originally reported, which could be attributed to slightly different parameters for text generation. We achieved a much worse result for the SQuAD 2.0 dataset, with F_1 only 46.1% rather than 67.6%. Trying to replicate the published scores with the original code[2], we obtained similar results to ours . However, we analyzed the difference and believe that at least some of them are due to unanswerable questions, as the F_1 score is 84.5% for questions that have an answer and only 7.8% for unanswerable questions. The UnifiedQA model, therefore, does a poor job of detecting if a question is unanswerable from the context.

Table 2: Our and published results of the UnifiedQA (UniQA) approach on English datasets using the T5_{small} model.

Dataset Metric	BoolQ CA	COPA CA	MCTest CA	MultiRC ROUGE-L	SQuAD 2.0 F_1
UniQA(publ.)	0.771	/	0.800	/	0.676
UniQA(ours)	0.757	0.560	0.762	0.536	0.461

4.3 Slovene Monolingual Results Using SloT5

In the Slovene monolingual setting, we compare different variants of Slovene UnifiedQA models and report the results in Table 3. We adapted the models for each QA format separately and obtained so-called specialized models. These provided a baseline for what could be achieved with each individual QA format. We then trained the SloUnifiedQA model using all available Slovene datasets. We also investigated the impact of unanswerable questions (SloUnifiedQA-NA, SloUnifiedQA-NA2, explained below) and the use of only lower case letters (SloUnifiedQA-LC).

Table 3: Comparing variants of Slovene UnifiedQA approach (based on the SloT5 model). Besides the unified model, we report the results of specialized models for each QA format (specialized), the best results published so far on these datasets (published), and the default classifier. The effect of unanswerable questions and lowercasing is analyzed in the bottom part of the table. Note that SloUniQA-NA is tested on modified datasets without unanswerable questions, so the results for this model are incomparable.

Dataset Metric	BoolQ CA	COPA CA	MCTest CA	MultiRC ROUGE-L	SQuAD 2.0 F_1	Avg.
SloUniQA	0.683	0.532	0.463	0.310	0.555	0.509
specialized	0.688	0.486	0.439	0.255	0.554	0.484
published	0.666	0.500	/	/	0.739	/
default	0.623	0.500	0.269	/	/	/
SloUniQA-NA	0.675	0.524	0.454	0.319	0.637	0.522
SloUniQA-NA2	**0.695**	**0.554**	**0.474**	**0.321**	**0.556**	**0.520**
SloUniQA-LC	0.686	0.530	0.449	0.259	0.533	0.491

Comparing the SloUnifiedQA model with specialized models, the models achieve better results for the multiple-choice datasets (COPA and MCTest) and the abstractive dataset (MultiRC). The improvement for the extractive dataset is minimal, and we observe a slight decrease in accuracy for the yes/no dataset (BoolQ). Better results are also obtained compared to all main classifiers.

[2] https://github.com/allenai/unifiedqa

Comparing SloUnifiedQA on Slovene with the English UnifiedQA model on English datasets (in Table 2), the English model gives better results for all selected formats except SQuAD 2.0. Interestingly, the English and Slovene models have different problems with SQuAD 2.0. The Slovenian one predicts unanswerable questions too often (it has F_1 score of 60,3% for unanswerable questions and only 50,4% for answerable ones, while incorrectly identifying 13% of answerable questions as unanswerable), the English one too rarely. At the same time, the English model never wrongly predicts that a question is unanswerable. This is likely due to unanswerable questions making up a larger proportion of the dataset in the Slovene training dataset than in the English one. For other datasets, the biggest difference in metrics can be observed in the MCTest multiple-choice dataset, where the difference is 33%. We attribute the worse result of SloUnifiedQA to machine translations and a much smaller training dataset, especially for the multiple-choice questions; as in the original work, the authors use three additional datasets in addition to MCTest.

Compared to other published works on the same datasets, we achieve better results with the SloUnifiedQA on the BoolQ and COPA datasets compared to Ulčar and Robnik-Šikonja [11], while on the SQuAD 2.0 dataset, Zupanič et al. [15] achieve a significantly better result (almost 20%). Here, Ulčar and Robnik-Šikonja [11] also use the SloT5 model with the textual output, while Zupanič et al. [15] use the SloBERTa model and only predict the span of the answer, which is an easier task.

4.3.1 *The Effect of Unanswerable Questions.*

Unanswerable questions account for about one-third of all training examples, and models could overfit such questions. To address this issue, we train two models, SloUnifiedQA-NA and SloUnifiedQA-NA2. For the SloUnifiedQA-NA model, we removed all unanswerable questions. As evident from Table 3, for yes/no questions and multiple-choice questions the accuracy deteriorates, while for abstractive and extractive questions the metrics improve. The biggest improvement occurred for the SQuAD 2.0 dataset, where the F_1 metric for answerable questions improved to 63.7%.

The SloUnifiedQA-NA was the basis for the SloUnifiedQA-NA2 model, which we trained on complete datasets, including unanswerable questions. The metrics slightly improved for BoolQ, COPA, and MCTest but may be due to the longer training time. No improvement is observed for SQuAD 2.0; the F_1 for answerable questions even drops to 51.5%.

4.3.2 *The Effect of Using Lower Case Letters.*

To analyze the effect of using only lower case letters, we trained the SloUnifiedQA-LC model. The results are comparable for BoolQ and COPA, but for MCTest, MultiRC, and SQuAD 2.0, the results are worse. The uppercase letters, therefore, contain relevant information in Slovene.

4.3.3 *Contribution of Datasets in the Unified Model.*

To assess the impact of each dataset in the SloUnifiedQA model, we dropped each training dataset in turn. The results are shown in Table 4. The largest individual performance drop is observed for the model without BoolQ, as the yes/no questions become unanswerable (the CA for the BoolQ dataset is almost 0%). This also strongly affects the average impact but causes even slight improvements on MCTest, MultiRC, and SQuAD 2.0. The second largest average performance drop is achieved by the model without SQuAD 2.0, where a drop is observed on all datasets. For other models, the drops are observed mainly on datasets on which models were not trained. Overall, the COPA dataset contributes the least to the performance of SloUnifiedQA, the corresponding model achieving almost the same performance.

Table 4: Contribution of datasets in the unified model by omitting one dataset at a time. The red color indicates the two largest performance drops for each dataset.

Dataset Metric	BoolQ CA	COPA CA	MCTest CA	MultiRC ROUGE-L	SQuAD2.0 F_1	Avg.
SloUniQA	0.683	0.532	0.463	0.310	0.555	0.509
no BoolQ	0.001	0.522	0.486	0.319	0.561	0.378
no SQuAD 2.0	0.664	0.516	0.451	0.258	0.120	0.402
no MCTest	0.676	0.510	0.351	0.317	0.560	0.483
no MultiRC	0.690	0.536	0.457	0.209	0.552	0.489
no COPA	0.683	0.510	0.456	0.319	0.554	0.504

4.4 Cross-Lingual Transfer Using mT5

There are only a few QA datasets in Slovene, so we checked if using transfer from additional English datasets can improve the Slovene results. We used three different collections of datasets.

- **SLO**: Slovene datasets BoolQ, COPA, MCTest, MultiRC and SQuAD 2.0 (described in Section 3).
- **ANG5**: English datasets BoolQ, COPA, MCTest, MultiRC, and SQuAD 2.0 (the English dataset, whose translations form the SLO collection).
- **ANG9**: English datasets BoolQ, COPA, MCTest, MultiRC, and SQuAD 2.0 and all datasets, used by Khashabi et al. [5], except SQuAD 1.1, i.e. NarrativeQA, RACE, ARC, and OBQA.

We trained five models using the multilingual mT5 model on these dataset collections and tested them on the SLO test sets. The first model, mSloUnifiedQA, was trained only on SLO datasets and gives a baseline performance of mT5, also enabling comparison to monolingual SloT5. The mSloUnifiedQA$_1$ models were trained on both English and Slovene datasets simultaneously (only one phase), with the English dataset collection being either ANG5 or ANG9. Only the SLO dataset group was used for validation. The mSloUnifiedQA$_2$ models were trained in two phases, first on the English datasets (ANG5 or ANG9), using the ROUGE-L metric to select the best model, and the obtained model was then finetuned on the SLO dataset collection.

The results of the five multilingual models are presented in Table 5. Comparison between the monolingual SloUnifiedQA model (in Table 3) and the multilingual mSloUnifiedQA shows that they perform on average equally well, with SloUnifiedQA performing better on the BoolQ, COPA and MultiRC datasets, and mSloUnifiedQA performing better on the MCTest and SQuAD 2.0 datasets.

Adding additional knowledge in English improved the average metrics by 3-4%, but the training time increased by about

Table 5: Results of cross-lingual transfer using additional English datasets and multilingual models based on mT5.

Dataset Meric	BoolQ CA	COPA CA	MCTest CA	MultiRC ROUGE-L	SQuAD 2.0 F_1	Avg.
mSloUniQA	0.646	0.488	0.515	0.298	0.571	0.504
mSloUniQA$_1$ (ANG5)	0.672	0.486	0.582	0.308	0.587	0.527
mSloUniQA$_1$ (ANG9)	0.676	0.508	0.579	**0.340**	0.598	**0.540**
mSloUniQA$_2$ (ANG5)	0.682	0.504	0.564	0.313	0.593	0.531
mSloUniQA$_2$ (ANG9)	**0.683**	0.486	**0.602**	0.323	**0.604**	**0.540**

four times for the models with the most datasets (ANG9). A slight improvement can be observed for models using nine English datasets (ANG9) relative to those with only five English datasets (ANG5). The additional datasets contribute the most to the MCTest multiple-choice results, but the performance on MultiRC and SQuAD 2.0 also improved. On the other hand, despite the additional datasets, the results for BoolQ and COPA are worse than for the monolingual model. Using one or two-phase training does not make a difference on average, but there are differences in individual datasets.

4.5 Qualitative Analysis

Qualitative analysis of our models showed that the generated answers are mostly substrings or given choices in multiple-choice questions. Models cannot paraphrase, rephrase or provide answers in the correct Slovene case. They also have problems with multi-part questions requiring multiple answers that are not listed in the same place in the context. Machine translations, which are not always grammatically correct or do not make it clear what the question is asking for, also make answering the questions difficult. The models performed best on factoid questions that require a short answer.

5 CONCLUSION AND FUTURE WORK

The main contributions of this work are the generative unified QA models based on SloT5 and mT5 encoder-decoder transformer models, which set new state-of-the-art results for QA in Slovene. An additional contribution is the machine-translated and corrected MCTest dataset.

We identify three possible directions for further work. First, better translations or dedicated Slovenian datasets would improve upon currently mainly machine-translated datasets. Second, larger T5 models and longer training times have shown better performance in English. In our work, we used only the smallest available T5 models due to the limited memory of the GPU; we also limited training sessions to a maximum of 25 epochs. Third, by using new datasets, especially additional multiple-choice datasets, as evidenced by the improvement brought by the introduction of English multiple-choice datasets. Further, additional abstractive datasets could teach the models to rephrase better or that answers shall not be just substrings of the provided context.

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REFERENCES

[1] Ines Čeh and Milan Ojsteršek. "Slovene language question answering system". In: *Recent advances in computers: Proceedings of the 13th WSEAS international conference on computers (part of the 13th WSEAS CSCC multiconference)*. 2009, pp. 502–508.

[2] Christopher Clark et al. "BoolQ: Exploring the Surprising Difficulty of Natural Yes/No Questions". In: *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*. 2019, pp. 2924–2936.

[3] *DeepL Translator*. [18 July 2022]. URL: https://www.deepl.com/translator.

[4] Daniel Khashabi et al. "Looking beyond the surface: A challenge set for reading comprehension over multiple sentences". In: *Proceedings of the 2018 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long Papers)*. 2018, pp. 252–262.

[5] Daniel Khashabi et al. "UnifiedQA: Crossing Format Boundaries With a Single QA System". In: *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: Findings*. 2020, pp. 1896–1907.

[6] Mike Lewis et al. "BART: Denoising Sequence-to-Sequence Pre-training for Natural Language Generation, Translation, and Comprehension". In: *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*. 2020, pp. 7871–7880.

[7] Colin Raffel et al. "Exploring the Limits of Transfer Learning with a Unified Text-to-Text Transformer". In: *Journal of Machine Learning Research* 21 (2020), pp. 1–67.

[8] Pranav Rajpurkar, Robin Jia, and Percy Liang. "Know What You Don't Know: Unanswerable Questions for SQuAD". In: *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics (Volume 2: Short Papers)*. 2018, pp. 784–789.

[9] Matthew Richardson, Christopher J.C. Burges, and Erin Renshaw. "MCTest: A Challenge Dataset for the Open-Domain Machine Comprehension of Text". In: *Proceedings of the 2013 Conference on Empirical Methods in Natural Language Processing*. 2013, pp. 193–203.

[10] Melissa Roemmele, Cosmin Adrian Bejan, and Andrew S Gordon. "Choice of Plausible Alternatives: An Evaluation of Commonsense Causal Reasoning." In: *AAAI spring symposium: logical formalizations of commonsense reasoning*. 2011, pp. 90–95.

[11] Matej Ulčar and Marko Robnik-Šikonja. "Sequence to sequence pretraining for a less-resourced Slovenian language". In: *arXiv preprint arXiv:2207.13988* (2022).

[12] Matej Ulčar and Marko Robnik-Šikonja. "SloBERTa: Slovene monolingual large pretrained masked language model". In: *Proceedings of the 24th International Multiconference Information Society - IS 2021, Data Mining and Data Warehouses - SiKDD*. 2021.

[13] Linting Xue et al. "mT5: A Massively Multilingual Pre-trained Text-to-Text Transformer". In: *Proceedings of the 2021 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies*. 2021, pp. 483–498.

[14] Aleš Žagar and Marko Robnik-Šikonja. "Slovene SuperGLUE Benchmark: Translation and Evaluation". In: *Proceedings of the Language Resources and Evaluation Conference*. 2022, pp. 2058–2065.

[15] Matjaž Zupanič et al. *Cross-lingual Question Answering with Transformers*. Assignmnet in the NLP course, University of Ljubljana, Faculty of Computer and Information Science. [20 June 2022]. URL: https://github.com/mtzcorporations/NLP_TeamJodka.

Social Media Analysis for Assessing Resilience

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ABSTRACT

In this paper, we describe tools developed to investigate the potential use of social media analysis for resilience assessment. We focus on tweets as a data source and apply sentiment analysis, topic detection and filtering approaches. We present computed aggregates with potential information on resilience, and a web application that was made for the use of domain experts. Finally, we discuss preliminary user feedback and lessons learned about the applicability of our approach.

KEYWORDS

social media, sentiment analysis, resilience, disaster management

1 INTRODUCTION

Resilience is generally understood as the ability to adapt and recover after a disruptive event. In this work, we focus on resilience of communities in the context of disaster management, and adopt the following UN definition: *Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management* [7]. Resilience research aims to develop strategies not focused on isolated risks, such as earthquakes or fires, but on approaches that subsume and address all relevant risks, both natural and man-made. The strategies need to identify and account for different human, social, environmental, economic and technological factors that influence behavior of a community when facing a disaster. The goal is that, by adopting these strategies, communities can perform their intended functions in normal and adverse times. A key element of a resilient community is active involvement of local citizens and their active role in a decision making process.

The EU-funded project RESILOC (Resilient Europe and Societies by Innovating Local Communities, https://www.resilocproject.eu/) aims to develop a holistic framework of studies, methods and software tools that can be used to assess the resilience of a community in practice by Local Resilience Teams (LRT).[1] The final goal is to use this framework to identify new strategies for improving the processes of preparedness of local communities against any kind of hazards.

The key element of the RESILOC framework is a methodology for assessing resilience structured along six dimensions: *Governance, Social, Economic, Infrastructure, Disaster Risk Reduction* and *Environmental.* Each dimension is described in terms of its attributes or *indicators,* the values of which are assessed with *proxies*, which are empirically measurable quantities. Indicators and proxies need to have associated scales and aggregation functions that allow their calculation within the RESILOC tool [5]. For example, the *social dimension* of the resilience of a community could be described with indicators such as *Community engagement, Social connectedness, Trust in authority* and *Risk awareness.* The *Community engagement* indicator could then be assessed with proxies such as *% of population who vote in local elections, Number of NGOs for pre- and post-disaster response per capita* and *% of population undertaking voluntary work.* Notably, the resilience assessment of different communities may include different indicators and proxies. The RESILOC platform seeks to provide an initial set of indicators and proxies, allow for the addition of new ones, and enable their aggregation and visualization.

As some of the indicators mentioned above can also be assessed through proxies based on social media analysis, we developed a tool for investigating this approach. For example, proxies (or their components) assessing the indicator *Trust in authority* could be assessed with techniques such as sentiment analysis. In particular, we could hypothesize that a more positive sentiment in social media posts related to public authorities, e.g., disaster response authorities, is related to higher trust in them (and consequently better adoption of any disaster relief measures they introduce). This is the primary motivation that led the investigation presented in this paper. As our social media data source, we use tweets, posts on the Twitter[2] microblogging platform. These are public, abundant and have well supported APIs for collection and filtering.

The rest of the paper is organized as follows. Section 2 briefly presents the the related work, Section 3 presents the social media data used in our analysis and Section 4 presents the results of said analyses. Section 5 presents our web tool for resilience assessment, which is part of the RESILOC framework. The final section concludes our presentation, summarizes lessons learned during our analysis and provides some avenues for further research.

2 RELATED WORK

Our work relates to two main fields of research. The first one is research on community resilience in the context of disaster management. Parker et al. Parker [14] addresses the problems of measuring and assessing resilience and warns that past attempts to define comprehensive resilience assessment frameworks frequently led to simplifications and focus on a single risk. Particular assessments of resilience can be found in the literature review conducted in the scope of the RESILOC project [11].

[1] An LRT is a team in charge of resilience assessment and risk management of a given community, typically organized within a civil protection organization.

[2] https://twitter.com/

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The second related field is social media sentiment analysis and associated techniques. Sentiment analysis [9] is a machine learning field, that has benefited from the current rapid development of natural language processing techniques [6] based on large corpora and deep learning developed in the recent years. Sentiment analysis of social media posts has previously been applied to resilience adjacent domains, such as disaster response and management [12, 1].

Research in the cross-section of both fields, i.e., resilience and social media, has mostly focused on investigations on how social media affects community and self resilience [8], including recent examples during the COVID-19 pandemic [16]. Using social media analysis to assess resilience is, to the best of our knowledge, novel, and we were not able to find any similar tools to the one presented in this paper.

3 DATA

The data used in our analyses and visualizations are tweets that specifically mention target communities (using a predefined keyword), which were collected through the Twitter API for Academic Research[3]. This allowed us to collect all tweets of interest, including those from the past.

Notably, a tweet is not only the posted text, but rather meta-data-rich data object containing a pleathora of information, such as its language, geolocation, author code, etc., and relations to other tweets, e.g., if it is a response to another tweet or a retweet. For our purposes, however, we only gather the unique tweet code/id (field *id*), creation time (field *created_at*), language (field *lang*) and text (field *text*).

The selected tweets are collected in dataset that we use for our analysis. The dataset is recreated during each repetition of the analysis, due to potential tweet removal according to Twitter's privacy mechanisms. Hence, the results shown in the online app are not static but can change with renewed analysis.

In RESILOC, four communities are studied as use-cases: Gorizia (Italy), Catania (Italy), West Achaia (Greece) and Tetovo (Bulgaria). These four communities vary widely in size, which is reflected in the amount of tweets in which they are mentioned. As the latter two communities are mentioned only in a couple of tweets per month, the social media analysis was executed only for the first two. We considered extending the pool of tweets by including tweets that are geo-tagged to the selected communities, but only a small fraction of tweets contain such information.[4]

The data gathering process consists of collection and filtering. In particular, we collect all tweets that contain the name of the community (Gorizia or Catania) in the text of the post during a given time period. These tweets are then filtered based on the language (*lang=it*) to gather local posts and to filter out some of the noise, e.g., caused by posts mentioning people (particularly celebrities) with names that match the two communities.

4 METHODS

There are four main data analysis results the online app: (1) volume and sentiment, (2) frequent tokens, (3) data for specific topics and (4) sentiment aggregates and trends.

Volume is the amount of tweets in a given time period, yearly or monthly, while *sentiment* refers to the yearly or monthly positive, neutral or negative sentiment detected in the tweets with the approach described below, in Section 4.1. *Frequent tokens* are commonly appearing words, numbers or emojis, that we identify on a monthly basis according to the procedure in Section 4.2. The volume and sentiment aggregates are also calculated for specific subsets of tweets called *topics*, which can be either automatically inferred by the mechanism in Section 4.3, or provided by the users.

4.1 Sentiment Analysis

The goal of the sentiment analysis is to assess the sentiment of tweets in a given community, its trends, and variations in sentiment in general and in specific resilience-related topics.

To assess the sentiment of tweets we use two machine-learned classifiers. The first is a three-class classifier, denoted as LOGREG, that classifies tweets as positive, neutral, or negative, and employs logistic regression. It is trained on high-dimensional vector representations of Italian tweets that include weighted words, pairs of consecutive words, 4-character sequences and emoji characteristics as representation elements, as presented in [10]. The second classifier is the two class (positive, negative) FEEL-IT sentiment classifier [2][5] for Italian that uses word or subword series of character representation in a high dimensional vector space. It is a fine-tuned BERT-based model [6] for Italian.

4.2 Frequent Tokens

In addition to the information on volume and sentiment, we also provide the most frequent tokens (words, numbers or emojis) that appear during any given month. These are provided separately for subsets of tweets, which are classified as positive, negative and neutral (when available).

Frequent tokens relate to the concepts mentioned in the tweets and could, as such, be used do discover aspects of resilience relevant to the community, thus potentially serving as proxy candidates. Frequent tokens are computed using the following procedure: (1) the text of all tweets is whitespace split into tokens and cast to lower case, (2) unwanted tokens are removed, (3) tokens are sorted by frequency of occurrence, and (4) the most frequent tokens are selected for presentation.

Unwanted tokens, mentioned in the second step, are the Italian stop-words. These are filtered using the *nltk* library [3], as well as using a custom unwanted tokens list, such as punctuation characters and various versions of the names of the communities. In the final step, we check that the frequent tokens appear in enough different tweets. Namely, repeated tokens in a single tweet all count towards token frequency, but count only once in terms of tweet appearance. We prevent presenting frequent tokens that do not appear in enough individual tweets, with a occurrence check using a predefined threshold.

4.3 Topic Modeling

To identify potential resilience-related topics, we wanted to automatically model topics in the collected tweets. Our motivation was that, given such topics, resilience experts could analyze the corresponding tweets and extract information useful for resilience assessment and proxy construction.

Topic detection or modeling [13] is a common task in natural language processing and aims at discovering topics, e.g., politics, sports, cycling, etc., that appear in a set of text documents, such as news articles or tweets. The assumption is that if a document discusses a specific topic, some words will appear more frequently.

[3] https://developer.twitter.com/en/products/twitter-api/academic-research

[4] In particular, out of 364531 tweets that mention Catania in 2020, only 8777 (approximately 2.4%) were labeled with geo-location meta-data.

[5] Available at https://github.com/MilaNLProc/feel-it.

Topic modeling is an unsupervised classification method, similar to soft or fuzzy clustering, since a document can belong to more than one topic or cluster. One popular algorithm for topic modeling is Latent Dirichlet Allocation (LDA) [15, 4], which takes the number of topics as an input parameter.

After standard preprocessing of tweets required for topic modeling (upper to lower case, removal of URLs, tokenization into words, removal of stopwords and other irrelevant words), we applied the LDA algorithm with a preset number[6] of topics ranging from 3 to 15. We visualized the resulting topics as word clouds and manually inspected them. We sought to identify topics related to resilience, such as sets of tweets discussing actions of authorities in response to natural disasters (floods, fires, etc.) or citizens perception of authorities' ability to act in case of such disasters. Our inspection was inherently subjective and mostly focused on the top-ranked words, although we also considered standard measures for topic evaluation (perplexity and coherence).

Figure 1: An example of a detected topic. It focuses on COVID-19 measures and conditions for crossing the border between Italy and Slovenia.

The most interesting topic is presented in Figure 1 and includes tweets discussing the COVID-19 measures (*mascherine* is Italian for masks) and conditions (*condizioni*) for crossing the border between Italy and Slovenia, as Gorizia is a border town. Unfortunately, we did not find any topics directly related to resilience, which could be used by resilience experts to assess resilience.

This analysis seems to infer that automatic topic modeling from tweets is likely not very useful for assessing resilience, at least not in the context that we tried to use it, though this might be due to the nature of topic modeling. Namely, the topics that we get obtained were *general*, in that they cover general, rather than resilience specific, concepts, and *unpredictable* in a sense that in some circumstances (and locations) we might obtain resilience related topics and in others not. Ultimately, the automatically constructed topics were not very informative, and, as such, we used topics constructed manually by resilience experts from the involved communities.

4.4 Aggregates and trends

To support facilitate the use of the results of our analyses in the RESILOC platform, several aggregates are explicitly calculated. These aggregates seek to capture the overall sentiment and sentiment trends over various time periods and are available to LRTs, who can use them as inputs for proxy construction. The aggregates are calculated monthly and yearly. The list of aggregates and their descriptions is as follows.

Positive ratio. Ratio of positive tweets vs the total number of total tweets in the current time period.
Neutral ratio. Ratio of neutral tweets vs the total number of total tweets in the current time period.
Negative ratio. Ratio of neutral tweets vs the total number of total tweets in the current time period.
Relative change of volume. Ratio of the number of tweets in the current time period and previous time period.
Relative change of positive tweets. Ratio of the number of positive tweets in the current and previous time period.
Relative change of neutral tweets. Ratio of the number of neutral tweets in the current and previous time period.
Relative change of negative tweets. Ratio of the number of negative tweets in the current and previous time period.
Absolute change in volume. Difference of the number of tweets in the current and previous time period.
Absolute change in positive tweets. Difference of the number of positive tweets in the current and previous time period.
Absolute change in neutral tweets. Difference of the number of neutral tweets in the current and previous time period.
Absolute change in negative tweets. Difference of the number of negative tweets in the current and previous time period.

5 WEB APPLICATION

We make the collected summaries of volume and sentiment analyses, frequent tokens and topic data available through a simple web interface. To access the tool, which is intended for internal use, a user provides a security access token, which determines which community data the user is privileged to view.

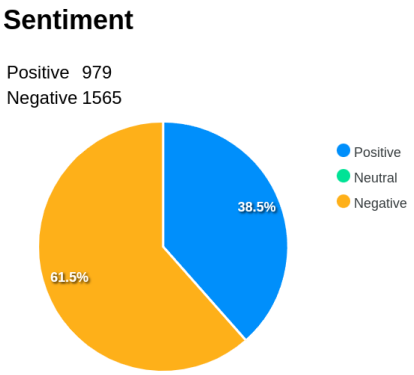

Figure 2: An example of a sentiment distribution as displayed in the web application.

All community data is split into sections based on available classifiers and time intervals. The application provides two options for the time interval, i.e., monthly and yearly views.

The monthly view is composed of the following sections: a total tweet count, tweet count by sentiment accompanied with a corresponding pie chart (as seen in Figure 2), a table of frequent tokens per classified sentiment (as seen in Table 1), a table with the calculated aggregates and trends and, finally, a topics section, that shows values for particular topics. In the final section, each defined topic has a subsection, where the user can see which tokens define the topic, its sentiment distribution and a corresponding pie chart, as shown in Figure 3.

[6]We selected 15 topics as an amount that can be inspected manually.

Table 1: An example set of detected frequent tokens.

(a) Positive		(b) Negative	
Token	**Occurence**	**Token**	**Occurence**
edizioni	174	stato	102
europea	141	recarsi	77
oggi	139	solo	57
nova	128	x	47
capitale	119	ospedali	39

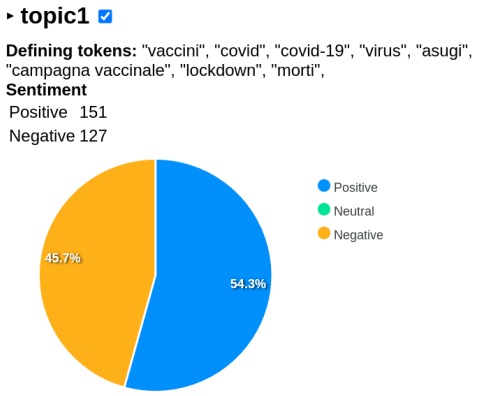

Figure 3: An example of a COVID-19 related topic.

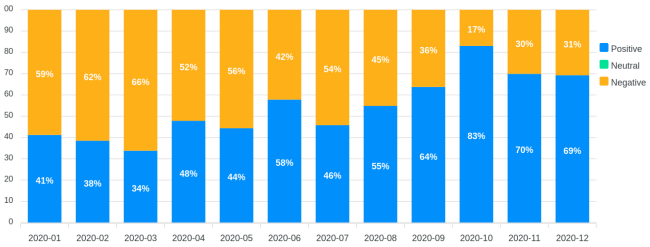

Figure 4: An example of a yearly view of relative sentiment.

The yearly view is composed of the same sections as the monthly view, however, it concerns data for the entire year. In addition to the global pie charts (for sentiment distribution), graphs for the progression of absolute and relative sentiment are shown based on month by month data, as shown in Figure 4.

6 CONCLUSION

We propose a novel approach to resilience assessment based on social media datasets. The analyses and tools described in the paper were developed and presented to potential users in preliminary try-out sessions, i.e., as sprints in Agile software development, as well as discussed with the project consortium's domain experts. The approach is currently being evaluated in the project trials, to quantify its usefulness based on expert feedback.

While automatic topic modeling resulted in some meaningful topics, these were mostly general and very few of them were related to resilience. The users expressed preference for more focused topics, which can now be defined manually, and find the new results interesting and potentially relevant. Interestingly, there is a general preference to not directly use the automatically calculated aggregates of volume and sentiment as inputs to the resilience assessment models, but to be considered and prepared for use by the users, i.e., employed with human oversight.

Analyses such as the ones presented in this paper are only useful for large enough communities that get mentioned in tweets frequently. Furthermore, tweets often do not represent the opinion of the population at large. While they are suitable for analysis, even in real time, their representativity is an issue that needs to be considered when using such data.

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REFERENCES

[1] Ghazaleh Beigi, Xia Hu, Ross Maciejewski, and Huan Liu. 2016. An overview of sentiment analysis in social media and its applications in disaster relief. *Sentiment analysis and ontology engineering*, 313–340.

[2] Federico Bianchi, Debora Nozza, and Dirk Hovy. 2021. "FEEL-IT: Emotion and Sentiment Classification for the Italian Language". In *Proceedings of the 11th Workshop on Computational Approaches to Subjectivity, Sentiment and Social Media Analysis*. Association for Computational Linguistics.

[3] Steven Bird, Ewan Klein, and Edward Loper. 2009. *Natural language processing with Python: analyzing text with the natural language toolkit*. O'Reilly Media.

[4] David M. Blei, Andrew Y. Ng, and Michael I. Jordan. 2003. Latent dirichlet allocation. *Journal of Machine Learning Research*, 3, (Mar. 2003), 993–1022.

[5] Uberto Delprato, Joe Cullen, Thomas Spielhofer, Daniele Del Bianco, Rajendra Akerkar, Nadia Miteva, and Zlatka Gospodinova. 2022. RESILOC Project Deliverable 3.1 – RESILOC Resilience Indicators. Tech. rep. The RESILOC Consortium. Retrieved Aug. 24, 2022 from https://www.resilocproject.eu/wp-content/uploads/2022/05/RESILOC_D3.1_V7.0.pdf.

[6] Jacob Devlin, Ming-Wei Chang, Kenton Lee, and Kristina Toutanova. 2019. BERT: pre-training of deep bidirectional transformers for language understanding. In *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*. Association for Computational Linguistics, Minneapolis, Minnesota, (June 2019), 4171–4186. DOI: 10.18653/v1/N19-1423.

[7] United Nations Office for Disaster Risk Reduction. 2012. Terminology. Retrieved Aug. 24, 2022 from https://www.undrr.org/terminology/resilience.

[8] Manon Jurgens and Ira Helsloot. 2018. The effect of social media on the dynamics of (self) resilience during disasters: a literature review. *Journal of Contingencies and Crisis Management*, 26, 1, 79–88. DOI: 10.1111/1468-5973.12212.

[9] Bing Liu. 2015. *Sentiment Analysis: Mining Opinions, Sentiments, and Emotions*. Cambridge University Press.

[10] Matej Martinc, Iza Skrjanec, Katja Zupan, and Senja Pollak. 2017. Pan 2017: author profiling-gender and language variety prediction. In *CLEF (Working Notes)*.

[11] Sjirk Meijer, Jon Hall, Rut Erdelyiova, Marcello Sabanes, Abby Onencan, and Kerstin Junge. 2022. RESILOC Project Deliverable 2.6 – Analysis of different approaches to resilience also outside EU, Section 6. Tech. rep. The RESILOC Consortium. Retrieved Aug. 24, 2022 from https://www.resilocproject.eu/wp-content/uploads/2021/04/RESILOC_D2.6-v6.0_Final.pdf.

[12] Ahmed Nagy and Jeannie A Stamberger. 2012. Crowd sentiment detection during disasters and crises. In *ISCRAM*.

[13] Christos H. Papadimitriou, Hisao Tamaki, Prabhakar Raghavan, and Santosh Vempala. 1998. Latent semantic indexing: a probabilistic analysis. In *Proceedings of the Seventeenth ACM SIGACT-SIGMOD-SIGART Symposium on Principles of Database Systems* (PODS '98). Association for Computing Machinery, Seattle, Washington, USA, 159–168. DOI: 10.1145/275487.275505.

[14] Dennis J Parker. 2020. Disaster resilience–a challenged science. *Environmental Hazards*, 19, 1, 1–9.

[15] Jonathan K Pritchard, Matthew Stephens, and Peter Donnelly. 2000. Inference of Population Structure Using Multilocus Genotype Data. *Genetics*, 155, 2, (June 2000), 945–959. DOI: 10.1093/genetics/155.2.945.

[16] Lola Xie, Juliet Pinto, and Bu Zhong. 2022. Building community resilience on social media to help recover from the covid-19 pandemic. *Computers in Human Behavior*, 134, 107294. DOI: 10.1016/j.chb.2022.107294.

Urban Mobility Policy Proposal Using Machine-Learning Techniques

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ABSTRACT

The world's demography is constantly increasing and most people move to big cities. This growth in urbanization affects people's daily activities by encountering congestion, air and noise pollution, water and energy usage etc. To deal with such issues, city authorities are taking various actions in order to provide the most optimal solution. In that terms testing, evaluating and implementing different scenarios are of great importance that cost money and time at the same time. Therefore, in the era of artificial intelligence, different approaches can be used to automate this process. In this paper, we propose a system that has the potential to automatically propose mobility policies based on previously defined city changes. The decision-makers input the required city changes, while the system outputs a mobility policy that satisfies that specification. To implement the idea, machine-learning algorithms are trained on data produced by a microscopic traffic simulator. The system is tested on data representing the city of Bilbao, where the policies are related to closing the Moyua square in the city centre at a specific time and for different duration, while the city changes are related to air pollution and usage of different means of transport.

KEYWORDS

traffic simulation, artificial intelligence, mobility policy

1 INTRODUCTION

According United Nations report [7] by 2050 two in three people will live in urban areas. However, as cities continue to grow they may face many challenges that affect the daily mobility services and people's movement in general. Therefore, finding a solution that satisfies people's needs is a crucial step toward building a more sustainable mobility system. Currently, many traditional approaches exist that rely on experts' knowledge using results from microscopic simulations. Those approaches include simulation of different mobility policies which are then analysed by the decision-makers. The key issue is how to choose the most appropriate mobility policy that will satisfy the requirements defined by the decision-makers that meet the user's needs. Achieving this goal is impossible without using the help of modern technologies such as machine learning.

In this paper, we propose a system that makes usage of machine learning methods to automate the process of mobility policy suggestions. As decision-makers are interested in achieving a particular set of goals (KPIs) such as reducing CO_2 emissions or increasing the usage of public transport, the system outputs the most appropriate policy that satisfies those requirements.

The rest of the paper is organised as follows. First, an overview of the proposed system is given. Then Section 3 describes the process of collecting the data by giving a brief overview of the simulation tool used, the implemented scenarios and the key performance indicators (KPIs). In Section 4 the machine learning approach is discussed followed by a description of the applied methods and the experimental results. Finally in Section 6 a conclusion is given.

2 SYSTEM

The key concept of the proposed system is to collect data from the microscopic traffic simulator. All the components are shown in Figure 1. The microscopic traffic simulator emulates the behaviour of all the people interacting on the mobility infrastructure. To run the simulator several input files are required such as network and travel demand. Then the output of the simulator is used to calculate the KPIs and later both are used to train the ML model as part of the ML module. The ML module takes as input a required city change defined by the decision-makers and using the trained model outputs a mobility policy that satisfies those requirements.

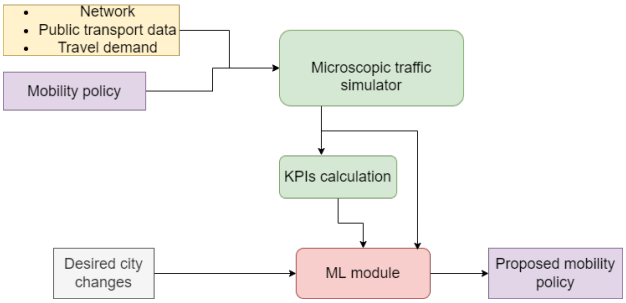

Figure 1: System description

3 DATA COLLECTION

Building a ML module/model that predicts the most suitable mobility policy requires a sufficient amount of data related to a particular set of policy actions and their consequences. In that terms, the main source of data for the proposed system comes from a microscopic traffic simulator as a very common research method for testing and evaluating different mobility situations. In the following sections, a brief overview of the simulation tool is given, and then different scenarios representing specific policies are discussed. Finally, the KPIs used for this study are presented.

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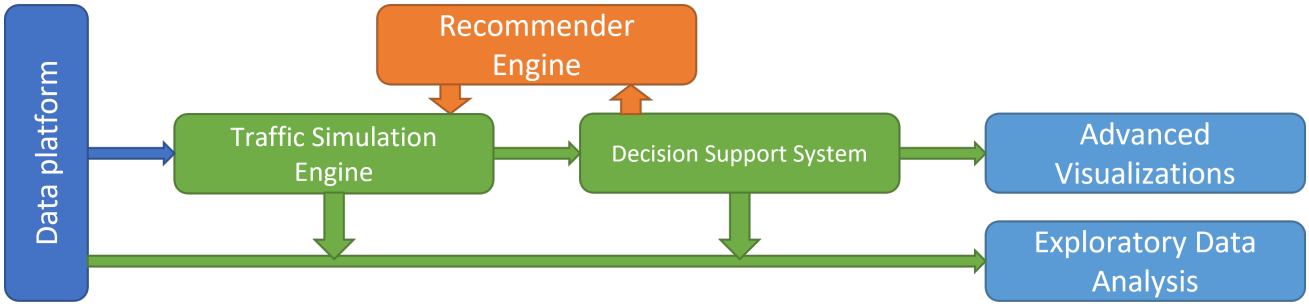

Figure 2: System for Urban mobility policy design architecture.

3.1 Simulation

In this study, MATSim was used as the most suitable microscopic simulation tool [3]. The main concept behind this tool is shown in Figure 3. It consists of an iterative process where plans from the travel demand are executed simultaneously in the mobsim and scored in the scoring module. The score is a metric to evaluate whether a plan is good or bad. It takes into account travelling and waiting time, activity duration etc. More about scoring can be read here [5]. Then a certain number of plans are chosen and modified in the replanning step. After a sufficient number of iterations (in our case 200) an equilibrium is reached where no more plans are evolving, producing higher scores.

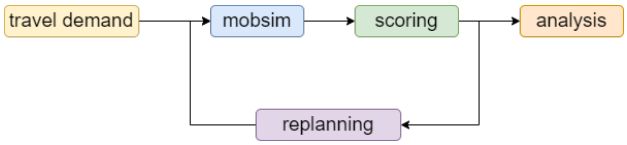

Figure 3: MATSim cycle

A crucial step before running the simulator is to provide data representative of the study area of our interest. The input data is related to the city network map, public transit schedules, travel demand etc. The most challenging part is to construct the travel demand as demographic and other people's movement data is hard to find. Therefore different techniques exist to solve the issue. One approach is to replicate a real population (construct synthetic population) using sample data and marginal distribution, and then assign activity location using origin-destination (OD) matrices. The iterative proportional fitting (IPF) [1] algorithm is used to construct the synthetic population using sample data from EUSILC [2] and demographic data provided by the city. The IPF algorithm is one of the most widely used algorithms for synthetic population reconstruction that combines both datasets (sample data and marginal distributions) to produce weights that show the number of replication of a specific person from the sample data to a specific geographical zone while maintaining the marginal distributions.

The simulation outputs a large amount of data that describes people's movements in form of events. Each event has a type such as "vehicle enters traffic", "vehicle enters/leave link", "person starts activity" etc., time and person's id that performs it. Other output files also exist as histograms of travel/wait times, usage of different transport modes etc. All this data is used in the calculation of KPIs for the ML module.

3.2 Scenarios

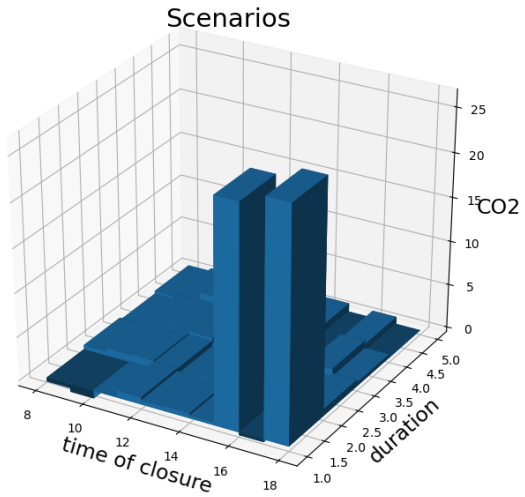

Figure 4: Scenarios CO_2

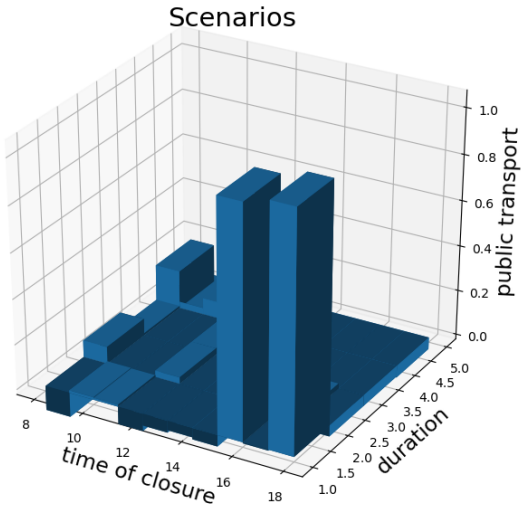

Figure 5: Scenarios Public Transport

We have tested 40 different situations of one policy represented by the closure of the Moyua square from 8 am to 5 pm with a

different duration from one to four hours. Results of the applied policy are shown in Figure 4 and Figure 5.

On both plots, the x-axis represents the start time of closure, while the y-axis represents the duration of closing the square for transport in hours. On the first bar plot, the z-axis shows the changes in percents of CO_2 warm emissions and the z-axis on the second bar plot shows the changes in percents in public transport usage compared to a situation when no changes in the city are applied. In terms of reducing the CO_2 emissions, the best scenario is if we close the square at 9 am for 1 hour. In that case the CO_2 has lowered for 0.9%. On the other hand, if the square is closed from 5 pm to 6 pm for traffic, the city gets congested in the surrounding areas and the CO_2 warm exhausts are increased by 26% even though the public transport usage has increased and car usage has decreased as shown on the second bar plot.

3.3 KPIs Calculation

The key performance indicators (KPIs) represent the objectives defined by the decision makers that need to be achieved. In collaboration with the city, a set of KPIs was defined as follows:

- **Air pollution**: CO_2, NOx, PM cold/warm emissions.
- **Usage of different modes**: car, bicycle, public transport, walk.
- **Bike safety, bikeability**

The first set of KPIs related to air pollution is modelled using MATSIm additional emission package [6]. The emissions are calculated using HBEFA (Handbook on Emission Factors for Road Transport) database [4] in combination with the simulation output. As air pollution is caused by different contributions of road traffic the emissions module considers both warm and cold emissions. Warm emissions are emitted while driving and depend on driving speed, stop duration, and vehicle characteristics while cold emissions are emitted during the warm-up phase and are dependent on the engine's temperature.

The second set of KPIs related to the usage of different modes of transport is produced during the simulation, while bike safety and bikeability are calculated from the simulation results.

4 MACHINE-LEARNING FOR POLICY PROPOSAL

The developed system proposes a ML module that helps decision-makers in suggesting mobility policies that satisfy a set of predefined KPIs. As mentioned before, the main source to train the ML models comes from the microscopic traffic simulator. The data used to train the models is shown in Table 1. The KPIs represent the features, while the policies, i.e., scenarios are treated as target variables where the start time and duration of closure are discretized into 30 and 15 minutes intervals respectively. By doing so, the most suitable scenario will be predicted according to the pre-selected KPIs values.

Table 1: Features and target variables

Features		Target variables
CO_2 warm	CO_2 cold	start time of closure
NOx warm	NOx cold	duration of closure
PM warm	PM	
car trips	bike trips	
PT trips	walk	
bikeability	bike safety	

4.1 Methods and Results

Since the target variables are continuous and there are multiple of them, we deal with a multi-output regression problem. This involves predicting more numerical values at the same time which limits the usage of many algorithms that are designed in predicting only a single numerical value. However, to solve the problem several solutions exist:

- Multi-output regression algorithms
- Wrapper multi-output regression algorithms
  - Direct multi-output regression
  - Chained multi-output regression

One approach is to use regression algorithms that support multiple outputs directly such as linear regression, k-nearest neighbours, decision tree, random forest etc. The other approach is to divide the multi-output regression problem into multiple sub-problems (wrapper multi-output regression) and then deal with single regression problems. On one hand, there is direct multi-output regression where independent models are developed for the prediction of each numerical value. On the other hand, the chained multi-output regression consists of dependent models when predicting each numerical value.

To evaluate the models a cross-validation technique was used. The mean absolute error (MAE) performance metric is used as a score. The mean and standard deviation of the MAE are calculated across all the folds and all repeats. Table 2 shows the results of inherently multi-output regression algorithms. K-Nearest Neighbours proved the best results with a mean value of MAE of 3.743 and a standard deviation (SD) of 0.852, which means that the difference between the predicted and true value is approximately 4-time intervals or 2 hours for start hour and 1 hour for the duration.

The plot on Figure 6 depicts the difference between true (blue dots) and predicted (red dots) values for 30% of the data. The x-axis represents the start hour, while the y-axis represents the duration of the closure. The smallest error (best-predicted instance) between a true and predicted value is marked with black and yellow dot respectively. Table 3 and Table 4 show results for direct and chained multi-output regression respectively where random forest and k-nearest neighbours proved the best results in both cases.

By applying different ML models, we examined which algorithm can prove the best results in predicting a mobility policy that satisfies a set of predefined city changes. On the other hand, when discussing the simulation results in Section 3.2 we concluded that closing the Moyua square in the afternoon (from 4 pm to 7 pm) decreases the CO_2 for 1%. Also if the square is closed at 11 am, the car usage decreases by 0.12% reducing the CO_2 emissions by 0.3%. Both situations can be implemented to achieve a more sustainable city but which one is better depends on the goals that the city wants to accomplish. If the aim is to decrease the CO_2 in the afternoon peak hours, the first situation is better. The latter situation provides better results if the city is interested in reducing car usage and increasing the usage of public transport. Therefore, selecting the best option when having multiple criteria that need to be satisfied is hard when only human knowledge is included. Additionally, the number of scenarios included in this work is limited as not every possible situation can be tested due to computational and time costs.

Table 2: Inherently Multi-Output Regression Algorithms

Model	MAE (mean)	MAE (SD)
Linear Regression	4.472	2.565
K-Nearest Neighbours	3.743	0.852
Decision Tree Regression	4.367	1.083

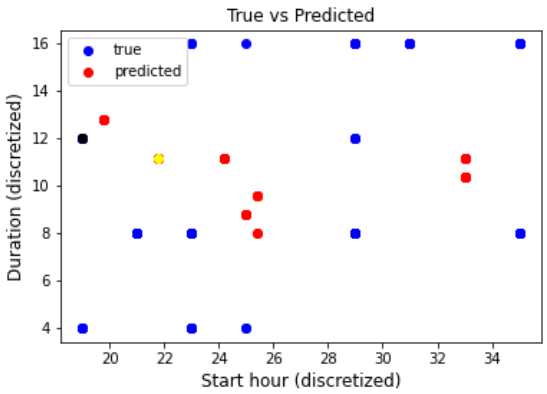

Figure 6: True vs Predicted Data

Table 3: Direct Multi-Output Regression

Model	MAE (mean)	MAE (SD)
Linear Support Vector Regression	5.684	4.709
Random Forest Regression	3.590	0.967
Linear Regression	4.472	2.565
K-Nearest Neighbors Regression	3.743	0.852
Decision Tree Regression	4.333	1.274

Table 4: Chained Multi-Output Regression

Model	MAE (mean)	MAE (SD)
Linear Support Vector Regression	5.718	4.364
Random Forest Regression	3.607	0.931
Linear Regression	4.472	2.565
K-Nearest Neighbors Regression	3.690	0.829
Decision Tree Regression	4.325	1.118

5 CONCLUSION

In this paper, we presented an approach for proposing mobility policies in an automatic way. First, an overview of the system was given. Then the simulation tool was described. 40 variations of one policy for closing the Moyua square in the centre of Bilbao for transport were simulated and evaluated. The variations refer to the start hour and duration of the closure. On the simulation data, the desired KPIs were calculated which together with other simulation output data were used as input to the ML models. Since the ML models output multiple variables (start hour and duration of closure) the problem becomes multi-output regression and limits the usage of many ML algorithms that are developed to deal with a single target. Therefore, two approaches were presented: multi-output and wrapper multi-output regression algorithms. Applying both sets of algorithms, the best results proved random forest regression using the chained method from the second approach.

6 FUTURE WORK

In order to provide the decision-makers with more options when implementing different strategies, in future work different areas around Moyua square will be closed. Closing multiple streets around the square might help in reducing the air pollution in the centre and in the city in general. Also, it can contribute to reducing congestion and other relevant KPIs during peak hours. Therefore, additional target variables such as the city areas to be closed and the length of the streets inside will be added. Since more simulation needs to be executed, three servers will be used to reduce the computational time. By doing this, the dataset will be expanded and more options will be available to the decision-makers in implementing the best scenario that meets the people's needs. Moreover, a mobility expert validation will be included in testing the ML module which will contribute to a more detailed analysis of the ML results.

ACKNOWLEDGMENTS

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REFERENCES

[1] Abdoul-Ahad Choupani and Amir Reza Mamdoohi. 2016. Population synthesis using iterative proportional fitting (ipf): a review and future research. *Transportation Research Procedia*, 17, 223–233. International Conference on Transportation Planning and Implementation Methodologies for Developing Countries (12th TPMDC) Selected Proceedings, IIT Bombay, Mumbai, India, 10-12 December 2014. DOI: https://doi.org/10.1016/j.trpro.2016.11.078.

[2] Eurostat. 2020. Eu statistics on income and living conditions microdata 2004-2019, release 2 in 2020. en. (2020). DOI: 10.2907/EUSILC2004-2019V.1.

[3] 2016. *Introducing matsim. The Multi-Agent Transport Simulation MATSim.* Ubiquity Press, (Aug. 2016), 3–8.

[4] Mario Keller, Stefan Hausberger, Claus Matzer, Philipp Wüthrich, and Benedikt Notter. 2017. Hbefa version 3.3. *Background documentation, Berne*, 12.

[5] Kai Nagel, Benjamin Kickhöfer, Andreas Horni, and David Charypar. 2016. A closer look at scoring. (Aug. 2016). DOI: 10.5334/baw.3.

[6] 2016. *Emission modeling. The Multi-Agent Transport Simulation MATSim.* Ubiquity Press, (Aug. 2016), 247–252. DOI: 10.5334/baw.36.

[7] 2017. *Population Facts No. 2017/4, October 2017: The impact of population momentum on future population growth.* https://population.un.org/wpp/Publications/Files/PopFacts_2017-4_Population-Momentum.pdf.

IMF Quality Assurance of Mammograms Using Deep Convolutional Neural Networks and Transfer Learning

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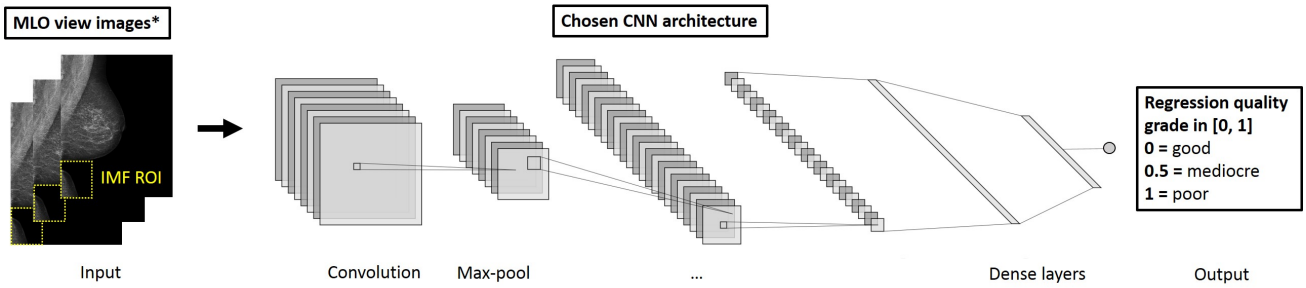

Figure 1: Pipeline of our proposed system. MLO mammograms are taken as input, fed into a chosen CNN architecture, which then outputs a quality grade in an ordinal regression task.

ABSTRACT

Quality assurance (QA) of mammograms is of vital importance, since they are the de-facto method used by doctors for detection of breast cancer and other tissue abnormalities. Despite this, there is a distinct lack of both experts and tools for this task. We thus investigated a deep-learning-based approach using convolutional neural networks for prediction of the inframammary fold (IMF) quality grade, which cannot be measured and determined quantitatively with rules (e.g., if some point x cm from edge, then grade y). We showed in a 5-fold cross-validation experiment that a relatively simple model can achieve respectable performance in terms of root mean squared error (RMSE), area under the ROC curve (AUC) and accuracy, predicting the IMF grade with 3 possible values. Finally we also showed that the model in fact derives features from the relevant ROI also looked at by the experts, hinting at real-world usefulness of such a QA model.

KEYWORDS

mammography, quality assurance, ordinal regression, neural networks, deep learning

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1 INTRODUCTION

Mammography is the process of using low-energy X-rays to examine human breast tissue for diagnosis and screening, with the typical goal being early detection of breast cancer through detection of anomalies in the tissue [3]. The procedure consists of compression of breast tissue using a dedicated mammography device with the aim of reducing and evening out the tissue thickness that X-rays must penetrate, in turn reducing the required radiation dose. There are two common views in which a mammogram is recorded, namely craniocaudal (CC) and mediolateral oblique (MLO). The former captures the breast tissue in a top-down direction along the pectoral muscle plane, while the latter captures it at an angle sideways.

The importance of regular mammographic screening can not be overstated, as it the de-facto method used by doctors for early breast cancer or other tissue-anomaly detection (e.g., tumors). However, the procedure itself is rather involved and can be tedious for the patient. Subsequently, it is of utmost importance to ensure high quality of taken images, as it is highly undesirable for a patient to have to revisit and repeat the procedure. To this end there are a number of guidelines available that are being followed by the radiologists with the aim of minimizing the amount of low-quality images taken. Some quality metrics can be quantified and measured precisely, while others are more subtle and often left to the expertise of the professionals. One such elusive metric is the Inframammary Fold (IMF). IMF is the inferior border of the breast and the crease between the breast and abdominal tissue.

It serves as an important anatomical landmark on an MLO mammogram to provide assurance to the radiographer that all of the posterior breast tissue has been included.

In Slovenia, only a single radiographer is responsible for weekly grading of randomly sampled mammographic segments from that week, as a part of the DORA oncology program. This is inefficient and the grade itself can be subjective, especially the metrics that are not clearly defined, such as IMF. There is thus a need for automated tools that would help radiologists with quality assurance (QA), optimizing the process while also potentially serving as a training tool for improvements in quality of mammograms being collected.

In this paper we highlight the importance and lack of QA methods for mammograms, and develop two deep convolutional-neural-network (CNN) computer vision models, aiming to recognize and successfully predict the IMF quality metric. The latter is known to be especially tricky and subjective. We evaluate and compare the performance of our proposed models on a custom dataset collected in Slovenia.

The rest of this paper is organized as follows: we first highlight related work about QA in mammography, together with existing computer vision methods that are important for QA in Section 2; in Section 3 we describe our dataset; Section 4 details our methodology and experimental results; and in Section 5 we summarize and discuss the implications with future directions for our work.

2 RELATED WORK

To ensure the key goals of mammography are achieved, quality assurance must be adopted in order for the mammograms to be suitable for diagnosis. In the past decades, several standards have been developed nationally and internationally to this end. A review study by Reis et al. [3] presents an overview of these, showing importance of both technical and clinical aspects, especially with the development of digital mammography.

In terms of QA, there are specific keypoints or region segmentations that are often required for individual grades. One such is the segmentation of pectoral muscle in the MLO view, which was traditionally segmented using pixel thresholding and region growing algorithms. Recently however, with the rise of deep learning, this task was successfully resolved. Soleimani et al. [6] proposed a two-stage algorithm that predicts precise pectoral muscle boundary using a CNN. Evaluating on three datasets they achieved average values of dice similarity and accuracy of 97% and 99% respectively.

Other researchers focused on the final task directly - prediction of anomalies related to cancer. For instance Abel et al. [1] proposed a CNN architecture for detection of abnormal axillary lymph nodes, which is a specific abnormality in the tissue. They reported accuracies of 96% for detection of suspicious lymph nodes. Shen et al. [5] have importantly shown that such end-to-end networks are not only performing well, but can be transferred between different datasets, for instance CBIS-DDSM and INBreast, hinting at good generalization capabilities.

Despite all existing work, we noticed a distinct lack of research dealing with machine learning QA prediction, meaning models that output grades of mammograms rather than try to predict some other subsequent outcome. The quality itself is however vital both for physicians or other models taking mammograms as inputs, as good quality mammograms are useful for detections, while poor quality is not only difficult for diagnosis, but requires a repeat measurement which is “expensive” for everyone involved.

3 DATA DESCRIPTION AND PREPROCESSING

The dataset used in our work was collected in the previously mentioned DORA program between 2011 and 2013 and graded by the single expert using a modified PGMI (Perfect, Good, Moderate, Inadequate) grading system, where there were just three grades (Good, Moderate, Inadequate/Poor). All the mammograms were anonymized and held by the Faculty of Health Sciences. In total there were 4928 mammograms, 2424 in the CC view and 2424 in the MLO view, each view in turn having a left (L) and right (R) image, each with a corresponding ground truth label. Example images can be seen as input in Figure 1.

Initially these images were saved in the widely-used Digital Imaging and Communications in Medicine (DICOM) format, which contains the image itself with a lot of corresponding metadata. These initial images are grayscale and come in varying resolutions, which is problematic for CNN inputs, which are expected to be of a constant shape. Subsequently we first extracted the images and standardized the resolution to 256 x 256 pixels, resaving them in lossless `.png` format. Some information loss can not be avoided however, since we are substantially decreasing resolution in this step.

Each image is by default also equipped with letters in the top-right or top-left corner of the image itself, denoting the view and side (e.g., CC-L or MLO-R). Since our computer vision models might use this information to learn some data-specific pattern between the view and quality, we semi-manually removed these letters by zeroing pixels in an empirically determined region, leaving only the breast tissue in each image.

Finally, some of the images have important keypoints or areas that are very difficult to see, especially with the naked eye. We thus investigated Adaptive Histogram Equalization methods, more specifically Contrast-Limited AHE (CLAHE), which was reported in related work to help substantially with visibility of important regions in mammograms [2]. The effects can be seen in Figure 2.

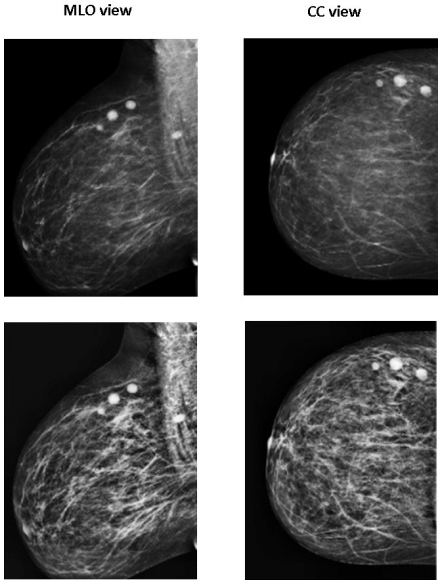

Figure 2: Effects of CLAHE image preprocessing on mammograms in both views. Top row are originals, bottom rows are preprocessed.

For our class label we used the one given by the expert for the IMF. It is a numeric value from 1 to 3, where 1 = good, 2 = moderate and 3 = poor. It is problematic since it is known to be subjective, but still the best we could obtain. It is also quite difficult to visualize clearly for a non-expert, but we show the relevant region of interest (ROI) looked at by the experts in Figure 1. Ideally the ground truth grade would be a voted value obtained by several experts, but that was not feasible. Since IMF is only evaluated on the MLO view, we used just those mammograms in further analysis.

4 METHODOLOGY AND RESULTS

The learning problem itself seems like a typical classification, however, after giving it some thought, we realized it is better to set it up as an ordinal regression problem, as we are predicting a range of grades. We thus mapped our class label values from discrete 1, 2 and 3 to the [0.0, 1.0] interval, where grade 1 = 0.0, grade 2 = 0.5 and grade 3 = 1.0. We thus obtain a numeric value from the network which gives us not only the class information but also the distance between prediction and ground truth (e.g., prediction of 0.96 is much better compared to prediction of 0.76, given ground truth 1.0).

Once our data was finalized in terms of inputs and outputs, we focused our attention towards a model. Related work dealing with visual tasks in general, as well as with mammograms specifically, shows convincing dominance of CNNs in the past decade. Subsequently we decided to investigate such architectures.

Our aim was to start with a simple architecture consisting of three 2D Conv layers with 16, 16 and 8 kernels (each of size 9 x 9), intermediate max pooling layers with kernel size 2 and stride 2, and one fully connected layer with 1000 neurons on top. We used batch normalization and dropout as commonly-used mechanisms to prevent overfitting. ReLU was used as the activation function and the network was trained for 100 epochs.

We then wanted to compare such a simple architecture with a more complex CNN. We decided to attempt a transfer learning approach, where we based it on the known VGG19 model trained on ImageNet. We replaced the final layer with two fully connected layers to instead predict our IMF grade, while keeping the bulk of the model intact with existing weights. Hyperparameters were mostly left at default values, except for learning rate which had a linear decay implemented in our simple architecture.

Initially the full data was split into training (80%), validation (10%) and test sets (10%), as traditional. However, using a random train-validation-test split can be volatile and is undesirable in terms of making any conclusions about robustness of the model. We thus instead used the 5-fold cross validation (CV) evaluation setup, where k-1 groups are taken for training and the remaining group is left for testing in each of the 5 iterations. Additionaly it was ensured that the distribution of labels is kept in each group, meaning we did a stratified split. This was important in our experiment since the class label distribution is relatively skewed (good / 1 / 0.0 = 65%, moderate / 2 / 0.5 = 30%, poor / 3 / 1.0 = 5%) and we are especially interested in the bad examples, which are in vast minority.

For evaluation metrics we used root mean squared error (RMSE) and area under the curve (AUC of ROC curve), while also looking at the classificaion accuracy (transforming from ordinal regression back to classification) as it is the most intuitive metric. In terms of AUC, we always compared all possible pairs of grades, meaning 1v2, 1v3 and 2v3. The most important is to have good separation between poor images and everything else, since those are the most problematic, while moderate images could be close to either good or poor. Numeric results are given in Table 1 and the ROC curves for all three cases (of the better performing model) are given in Figures 3, 4 and 5.

Table 1: Numeric results from the 5-fold CV using our simple model and transfer learning with VGG19.

Simple model					
Fold Nr.	RMSE	AUC 1v3	AUC 1v2	AUC 2v3	Accuracy
1	0.26	0.90	0.79	0.78	0.93
2	0.25	0.98	0.80	0.92	0.95
3	0.24	0.98	0.79	0.95	0.91
4	0.23	0.97	0.78	0.89	0.96
5	0.24	0.94	0.78	0.84	0.95
Avg.	**0.24**	**0.95**	**0.79**	**0.88**	**0.94**
Transfer VGG19 model					
1	0.29	0.78	0.73	0.60	0.79
2	0.27	0.89	0.73	0.77	0.75
3	0.28	0.85	0.70	0.71	0.66
4	0.28	0.94	0.65	0.92	0.70
5	0.30	0.85	0.69	0.73	0.77
Avg.	**0.28**	**0.86**	**0.70**	**0.75**	**0.73**

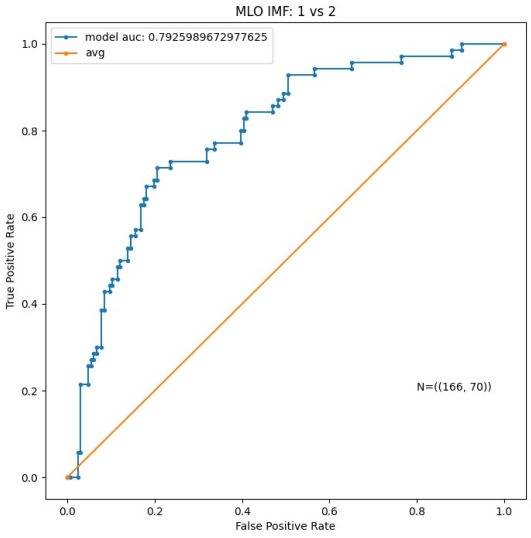

Figure 3: ROC curve of the better performing (simple) model for 1v2 class combination.

5 DISCUSSION AND CONCLUSION

Looking at the results, we can initially observe the overall better performance of our simple model compared to the pre-trained VGG19 transferred to our domain. All the metrics are more stable across fold while also achieving better overall values. Since we were especially interested in the separation of the good and poor mammograms (grade 1 vs. grade 3), we can also see that this

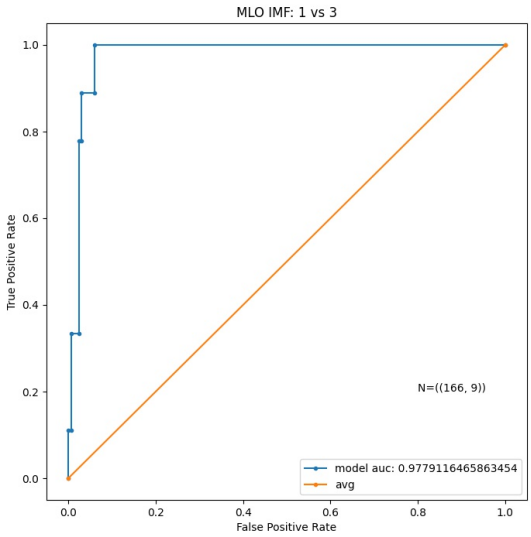

Figure 4: ROC curve of the better performing (simple) model for 1v3 class combination.

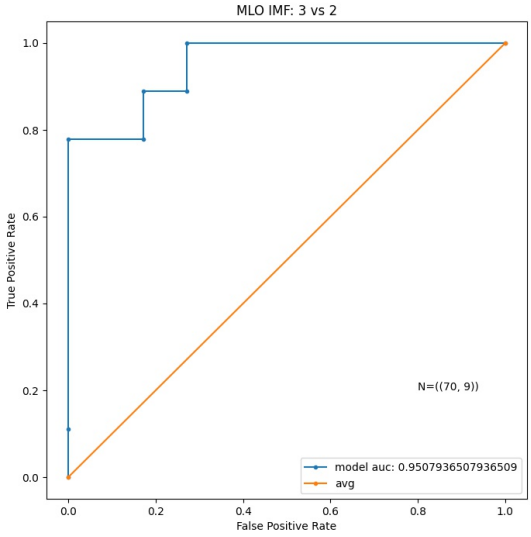

Figure 5: ROC curve of the better performing (simple) model for 2v3 class combination.

separation is indeed consistently successful and seems relatively robust. As expected the separation of moderate (grade 2) mammograms from others is more challenging, but still can be done reasonably well.

Deep learning models are often criticized for being black-box and not offering explainability for their decisions. We also wanted to do a quick investigation of this by using the Grad-CAM approach [4], which is a popular technique for producing "visual explanations" for decisions from a large class of CNN-based models in the form of a heatmap showing where the model focused the most on an image. An example is shown in Figure 6, where we can see the model commonly focused on the relevant IMF ROI that is also focused by the experts. However, this focus was not exclusive, meaning it did not focus just that region and also it wasn't the same on all images, but still rather consistent, which is a good indicator that the model actually learned the relevant features for IMF QA.

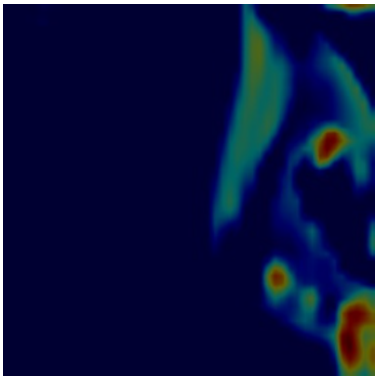

Figure 6: Grad-CAM heatmap showing the areas on the mammogram that were focused by the model to derive features.

To summarize, we investigated the possibility of CNN-based IMF QA for mammograms, looking at a simple CNN model and a transferred slightly-modified VGG19 model. The simple CNN architecture achieved respectable results in terms of several metrics and importantly also focused on the correct part of the image without any guidance, hinting that it learned the relevant features also looked at by the experts. Extensions to prediction of other QA grades might allow for a system that could help with continuous QA, as well as expert training.

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REFERENCES

[1] Frederik Abel, Anna Landsmann, Patryk Hejduk, Carlotta Ruppert, Karol Borkowski, Alexander Ciritsis, Cristina Rossi, and Andreas Boss. 2022. Detecting abnormal axillary lymph nodes on mammograms using a deep convolutional neural network. *Diagnostics*, 12, 6, 1347.

[2] Etta D Pisano, Shuquan Zong, Bradley M Hemminger, Marla DeLuca, R Eugene Johnston, Keith Muller, M Patricia Braeuning, and Stephen M Pizer. 1998. Contrast limited adaptive histogram equalization image processing to improve the detection of simulated spiculations in dense mammograms. *Journal of Digital imaging*, 11, 4, 193–200.

[3] Cláudia Reis, Ana Pascoal, Taxiarchis Sakellaris, and Manthos Koutalonis. 2013. Quality assurance and quality control in mammography: a review of available guidance worldwide. *Insights into imaging*, 4, 5, 539–553.

[4] Ramprasaath R. Selvaraju, Michael Cogswell, Abhishek Das, Ramakrishna Vedantam, Devi Parikh, and Dhruv Batra. 2019. Grad-CAM: visual explanations from deep networks via gradient-based localization. *International Journal of Computer Vision*, 128, 2, (Oct. 2019), 336–359. DOI: 10.1007/s11263-019-01228-7.

[5] Li Shen, Laurie R Margolies, Joseph H Rothstein, Eugene Fluder, Russell McBride, and Weiva Sieh. 2019. Deep learning to improve breast cancer detection on screening mammography. *Scientific reports*, 9, 1, 1–12.

[6] Hossein Soleimani and Oleg V. Michailovich. 2020. On segmentation of pectoral muscle in digital mammograms by means of deep learning. *IEEE Access*, 8, 204173–204182. DOI: 10.1109/ACCESS.2020.3036662.

Vehicle Axle Distance Detection From Time-series Signals Using Machine Learning

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ABSTRACT

In this study, we compare a signal decomposition and a convolutional autoencoder approach in determining vehicle axle distances. Our dataset consists of 62076 instances of vehicles crossing a bridge. Each vehicle is detected by eight identical sensors placed under the bridge that record time series vibration data. We compare our results to those computed using an expert's model, which we consider to be the ground truth. The signal decomposition approach achieves accuracies of up to 0.89, 0.98, and 1, with the calculated distances matching the expert model within 2%, 5%, and 10%, respectively. The convolutional autoencoder, on the other hand, achieves accuracies of up to 0.97, 0.99, and 1 with the same error margins compared to the expert model.

KEYWORDS

vehicle detection, axle distance, neural network, peak detection, machine learning

1 INTRODUCTION

In order to accurately weigh the vehicles crossing the bridge and determine if they weigh too much and damage the road, the vehicle speed, the number of vehicle axles, and their in-between distances must first be determined.

In recent years, many types of sensors have been used for vehicle detection. These include acoustic sensors, inductive loop sensors, strain sensors, magnetic sensors, and imaging sensors. Researchers around the world have developed various methods for using sensor data for vehicle axle detection, weight detection, and classification.

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The authors of Marszalek et al. [5] measured vehicle axle distances based on multifrequency impedance measurement of a slim inductive loop sensor. Using test vehicles, they were able to confirm that their method can successfully determine the distances. In the work by Chatterjee et al. [1] they used data from sensors on the bridge and a wavelet-based analysis to determine the axle distances. In the work of Khalili et al. [3], piezoelectric elements were used for a system to detect the weight of vehicles in motion. They used the weight-in-motion system to determine both the axle distances and vehicle weights with sufficient accuracy. Rujin et al. [4] developed a deep learning system for vehicle recognition based on strain sensor data. They were able to classify 11 different vehicle types with a very high average precision.

In this work, we use data collected from a single bridge to test two machine learning approaches for vehicle axle distance detection. The first approach is based on signal decomposition and the second approach is based on the convolutiona neural network autoencoder.

We begin in section 2 with a description of the dataset used in this study. In section 3, we explain our approaches and illustrate them with examples. Results are presented and discussed in section 4. The paper concludes with section 5.

2 DATASET

Our dataset consists of sensor data from vehicles crossing the bridge. The sensors are placed under the bridge in the configuration shown in the Figure 1. The sensors are identical and record the vibrations of the crossing vehicles at a sampling rate of $512Hz$. In this study, only data from vehicles travelling in lane 1 were used (orange sensors 1–8 in Figure 1). The vibration data from the sensors in the first and last columns (1 and 2) are also used to calculate the vehicle speed. The vehicle speed is calculated by superimposing the signals using a cross-correlation method. Our dataset consists of 62076 instances, where each instance contains data for one vehicle. In addition, each instance also contains the axle distances calculated by the expert model and the times at which each vehicle axle crossed the signal.

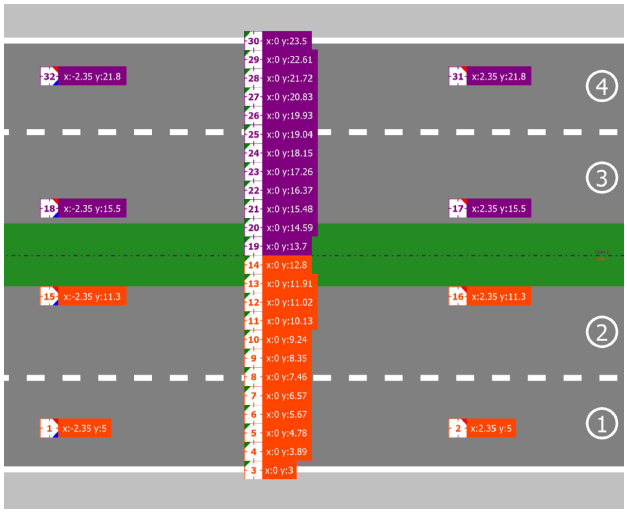

Figure 1: Placement of the sensors on the bridge.

An example of sensor data for a vehicle with 5 axles is shown in Figure 2. The signal peaks correspond to the vehicle axles crossing the sensor, while the amplitude corresponds to the weight of the vehicle on that axle. Although the peaks in the signal correspond to the vehicle axles, the intervening spacing of the peaks generally does not represent the actual axle spacing. Due to interference between the signals from the individual axles, the peaks shift relative to the position of the peaks if the signals from the individual axles were isolated. A small effect of this can be seen in the peak triplet in the right part of the signal in Figure 2. In some cases, where two of the adjacent vehicle axes are very close to each other, the peaks may overlap and become indistinguishable from each other, resulting in a single peak.

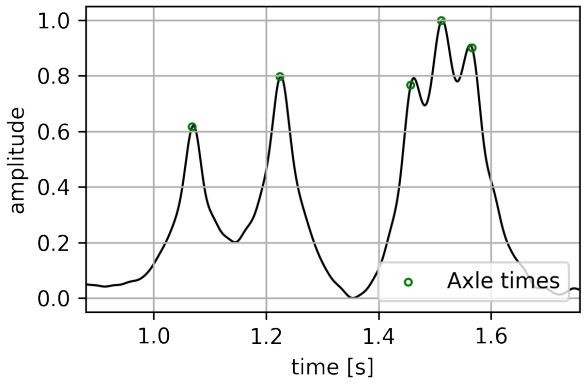

Figure 2: Example sensor data for a vehicle with 5 axles. The green markings correspond to the crossing points of the vehicle axles as calculated by the expert model.

3 METHODOLOGY

The objective of this study is to evaluate the performance of signal decomposition and convolutional autoencoder approaches in computing vehicle axle distances from sensor data. In our two approaches, the signal timing of the axles is first determined and then their intermediate distances are computed based on the vehicle speed.

We compare our results with those of the expert model, which has a measured accuracy of 98% in practise. Our results are considered correct if all calculated axle distances match those of the expert model within the specified margin of error. In addition, we have the option to skip the predictions of the results whose confidence level is below a certain threshold.

3.1 Signal Decomposition

The first step of a signal decomposition approach was to determine the most appropriate signal for each instance. For this purpose, peak detection was performed for all eight signals, calculating the first and second derivatives. A 62076×8 matrix was then created, with the eight columns indicating the number of detected peaks from each of the signals. A gradient boosting regression model was then trained on this matrix, the output of which was an array with the correct number of peaks. In addition, eight gradient boosting classifiers were trained, one for each of the signals. The output of each classifier was an array giving the probabilities that the number of detected peaks was correct for that signal.

For each test instance, the regression model first predicted the axis number, rounding the result to the nearest integer. All eight signals were then run, starting with the signal from sensor one. For each signal, a check was made to see if the number of peaks determined matched the number predicted by the regression model. If it did, we checked whether the probability that the number of detected peaks, as predicted by the classifier for that signal, was above a *confidence* threshold. Iteration was stopped if both criteria were met, and the signal was selected as the most appropriate for that instance. This means that in most cases not all signals were checked. Although in principle there could be a signal that would be even more suitable, we found experimentally that in more than 90% of cases signal 1 was the best, followed by signals 2, 5, and 6, in that order. If none of the eight signals met the criteria, the instance was skipped. In our experiments, we used *confidence* values between 0 and 0.997.

After the best signal for each instance was determined, the signals were decomposed into what are called base waves. A base wave is a function designed to have the form of an isolated wave, and can be constructed with three parameters: x-location, scaling in the x-direction, and scaling in the y-direction. The signal decomposition can be defined as an optimization problem where we want to find the best parameters for the base waves. The objective function we want to minimize is the mean square error between the original signal and the sum of the base waves. Once the signal was optimally decomposed, the peaks of the base waves were used to calculate the axle distances. The base wave peaks now correspond to the actual axle times and represent isolated waves, thus their peaks are not shifted by interference. This can also be seen in Figure 3: the green and black vertical lines do not exactly coincide, which is most obvious in the triplet on the right.

Peak detection and models' training was performed using Python 3.7 and libraries Scikit 0.24.2 [7] and Numpy 1.18.5 [2].

3.2 Convolutional Autoencoder

The second approach is a convolutional neural network as an autoencoder. The schematic of the model is shown in Figure 5. The first layer is the input layer. It consists of 4000 nodes, since this was the number of samples of the longest signal, and takes the raw signal as input. The signals with length less than 4000

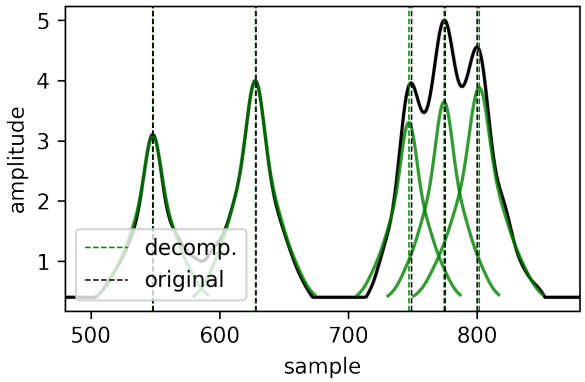

Figure 3: Example of signal decomposition. The black vertical lines represent the peaks as detected during peak detection, while the green lines represent the peaks after decomposition.

were padded with zeros. For all instances, signal 1 was chosen as the input signal, since it worked best in most cases. The encoding part of the autoencoder consists of three convolutional layers with sizes 5, 2 and 3 and the number of filters 8, 16 and 32. Each convolutional layer is followed by a batch normalization and a max-pooling of size 2. The decoder has the opposite structure compared to the encoder and the max-pooling layers are replaced by up-sampling layers. The output layer has the same size as the input layer. The loss function used for model training was a binary cross entropy.

The output for each training instance was a binary array, with ones at the sample locations containing a peak and zeros everywhere else. Thus, for the unseen (test) instances, the model outputs the probabilities for each of the input signal samples to include a peak. An example output for a test instance is shown in Figure 4. It can be seen that the probabilities for the peaks are almost always less than one, but the number of probabilities that are not zero (or not very close to zero) is equal to the number of actual peaks. It can also be seen that the model has learned to shift the peaks where necessary (triplet on the right).

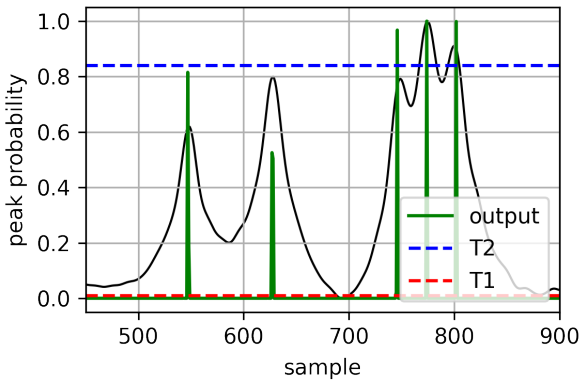

Figure 4: Example output of convolutional autoencoder.

After decoding, we selected lower and upper probability thresholds, *T1* and *T2* (red and blue dashed lines in Figure 4). If all peaks had a probability of at least *T1* and the highest probability was at least *T2*, the axle distances were calculated, otherwise the instance was skipped. In our experiments, *T1* was fixed at 0.01, while we tried values between 0 and 0.7 for *T2*.

Convolutional autoencoding was performed using Python 3.7 and library Tensorflow 2.9.1 [6].

4 RESULTS

Both approaches were tested with 5-fold cross-validation, and the folds were the same in both experiments. The results are shown in tables 1 and 2. They are given for a percentage of skipped instances between 0 and 50 %. The "$\pm x$" values in the brackets of the accuracy columns represent percentages within which the calculated axle distances must match those given by the expert models for the prediction to be considered correct. In the Table1, the confidence column corresponds to the *confidence* threshold of the prediction model for the number of peaks, while the T2 column in Table 2 corresponds to the minimum peak probability of the peak with the highest probability. If these criteria are not met, an instance is skipped. The corresponding amounts of skipped instances are given in the skipped columns.

We see that the signal decomposition approach achieves accuracies up to 0.89, 0.98, and 1, with the calculated distances matching the expert model within 2%, 5%, and 10%, respectively. The convolutional autoencoder, on the other hand, achieves accuracies of up to 0.97, 0.99, and 1 compared to the expert model, with the same error margins.

It can also be seen that for both approaches, the accuracies start to converge when about 15% of the instances are skipped, and do not improve significantly even when the percentage of skipping is 50. The convolutional autoencoder generally has higher accuracy than the signal decomposition approach, except in cases where the margin of error is 10 %, in which case the performances of both approaches are similar.

5 CONCLUSION

In this work, we tested a signal decomposition and convolutional autoencoder approach for vehicle axle distances detection using data from eight sensors mounted under the bride. We used a dataset of 62076 vehicles travelling in the same lane. We compared our results to those computed by an expert's model, which we considered to be the ground truth. Using the signal decomposition approach, we achieved accuracies of up to 0.89, 0.98, and 1 for the cases where each vehicle axle distance matched the expert model within 2%, 5%, and 10%, respectively. For the convolutional autoencoder, the accuracies obtained were 0.97, 0.99, and 1 for the same error margins compared to the expert model. The models will be improved in future work to include detection of vehicle axle weights.

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REFERENCES

[1] Pranesh Chatterjee, Eugene OBrien, Yingyan Li, and Arturo González. 2006. Wavelet domain analysis for identification of vehicle axles from bridge measurements. *Computers & Structures*, 84, 28, 1792–1801. DOI: https://doi.org/10.1016/j.compstruc.2006.04.013.

[2] Charles R. Harris, Jarrod K. Millman, Stefan J. van der Walt, Ralf Gommers, Pauli Virtanen, and David Caurnapeau. 2020. Array programming with numpy. *Nature*, 585, 357–362. DOI: https://doi.org/10.1038/s41586-020-2649-2.

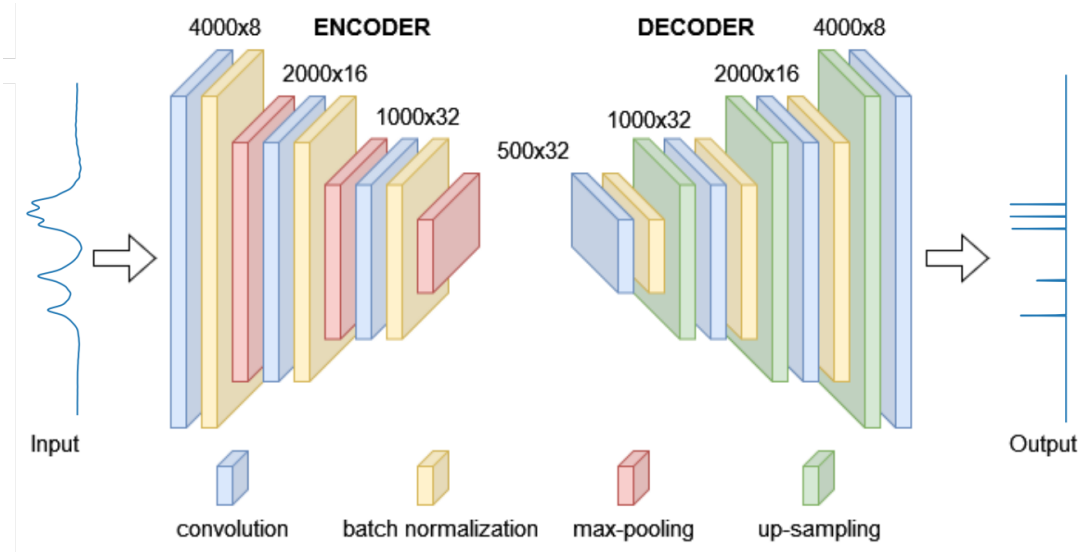

Figure 5: Scheme of the convolutional autoencoder structure.

Table 1: Results for the signal decomposition approach.

Confidence	Skipped	Accuracy (± 2%)	Accuracy (± 5%)	Accuracy (± 10%)
0.0	0.01	0.79	0.88	0.91
0.75	0.05	0.82	0.92	0.95
0.865	0.1	0.84	0.95	0.97
0.915	0.15	0.86	0.96	0.98
0.95	0.2	0.87	0.96	0.99
0.974	0.25	0.88	0.98	0.99
0.977	0.3	0.88	0.98	0.99
0.982	0.35	0.88	0.98	0.99
0.988	0.4	0.88	0.98	0.99
0.996	0.46	0.89	0.98	1.0
0.997	0.5	0.89	0.98	1.0

Table 2: Results for the signal convolutional autoencoder approach.

T2	Skipped	Accuracy (± 2%)	Accuracy (± 5%)	Accuracy (± 10%)
0.0	0.0	0.85	0.88	0.89
0.021	0.06	0.91	0.94	0.95
0.12	0.1	0.94	0.97	0.98
0.431	0.15	0.95	0.98	0.99
0.488	0.2	0.96	0.99	0.99
0.53	0.25	0.96	0.99	0.99
0.566	0.3	0.96	0.99	0.99
0.601	0.35	0.96	0.99	0.99
0.636	0.4	0.97	0.99	1.0
0.665	0.45	0.97	0.99	1.0
0.7	0.5	0.97	0.99	1.0

[3] Mohamadreza Khalili, Gopal Vishwakarma, Sara Ahmed, and Athanassios Thomas Papagiannakis. 2022. Development of a low-power weigh-in-motion system using cylindrical piezoelectric elements. *International Journal of Transportation Science and Technology*, 11, 3, 496–508. DOI: https://doi.org/10.1016/j.ijtst.2021.06.004.

[4] Rujin Ma, Zhen Zhang, Yiqing Dong, and Yue Pan. 2020. Deep learning based vehicle detection and classification methodology using strain sensors under bridge deck. *Sensors*, 20, 18. https://www.mdpi.com/1424-8220/20/18/5051.

[5] Zbigniew Marszalek, Waclaw Gawedzki, and Krzysztof Duda. 2021. A reliable moving vehicle axle-to-axle distance measurement system based on multi-frequency impedance measurement of a slim inductive-loop sensor. *Measurement*, 169, 108525. DOI: https://doi.org/10.1016/j.measurement.2020.108525.

[6] Martín Abadi et al. 2015. TensorFlow: large-scale machine learning on heterogeneous systems. Software available from tensorflow.org. (2015). https://www.tensorflow.org/.

[7] F. Pedregosa et al. 2011. Scikit-learn: machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830. http://www.jmlr.org/papers/volume12/pedregosa11a/pedregosa11a.pdf.

Študija učinkovitosti algoritma za razporejanje terenskega dela

A Study of the Performance of a Fieldwork Scheduling Algorithm

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POVZETEK

Razporejanje terenskega dela je zahteven optimizacijski problem. Za njegovo reševanje smo razvili trinivojski algoritem. Na prvem nivoju evolucijski algoritem razporedi naloge po delavcih, na drugem nivoju hevristika za vsakega delavca razporedi naloge po dnevih, na tretjem nivoju pa algoritem razveji in omeji rešuje problem mešanega celoštevilskega linearnega programiranja (angl. Mixed-Integer Linear Programming, MILP), kjer nalogam za vsakega delavca in vsak dan posebej dodeli čas njihovega začetka. V tem prispevku se posvečamo študiji učinkovitosti algoritma na tretjem nivoju. Izkaže se, da ta nalog ne more razporediti dovolj hitro za praktično uporabo, zato za povečanje njegove učinkovitosti MILP poenostavimo. Rezultati poskusov kažejo, da poenostavitev izboljša učinkovitost algoritma na tretjem nivoju, medtem ko je učinek na celoten algoritem načeloma ugoden, a odvisen od problema.

KLJUČNE BESEDE

problem razporejanja, evolucijski algoritem, hevristika, algoritem razveji in omeji, mešano celoštevilsko linearno programiranje, učinkovitost

ABSTRACT

Fieldwork scheduling is a demanding optimization problem. To solve it, we developed a three-level algorithm. At the first level, an evolutionary algorithm distributes tasks to workers, at the second level, a heuristic algorithm distributes tasks of each worker over days, and at the third level, a branch-and-bound algorithm solves the problem in the form of mixed-integer linear programming (MILP), where the starting times of tasks need to be scheduled for each worker and each day separately. In this paper, we study the efficiency of the algorithm at the third level. Because it cannot schedule the tasks fast enough for practical use, we try to increase its efficiency by simplifying the MILP. Experimental results show that the simplification improves the performance of the algorithm at the third level, while the effect on the overall algorithm is in principle favorable, but depends on the problem.

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KEYWORDS

scheduling problem, evolutionary algoirthm, heuristic algorithm, branch-and-bound algorithm, mixed-integer linear programming, efficiency

1 UVOD

Razporejanje terenskega dela je optimizacijski problem, ki zahteva dodelitev delavca in časa začetka opravljanja vsaki terenski nalogi tako, da je zadoščeno vsem omejitvam razporejanja in je cena celotnega urnika čim nižja. Obstajajo številne različice tega problema, ki se razlikujejo tako po omejitvah kot po načinu izračuna cene razporeda. Posledično obstajajo tudi različni pristopi za njegovo reševanje [6]. Študija [3] primerja dve formulaciji problema, in sicer v obliki problema usmerjanja vozil (angl. Vehicle Routing Problem, VRP) in v obliki problema mešanega celoštevilskega linearnega programiranja (angl. Mixed-Integer Linear Programming, MILP). Rezultati poskusov študije nakazujejo, da je oblika MILP za zapis razporejanja nalog terenskega dela ustreznejša od oblike VRP, zato tudi naš pristop uporablja obliko MILP.

Vendar pa je učinkovitost reševanja takšnih kombinatoričnih problemov zelo odvisna od njihove velikosti. Že pri relativno majhnih problemih se namreč pogosto zgodi, da jih ni moč rešiti v doglednem času. Zato se v našem pristopu zgledujemo po podobnih prijemih iz sorodnega dela (glej npr. [1]) in problem razdelimo na manjše, lažje obvladljive podprobleme. Problem razporejanja terenskega dela tako rešujemo s trinivojskim optimizacijskim algoritmom, pri katerem na prvem nivoju evolucijski algoritem razporedi naloge po delavcih, na drugem nivoju hevristika za vsakega delavca razporedi naloge po dnevih, na tretjem nivoju pa algoritem razveji in omeji rešuje problem v obliki MILP, tj. nalogam za vsakega delavca in vsak dan posebej dodeli čas njihovega začetka.

Tak trinivojski algoritem je sposoben v uri zadovoljivo rešiti tudi nekoliko večje probleme (npr. z 20 delavci, 20 dnevi in več sto nalogami), a je ta čas za praktično uporabo predolg. Zato želimo algoritem pohitriti. Ozko grlo predstavlja reševanje problema MILP, saj sta evolucijski algoritem in hevristika zelo hitra, tako da lahko največjo pohitritev celotnega algoritma dosežemo s pohitritvijo na tretjem nivoju.

V nadaljevanju prispevka v 2. razdelku najprej predstavimo našo različico problema razporejanja terenskega dela, nato pa v 3. razdelku na kratko opišemo trinivojski algoritem za njeno reševanje. V 4. razdelku analiziramo učinkovitost algoritma na tretjem nivoju, v 5. razdelku pa predlagamo poenostavitev problema MILP in preverimo njen učinek najprej na algoritem na

tretjemu nivoju in končno na celoten trinivojski algoritem. Prispevek sklenemo z zaključki v 6. razdelku.

2 PROBLEM RAZPOREJANJA TERENSKEGA DELA

Problem razporejanja terenskega dela opišemo s scenarijem razporejanja, spremenljivkami problema, omejitvami in optimizacijskim kriterijem (podrobne formalne definicije tu ne moremo zapisati zaradi pomanjkanja prostora). Obravnavamo najbolj splošno različico problema, v kateri želimo razporediti večino nalog, saj ta pokriva tudi posebni primer, ko je zaradi spremembe v zadnjem trenutku treba prerazporediti samo nekaj nalog.

2.1 Scenarij razporejanja

Časovno obdobje razporejanja je razdeljeno na dneve, znotraj njih je čas obravnavan zvezno. Za vsak dan poznamo začetek in konec rednega delovnika ter trajanje morebitnih nadur (bodisi na začetku bodisi na koncu dneva). Dane imamo tudi množico *lokacij*, časovne oddaljenosti za vsak par lokacij ter množico *kompetenc*, ki so skupne nalogam in delavcem. Scenarij razporejanja vsebuje tudi podatke o *delavcih*, in sicer za vsakega kompetence, dovoljeno število nadur ter začetno in končno lokacijo. Podatki o *nalogah* pa za vsako obsegajo njeno trajanje, želeno in obvezno časovno okno, prioriteto, zahtevane kompetence in morebitne želene delavce. *Malice* so posebne naloge, za katere lokacija ni definirana (malica se vedno izvaja na isti lokaciji kot predhodna naloga in se ne more prekrivati z drugimi nalogami).

Dodatno lahko scenarij razporejanja vsebuje že vnaprej pripravljene razporede posameznih nalog, ki so dveh tipov. *Obveznih razporedov* se ne sme spreminjati, a jih je treba vseeno upoštevati, saj postavljajo omejitve k razporejanju ostalih nalog. Po drugi strani pa se *želene razporede* lahko spreminja, a to vpliva na ceno končnega urnika.

2.2 Spremenljivke

Spremenljivke optimizacijskega problema v celoti določijo urnik, saj za vsako nalogo povedo ali je razporejena ali ni (ni namreč treba razporediti vseh nalog) in če je, kateri delavec jo bo opravil ter kdaj se bo začela izvajati.

2.3 Omejitve

Urnik, ki predstavlja rešitev problema, je dopusten samo, če izpolnjuje vse naslednje omejitve:

- Delavec lahko izvaja samo eno nalogo hkrati (v časovnem razporejanju nalog je treba poskrbeti tudi za upoštevanje trajanja potovanja med lokacijami).
- Delavec lahko izvaja naloge le znotraj delovnega časa in ima omejeno število nadur.
- Delavec mora imeti zahtevane kompetence za opravljanje naloge.
- Naloge morajo biti razporejene znotraj svojih obveznih časovnih oken.
- Nalog z obveznim razporedom se ne sme prerazporejati.

2.4 Optimizacijski kriterij

Optimizacijski kriterij oz. cena urnika, ki jo želimo minimizirati, je definirana kot utežena vsota naslednjih delnih kriterijev (prve tri postavke so si v nasprotju, zato je smiselno upoštevati samo eno od njih naenkrat):

- Vsi delavci naj bodo čim bolj enakomerno obremenjeni.
- Dnevno aktivnih delavcev naj bo čim manj.
- Aktivni delavci naj bodo čim bolj enakomerno obremenjeni.
- Skupno trajanje potovanj med lokacijami naj bo čim krajše.
- Izvede naj se čim več nalog.
- Naloge naj se izvedejo čim prej.
- Delavci naj imajo čim manj neaktivnega časa.
- Nadur naj bo čim manj.
- Naloge z višjo prioriteto naj se začnejo izvajati pred nalogami z nižjo prioriteto.
- Naloge, ki zapadejo prej, naj se začnejo izvajati pred nalogami, ki zapadejo kasneje.
- Naloge naj se izvedejo čim bliže želenemu časovnemu oknu.
- Nalogo, ki ima želene delavce, naj opravi eden izmed želenih delavcev.
- Nalogo z želenim razporedom naj se izvede čim bliže temu razporedu.

Uteži posameznih delnih kriterijev so zelo pomembne, saj določajo njihova medsebojna razmerja in drastično vplivajo na dobljene rešitve. Nastavili smo jih s pomočjo ekspertnega znanja in poskusov na številnih različnih scenarijih.

3 TRINIVOJSKI OPTIMIZACIJSKI ALGORITEM

V nadaljevanju na kratko predstavimo vse tri nivoje optimizacijskega algoritma.

3.1 Prvi nivo: razporejanje nalog po delavcih

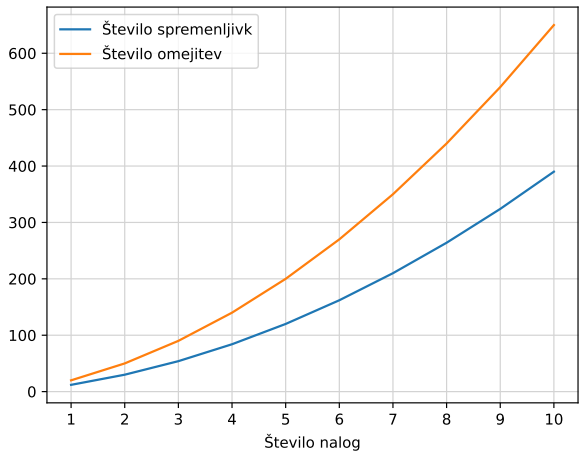
Na tem nivoju z evolucijskim algoritmom [5] vsaki nalogi dodelimo delavca, ki jo bo izvedel. Evolucijski algoritem začetno populacijo N_p rešitev ustvari naključno, vendar tako, da vse rešitve ustrezajo omejitvam za delavce (prve tri omejitve v razdelku 2.3). Potem algoritem izvaja naslednje korake največ N_g generacij. V vsaki generaciji algoritem najprej izbere N_p staršev s turnirsko selekcijo. Nato pare staršev križa in mutira (pri mutaciji uporabimo različne strategije zasnovane po meri delnih kriterijev (glej razdelek 2.4), ki jih izbiramo tako, da se pogostost uporabe sklada z njihovimi utežmi). Tako dobljeno populacijo evolucijski algoritem ovrednoti tako, da za vsako rešitev izvede drugi in tretji nivo algoritma. Nato staro populacijo prepiše z novo (najboljšo staro rešitev ohrani) in nadaljuje z enakimi koraki.

3.2 Drugi nivo: razporejanje nalog delavca po dnevih

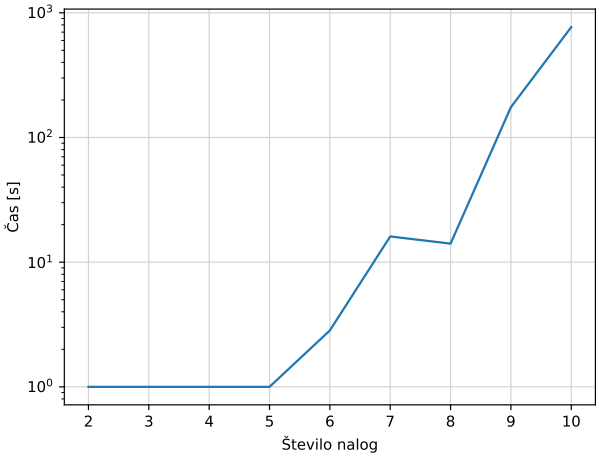
Hevristika na drugem nivoju naloge vsakega delavca razporedi po dnevih. Po vrsti vsem nalogam, urejenim naraščajoče po številu dni, v katerih se lahko izvedejo, dodelimo zanje najugodnejši dan. Ugodnost dne določimo z glasovanjem, ki poteka tako, da različni delni kriteriji (glej razdelek 2.4) glasujejo za dneve, ki so zanje najugodnejši. Glasovi so uteženi z utežmi delnih kriterijev, nalogi pa dodelimo dan z največ glasovi.

3.3 Tretji nivo: določitev časa začetka nalog za en dan enega delavca

Na tretjem nivoju z algoritmom razveji in omeji nalogam za en dan enega delavca dodelimo začetni interval. Problem torej zapišemo v obliki MILP tako, da upoštevamo samo tiste omejitve in delne kriterije, ki so na tem nivoju še smiselni (npr. na tem



Slika 1: Odvisnost števila spremenljivk in omejitev v formulaciji problema MILP na tretjem nivoju od števila nalog.



Slika 2: Povprečen čas, potreben za optimalno rešitev problema glede na njegovo velikost.

nivoju se ne ukvarjamo več s kompetencami, enakomerno obremenjenostjo delavcev in podobnimi delnimi kriteriji, saj je zanje poskrbljeno na prvih dveh nivojih).

Podobno kot pri predstavitvi problema tudi tu zaradi omejenega prostora ne moremo navesti celotne formulacije problema MILP. Za razumevanje nadaljevanja je najpomembneje vedeti, da imamo pri takšni formulaciji za problem z n nalogami $3n^2 + O(n)$ spremenljivk in $5n^2 + O(n)$ omejitev, kot prikazuje slika 1.

4 PREIZKUS UČINKOVITOSTI

Kot je razvidno iz slike 1, je število spremenljivk problema MILP zelo veliko že za probleme z majhnim številom nalog, kar otežuje nalogo optimizacijskemu algoritmu. Čas, ki ga potrebuje za najdbo optimalne rešitve, preverimo s poskusom na množici testnih problemov, ki imajo lastnosti podobne problemom iz prakse.

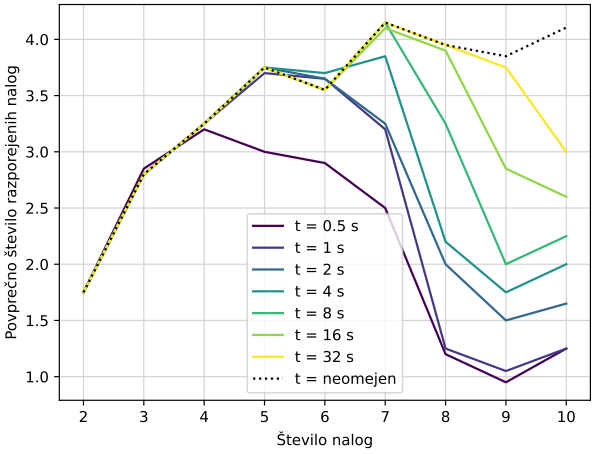
Ta množica vsebuje 180 testnih problemov (20 za vsako velikost problema od dveh do desetih nalog), pri katerih je treba določiti čas izvajanja nalog za enega delavca v enem dnevu. Nekateri problemi imajo samo navadne naloge, lahko pa imajo tudi malico, eno nalogo z obveznim razporedom ali pa oboje. Trajanje malice je vedno pol ure, trajanje ostalih nalog pa je izbrano naključno iz porazdelitve, ki skuša posnemati probleme iz prakse. Tako je večina nalog krajših od 90 minut, nekaj pa jih ima dolžino do štirih ur. Prioriteta vsake naloge je izbrana naključno med 1 in 9. Prav tako so lokacije izvajanja nalog in začetna lokacija delavca izbrane naključno izmed lokacij nekaterih večjih slovenskih mest. Večina nalog ima neomejeno časovno okno, pri nekaterih pa je okno skrajšano na začetku ali koncu dneva. Trajanje delovnega časa je izbrano naključno med 6 in 10 ur, lahko pa delavec vedno opravlja do dve naduri.

Vse testne probleme rešujemo z algoritmom razveji in omeji iz reševalnika SCIP [2] preko knjižnice OR-Tools [4]. Pri tem beležimo čas, ki ga algoritem potrebuje, da najde optimalno rešitev. Reševanje poteka na osebnem računalniku s 16 GB pomnilnika in frekvenco procesorja 3,60 GHz.

Rezultati poskusa so prikazani na sliki 2. Vidimo, da algoritem praviloma potrebuje eksponentno več časa z dodajanjem vsake naloge. Če želimo, da je celoten trinivojski algoritem koristen v praksi, si lahko za reševanje problema MILP privoščimo le nekaj sekund, kar pomeni, da je za naše potrebe algoritem neučinkovit že za probleme s sedmimi ali več nalogami.

Preverimo še, kako dobro deluje algoritem, če mu omejimo čas, ki ga ima na voljo za iskanje rešitev. Poskuse izvedemo z naslednjimi časovnimi omejitvami: 0.5 s, 1 s, 2 s, 4 s, 8 s, 16 s in 32 s. Pri tem opazujemo, koliko nalog je algoritem razporedil, in to število primerjamo z optimalnim številom razporejenih nalog (dobljenim v prejšnjem poskusu, ko algoritem ni bil časovno omejen). Čeprav cilj algoritma ni samo razporediti čim več nalog, je število razporejenih nalog dober pokazatelj kakovosti delovanja algoritma.

Na sliki 3 vidimo, da ob prekratkem času na problemih z veliko nalogami algoritem odpove (večino nalog zavrne, čeprav bi jih lahko razporedil). Na primer, ko ima algoritem na voljo le 0,5 s, primerno deluje le za probleme z do štirimi nalogami, za večje probleme pa njegova uspešnost pade in ko je nalog osem ali več, v povprečju razporedi le eno nalogo. Delovanje algoritma je nekoliko boljše, če ima na voljo daljši čas, a šele pri 32 s se



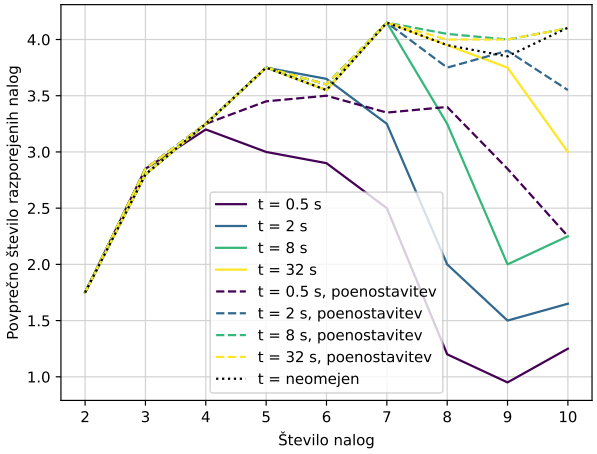
Slika 3: Povprečno število razporejenih nalog pri različnih časovnih omejitvah in velikostih problemov (s črtkano črno črto je prikazano optimalno število razporejenih nalog).

število razporejenih nalog na problemih z devetimi in desetimi nalogami približa optimalnemu številu razporejenih nalog.

5 POENOSTAVITEV PROBLEMA

Ker z delovanjem algoritma nismo zadovoljni, poskusimo problem poenostaviti. Za zapis delnih kriterijev za prioriteto in čas zapadlosti potrebujemo $2n^2 + O(n)$ spremenljivk ter $4n^2 + O(n)$ omejitev, kar je zelo veliko, sploh ker ta dva delna kriterija nista zelo pomembna. Zato preizkusimo, kako algoritem deluje, če ju izpustimo (zanju lahko do neke mere poskrbimo na zgornjih dveh nivojih optimizacijskega algoritma). Število spremenljivk in omejitev se še vedno povečuje kvadratično s številom nalog, vendar pa smo koeficienta pred kvadratnim členom s 3 oziroma 5 zmanjšali na 1.

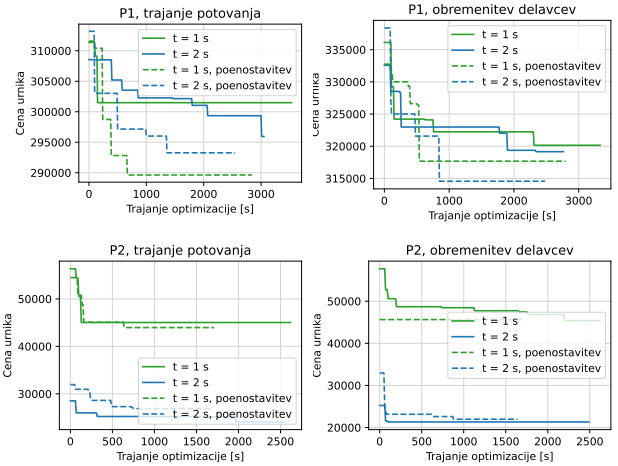
Za poenostavljeni problem izvedemo podoben test kot v razdelku 4, le da testiramo samo pri časovnih omejitvah 0.5 s, 2 s, 8 s in 32 s. Na sliki 4 primerjamo število razporejenih nalog pri osnovnemu ter poenostavljenemu problemu. Vidimo, da na večjih poenostavljenih problemih algoritem deluje mnogo bolje.



Slika 4: Primerjava delovanja algoritma na izvirni (polne črte) in poenostavljeni formulaciji problema (črtkane črte) pri različnih časovnih omejitvah in velikostih problemov (s črno črtkano črto je prikazano optimalno število razporejenih nalog izvirne formulacije problema).

S poenostavitvijo torej dosežemo, da algoritem na tretjem nivoju deluje zadovoljivo tudi za praktične potrebe. Vendar pa to še ne pomeni nujno, da poenostavitev izboljša delovanje celotnega trinivojskega algoritma. To preverimo s poskusom na dveh testnih problemih, P1 in P2, pri katerih damo enkrat večjo utež delnemu kriteriju trajanja potovanja, drugič pa enakomerni obremenitvi delavcev. Na ta način dobimo štiri različne testne probleme. P1 obsega 220 nalog, deset delavcev in sedem dni, P2 pa 114 nalog (vsebuje tudi malice), pet delavcev in tri dni. Za vsak testni problem poženemo štiri različice trinivojskega algoritma, ki se razlikujejo samo na tretjem nivoju – ta uporablja bodisi izvirni bodisi poenostavljeni problem, izvajanje algoritma pa je omejeno bodisi na 1 s bodisi na 2 s.

Slika 5 kaže rezultate teh poskusov. Na problemu P1 (zgornja dva grafa na sliki) lahko jasno vidimo, da poenostavitev problema na tretjem nivoju koristi učinkovitosti celotnega algoritma. Tega ne moremo trditi za problem P2, na katerem je delovanje izvirne in ponostavljene različice zelo podobno, vidimo pa veliko boljše delovanje v primeru omejitve izvajanja na 2 s.



Slika 5: Rezultati optimizacije za štiri različice algoritma na dveh problemih (P1 zgoraj in P2 spodaj) z dvema različnima delnima kriterijema (trajanje potovanja levo in enakomerna obremenitev delavcev desno). Manjše vrednosti so boljše.

6 ZAKLJUČKI

V prispevku smo analizirali učinkovitost algoritma za razporejanje terenskega dela. Posvetili smo se le časovno najzahtevnejšemu delu trinivojskega algoritma – reševanju problema MILP na tretjem nivoju. Z dvema poskusoma smo pokazali, da algoritem razveji in omeji ni dovolj učinkovit za reševanje praktičnih problemov, zato smo problem MILP poenostavili. To ne spremeni kriterijev celotnega problema, algoritmu na tretjem nivoju pa omogoči, da učinkovito reši tudi probleme z desetimi nalogami (več jih v praksi ne pričakujemo). Primerjali smo tudi, kako poenostavitev vpliva na delovanje celotnega algoritma, in ugotovili, da čeprav obstajajo problemi, za katere poenostavitev ni koristna, v splošnem daje dobre rezultate in se je bomo posluževali tudi v praksi.

ZAHVALA

To delo je nastalo v okviru projekta Inteligentno in okolju prijazno razporejanje terenskega dela – MF-Scheduler, katerega naročnik je Comland d.o.o., sofinancerja pa Ministrstvo za gospodarski razvoj in tehnologijo Republike Slovenije in Evropski sklad za regionalni razvoj Evropske unije, ter raziskovalnega programa P2-0209, ki ga financira Javna agencija za raziskovalno dejavnost Republike Slovenije iz državnega proračuna.

LITERATURA

[1] S. Bertels in T. Fahle. 2006. A hybrid setup for a hybrid scenario: Combining heuristics for the home health care problem. *Computers & Operations Research*, 33, 10, 2866–2890. DOI: 10.1016/j.cor.2005.01.015.

[2] K. Bestuzheva in sod. 2021. The SCIP Optimization Suite 8.0. Technical Report. Optimization Online, (dec. 2021). http://www.optimization-online.org/DB_HTML/2021/12/8728.html.

[3] J. A. Castillo-Salazar, D. Landa-Silva in R. Qu. 2016. Workforce scheduling and routing problems: Literature survey and computational study. *Annals of Operations Research*, 239, 1, 39–67. DOI: 10.1007/s10479-014-1687-2.

[4] Google Developers. 2021. About OR-Tools. Retrieved 19. avg. 2022 from https://developers.google.com/optimization/introduction/overview.

[5] A. E. Eiben in J. E. Smith. 2015. *Introduction to Evolutionary Computing*. (2. izd.). Springer. DOI: 10.1007/978-3-662-44874-8.

[6] D. C. Paraskevopoulos, G. Laporte, P. P. Repoussis in C. D. Tarantilis. 2017. Resource constrained routing and scheduling: Review and research prospects. *European Journal of Operational Research*, 263, 3, 737–754. DOI: 10.1016/j.ejor.2017.05.035.

Interaktivno eksperimentiranje z besednimi vložitvami v platformi ClowdFlows

Interactive Experimentation with Word Embeddings in the ClowdFlows platform

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POVZETEK

V članku predstavimo spletno platformo ClowdFlows, ki je namenjena analiziranju podatkov in strojnemu učenju in omogoča uporabo interaktivnih delotokov. Posebej predstavimo značilnosti platforme, ki lajšajo njeno uporabo programiranja neveščim uporabnikom in elemente platforme, ki omogočajo analizo teksta z najsodobnejšimi pristopi vektorskih vložitev. Poročamo tudi o praktičnem preizkusu uporabnosti platforme in njenih orodij z vektorskimi vložitvami za izbrane ciljne uporabnike s področij humanistike in družboslovja.

KLJUČNE BESEDE

procesiranje naravnega jezika, besedne vložitve, spletna aplikacija, delotoki

ABSTRACT

The paper presents the ClowdFlows web platform for machine learning and data analysis using interactive workflows. In particular, we highlight selected features that facilitate its use by non-programmers as well as selected elements of the platform that enable text analysis using state-of-the-art word embedding approaches. We also report on a hands-on evaluation of the usability of the platform and its word embedding components in a selected group of end users from the fields of humanities and social sciences.

KEYWORDS

natural language processing, word embeddings, web application, workflows

1 UVOD

Področja, povezana z metodami umetne inteligence, kot so rudarjenje podatkov, strojno učenje in avtomatska obdelava naravnega jezika, v zadnjih letih doživljajo razmah v praktični uporabi. Najnovejši metodološki dosežki so običajno najprej na voljo v obliki programskih knjižnic ali spletnih storitev (angl. *web services*), pozneje v platformah za razvijanje rešitev z udobnim uporabniškim vmesnikom in običajno še pozneje v namenskih orodjih, ki to metodologijo uporabljajo interno in omogočajo njeno uporabo brez ali z zelo omejenim vplivom na način delovanja tudi uporabnikom brez računalniškega predznanja. Slednjim samostojno rabo tovrstnih metod med drugim otežuje potrebno predznanje, ki je potrebno za njihovo smiselno uporabo, včasih pa tudi postopki namestitve in nastavitev programske opreme. Prototipno raziskovalno orodje ClowdFlows, ki ga razvijamo na Odseku za tehnologije znanja na Institutu "Jožef Stefan", naslavlja ti dve oviri in kaže potencial za praktično uporabo. V sklopu projekta EMBEDDIA [14, 13, 16] smo razširili nabor zmogljivosti tega orodja predvsem na področju analize naravnega jezika, zato se v tem prispevku osredotočamo na metode in končne uporabnike s tega področja. Natančneje, predstavimo primer učenja in uporabe modelov za besedne vektorske vložitve in izkušnje novih uporabnikov s področja humanistike in družboslovja.

V razdelku 2 predstavimo osnovno sorodno delo. Platforma ClowdFlows je opisana v razdelku 3. Razdelek 4 predstavi primer uporabe vektorskih vložitev in uporabniške izkušnje. Zaključki so podani v razdelku 5.

2 OZADJE IN SORODNO DELO

2.1 Platforme za vizualno programiranje in deljenje rešitev

Programsko orodje ClowdFlows, ki je predstavljeno in uporabljeno v tem prispevku, je podobno nekaterim drugim orodjem za upravljanje delotokov podatkovnega rudarjenja. Slovenskim uporabnikom je verjetno najbolj poznano orodje Orange [2], podobni pa sta orodji tudi Weka [18] in RapidMiner [8, 5]. Vsa ta orodja omogočajo vizualno programiranje s programskimi gradniki in upravljanje tako izdelanih programov. Manj razširjene so rešitve za skupno rabo delovnih tokov. To recimo ponuja portal myExperiment [15] ali spletna stran pobude OpenML [17]. Je pa uporabnost teh rešitev omejena predvsem na dobro podprto javno deljenje rešitev, za izvajanje ali urejanje delovnih tokov pa mora uporabnik še vedno namestiti posebno programsko opremo, v kateri so bili le-ti zasnovani. ClowdFlows, po drugi strani, omogoča tako izdelavo kot tudi deljenje in izvajanje delotokov.

2.2 Besedne vložitve

Besedne vektorske vložitve, ki so strojno naučene z uporabo nevronskih mrež, so predstavitve besed v prostoru, kjer vsako besedo opisuje vektor z veliko dimenzijami (tipično od nekaj deset do nekaj sto). Besede, ki so si blizu v vektorskem prostoru (kar lahko merimo s kosinusno razdaljo), so si tudi semantično podobne. Med vektorskimi vložitvami je mogoče računati tudi odnose, ki presegajo enostavno sorodnost besed, npr. preko analogij. Na primer, odnos *Madrid:Španija* je podoben odnosu *Pariz:Francija* [10]. Pri statičnih vložitvah, kot so modeli word2vec [9] in fastText [1], je posamezna beseda v korpusu predstavljena z enim vektorjem. Pri metodi fastText je vsaka

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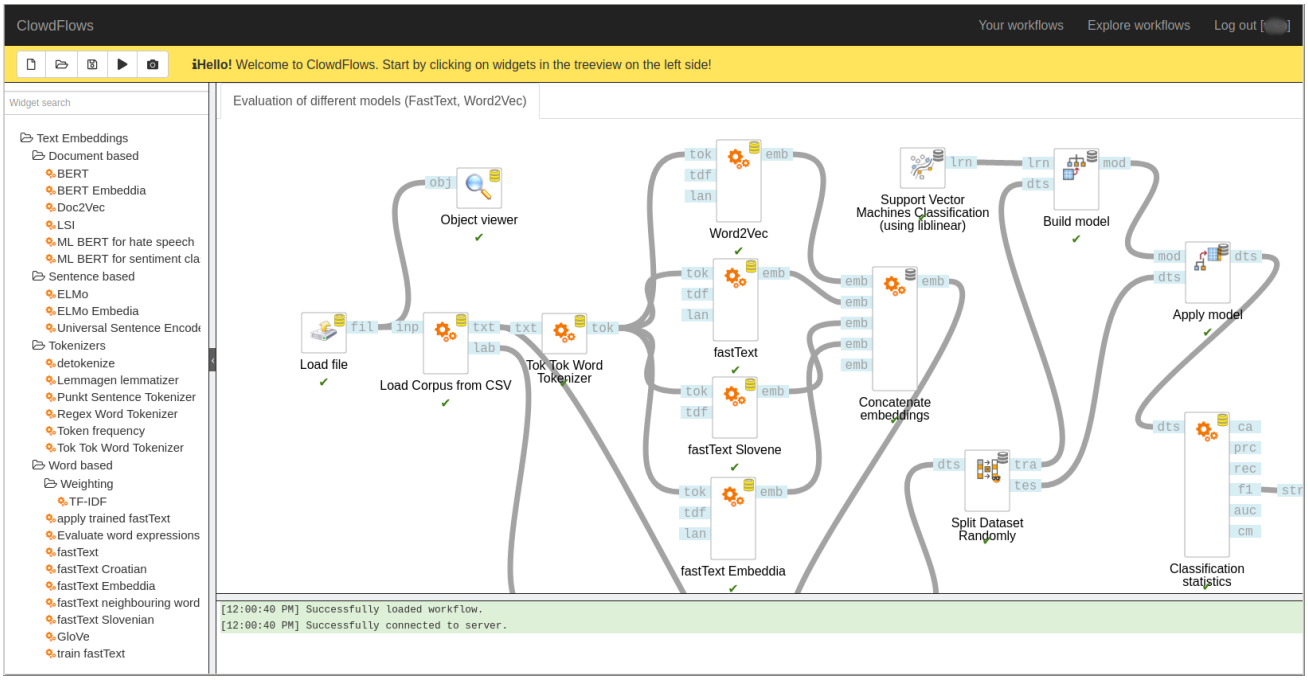


Slika 1: Glavni pogled v ClowdFlows.

beseda predstavljena kot vsota vektorskih vložitev znakovnih n-gramov, ki jih beseda vsebuje. V praksi to pomeni, da metoda pri modeliranju semantične bližine upošteva tudi morfološko podobnost besed, zaradi česar je ta metoda še posebej uporabna za izračun besednih vložitev v morfološko bogatih jezikih, kot je slovenščina. Za razliko od statičnih vložitev pa pri kontekstualnih vložitvah, kot sta na primer modela ELMo [12] in BERT [3], vsako pojavitev besede opisuje svoj vektor. To je pomembno predvsem z vidika večpomenskih besed pa tudi v primerih, kjer analiziramo razlike med besedami v različnih kontekstih. Za veliko jezikov obstajajo prednaučeni modeli na velikih jezikovnih korpusih [4, 3], ki jih je mogoče priučiti za posamezne domene in naloge.

3 CLOWDFLOWS

ClowdFlows [6, 7] je spletna platforma za analiziranje podatkov in strojno učenje z grafičnim uporabniškim vmesnikom, ki omogoča izvajanje v brskalniku brez zahtev po lokalni namestitvi programske opreme, ponuja pa tudi preprosto javno deljenje izdelanih rešitev. Gre za odprtokodno raziskovalno orodje, katerega zadnja stabilna različica ClowdFlows 3 je na voljo na naslovu: `https://cf3.ijs.si/`.

Grafičen način sestave delovnih tokov in uporaba javno deljenih rešitev brez nameščanja dodatne programske opreme sta značilnosti, ki lajšata uporabo tudi uporabnikom, ki nimajo programerskega predznanja, imajo pa zanimive podatke in raziskovalne probleme, pri katerih bi jim prav prišle metode, ki so na voljo v ClowdFlows. Za raziskovalce je poleg tega pomembno tudi preprosto deljenje in preprostost ponavljanja ali nadgrajevanja obstoječih eksperimentov.

Elementi v ClowdFlows 3 vsebujejo vrsto programskih gradnikov, ki ponujajo delo z vektorskimi vložitvami. Vsebujejo prednaučene statične in kontekstualne modele za več jezikov kakor tudi nekaj orodij, ki na njih temeljijo, kot so na primer klasifikatorji za analizo sentimenta novic [11] in prepoznavanje sovražnega govora [11].

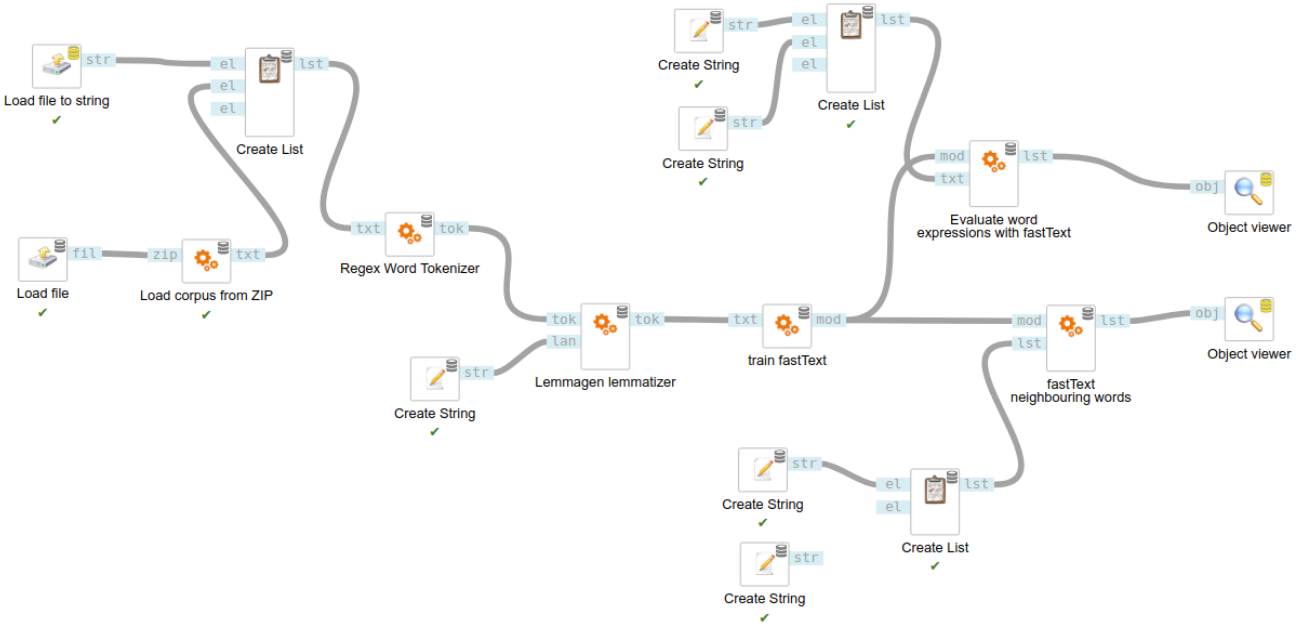
Po prijavi v ClowdFlows imamo na voljo kratek tečaj o osnovah, izdelavo novega delotoka ali pregled javno dostopnih rešitev. Glavni pogled je namenjen izdelavi, pregledu in poganjanju delotokov. Prikazan je na sliki 1. Večji del tega pogleda predstavlja delovna površina, na katero lahko potegnemo (ali uvrstimo z dvoklikom) željeni programski gradnik (angl. *widget*) iz seznama razpoložljivih gradnikov na levi strani pogleda. Smiselno povezani gradniki predstavljajo delotok, ki ga lahko poženemo z nadzornim gumbom *Play*.

Povezave med gradniki vzpostavimo s klikom na izhod enega gradnika in vhod drugega. Vhodi so predstavljeni kot svetlo modri pravokotniki na levi strani gradnika in izhodi kot tovrstni pravokotniki na desni. Povezave lahko odstranimo tako, da z desno tipko miške kliknemo povezavo in izberemo možnost *Remove*. Delotoki se shranjujejo samodejno, lahko pa jih tudi eksplicitno shranimo s pritiskom na kontrolnik za shranjevanje, kar nam omogoča tudi lastno poimenovanje shranjenega dela. Shranjene delotoke lahko pregledujemo, kopiramo, brišemo, izvažamo ali javno delimo na pogledu, ki se pokaže ob izbiri *Your workflows*. Javno objavljeni delotoki dobijo nespremenljiv URL naslov, ki ga lahko delimo in vsakemu uporabniku ClowdFlows omogoča, da ustvari svojo kopijo tako deljenega dela.

4 UPORABA VEKTORSKIH VLOŽITEV

4.1 Učenje modela vložitev v ClowdFlows

Za pridobitev predstavitve teksta v obliki vektorskih vložitev lahko uporabimo predpripravljene modele ali pa take modele sami strojno naučimo. Tovrstno strojno učenje je običajno računsko zelo zahtevno in za smiselne rezultate potrebuje velike količine podatkov. V praksi se zato pogosto uporablja predhodno naučene modele. ClowdFlows ponuja več prednaučenih modelov, naprimer ELMo, Word2Vec in razne modele pristopa BERT in fastText, tudi za slovenščino.



Slika 2: Delotok, ki je bil uporabljen na delavnici s ciljnimi uporabniki. Dostopen je na: https://cf3.ijs.si/workflow/283

.

Učenje lastnih modelov je smiselno, ko gre za posebna besedila ali naloge, pri katerih jih želimo uporabljati. Velika računska zahtevnost, velike količine podatkov in z njima povezani daljši časi obdelave namreč niso združljivi z interaktivno uporabo, ki je značilna za ClowdFlows. Pri uporabnikih digitalne humanistike in družboslovja smo zaznali potrebo za učenje vložitev na majhnih, specifičnih korpusih, kot so pesniške zbirke, specializirani novičarski članki ipd. Takšni korpusi so pogosto bistveno manjši od tipičnih korpusov, ki se uporabljajo za učenje vektorskih vložitvev. Glede na potrebe uporabnikov in zmogljivosti platforme smo se odločili za implementacijo gradnika za učenje modelov *train fastText*, saj je algoritem *fastText* eden najučinkovitejših in najmanj računsko zahtevnih. Implementacija gradnika v ClowdFlows vsebuje tudi namige, kako prilagoditi privzete parametre za učenje na majhnih korpusih. Za sprejemljivo hitro interaktivno delo vseeno priporočamo, da vhodni korpus ne presega dveh milijonov besed ali približno 10 MB neobdelanega besedila.

Gradnik *train fastText* z uporabo algoritma fastText nauči nov vektorski model na vhodnem korpusu. Tak model lahko nato posredujemo drugim gradnikom. Vhod v *train fastText* je besedilni korpus, kot je na primer izhod gradnika *Load Corpus from CSV*. Korpus je mogoče tokenizirati, lematizirati ali pa uporabiti tudi brez tovrstne predobdelave.

train fastText uporabniku ponuja nastavljanje sledečih parametrov:

bucket - število skupin (značilke besednih in znakovnih *n*-gramov so zgoščene v fiksno število skupin);
epoch - število epoh učenja;
lr - hitrost učenja;
dimension - velikost besednih vektorjev;
window - velikost kontekstnega okna;
model - vrsta nenadzorovanega fastText modela (cbow ali skipgram) ter
min_count - najmanjše število pojavitev besede, pri katerem se beseda še upošteva.

Kjer je primerno, opis parametra vključuje namig, ali je v primeru majhnih učnih podatkov priporočljivo povečati oz. zmanjšati vrednost parametra.

4.2 Izkušnje uporabnikov

Uporabnost platforme ClowdFlows in najpomembnejših komponent za analizo naravnega jezika z vidika ciljnih končnih uporabnikov smo preverjali v okviru enodnevne delavnice, ki je potekala (na daljavo) 27. januarja 2022. Delavnica je bila namenjena eni od naših primarnih ciljnih skupin: raziskovalcem z različnih področij humanistike in družboslovja, ki (predvidoma) niso vešči programiranja.

Za potrebe delavnice smo pripravili primer delotoka za analiziranje besedil z vektorskimi vložitvami. Prikazan je na sliki 2. Delotok se začne z dvema možnima načinoma vnosa vhodnih podatkov, nadaljuje z opcijsko uporabo tokenizatorja in lematizatorja (ta kot vhodni podatek sprejema tudi oznako jezika), čemur sledi učenje modela fastText. Naučeni model nato v delotoku uporabimo na dva načina: v gradniku *fastText neighboring words* pregledujemo okolico (sosednje besede) izbranih besed, v gradniku *Evaluate word expressions with fastText* pa na modelu preizkušamo uporabo izrazov (seštevanje, odštevanje) na vektorskih predstavitvah besed. Ogled rezultatov v obeh primerih omogočimo z gradnikom *Object viewer*.

Delavnica se je začela s skupno uvodno predstavitvijo platforme ClowdFlows in primera delotoka s slike 2, ki je trajala 20 minut in v kateri smo izbrane primere prikazali z uporabo besedila novele *Deseti brat* Josipa Jurčiča.

Temu je sledilo osem 20-minutnih sej, v katerih je vsak uporabnik ustvaril svoj primerek delotoka, naložil svoj korpus in preizkusil izbrane komponente ClowdFlows. Ena seja je bila namenjena enemu uporabniku in njegovim podatkom, drugi uporabniki pa

so lahko prisostvovali kot opazovalci. Uporabnikom smo pri njihovem delu pomagali, če so imeli težave pri uporabi platforme ali pri pripravi svojih vhodnih podatkov. Udeležba na delavnici je bila na povabilo. Udeleženci, ki so bili povabljeni na delavnico, so raziskovalci s področij literarnih ved, sociologije, socialnega dela in sorodnih področij. Pripravili so lastne korpuse s svojih področij, kot so na primer tematski korpusi migracij, korpus del slovenskih literatov, korpus francoske poezije, LGBT, novice, ki govorijo o socialnem delu in podobno. Nekateri udeleženci so bili vabljeni v okviru interdisciplinarnih projektov SOVRAG in CANDAS. Nihče od udeležencev pa ni imel predhodnih izkušenj s ClowdFlows. Zaradi velikega zanimanja smo število sej povečali s predvidenih 8 na 10.

Uporabljeni korpusi so bili zelo raznoliki, udeležence pa so zanimali različni vidiki obdelave besedil. V večini primerov so bili začetnemu delotoku dodani dodatni gradniki, da bi rešili določeno težavo ali zadovoljili posebne interese. Udeleženci so na primer iskali podobnosti in razlike v sosedstvu besed na podlagi korpusov iz različnih obdobij ali od različnih avtorjev. Zanimale so jih tudi osnovne značilnosti takih korpusov, kot so recimo najpogosteje uporabljene besede, s čimer so bile povezane tudi druge osnovne operacije, kot je na primer filtriranje besed. Med delavnico sta bili odkriti dve specifični tehnični težavi: (I) napake so se pojavile v primeru vnosa besedila s posebnimi znaki, ki ni bilo kodirano v kodni tabeli UTF, in (II) nekateri gradniki, ki vsebujejo klice na spletne storitve, so poročali o preseženi časovni omejitvi.

Za udeležence je bil pripravljen anonimen vprašalnik, povezava do vprašalnika pa je bila posredovana po delavnici. Večini udeležencev se je prikazani potek dela zdel zelo uporaben. Velika večina (80%) še nikoli ni poskusila uporabljati vektorskih vložitev. O uporabniškem vmesniku ClowdFlows so večinoma poročali kot o preprostem za uporabo (preprost: 60%, zelo preprost: 30%), le enemu udeležencu pa se je zdel zapleten. Te rezultate je sicer treba upoštevati v kontekstu dejstva, da so odzivi zbrani kmalu po uporabi ClowdFlows, pri čemer je bila na voljo pomoč. Brez uvoda in pomoči odgovori morda ne bi bili tako pozitivni, vendar tega še nismo preizkusili. Večina udeležencev je menila, da bi ponovno uporabili ClowdFlows, če bi jim zagotovili vnaprej pripravljen delotok za njihov problem.

5 ZAKLJUČEK

Predstavili smo spletno platformo ClowdFlows, izbrane elemente, ki omogočajo napredno uporabo pristopov za učenje besednih vektorskih vložitev, in izkušnje nekaterih od naših ciljnih uporabnikov teh orodij.

Eden od ciljev platforme ClowdFlows je približanje uporabe najnovejših metod analize podatkov in strojnega učenja tudi uporabnikom, ki niso vešči programiranja. Izkušnje naše delavnice z nekaterimi od potencialnih uporabnikov so pokazale, da je to vsekakor smiselno, saj so na podlagi predpripravljenih delotokov uporabniki (sicer strokovnjaki na drugih področjih) lahko opravili analize na lastnih podatkih in tudi že iskali in predlagali nadaljnje postopke analiz, ki so smiselni in uporabni pri njihovem delu. Poleg metodoloških razširitev in tehničnih izboljšav platforme bomo zato v bodoče več pozornosti namenjali tudi razvoju primerov rešitev za ciljne uporabnike, v prvi vrsti za raziskovalce s področij, ki niso povezana z računalništvom.

ZAHVALA

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LITERATURA

[1] Piotr Bojanowski, Edouard Grave, Armand Joulin in Tomas Mikolov. 2017. Enriching word vectors with subword information. *Transactions of the Association for Computational Linguistics*, 5, 135–146.

[2] Janez Demšar in sod. 2013. Orange: data mining toolbox in python. *Journal of Machine Learning Research*, 14, 1, 2349–2353.

[3] Jacob Devlin, Ming-Wei Chang, Kenton Lee in Kristina Toutanova. 2019. BERT: pre-training of deep bidirectional transformers for language understanding. V *Proceedings of the 2019 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long and Short Papers)*, 4171–4186.

[4] Edouard Grave, Piotr Bojanowski, Prakhar Gupta, Armand Joulin in Tomas Mikolov. 2018. Learning word vectors for 157 languages. V *Proceedings of the International Conference on Language Resources and Evaluation (LREC 2018)*.

[5] Markus Hofmann in Ralf Klinkenberg. 2016. *RapidMiner: Data mining use cases and business analytics applications*. CRC Press.

[6] Janez Kranjc. 2017. *Web Workflows for Data Mining in the Cloud*. Doktorska disertacija. Jožef Stefan International Postgraduate School.

[7] Janez Kranjc, Vid Podpečan in Nada Lavrač. 2012. ClowdFlows: a cloud based scientific workflow platform. V *Machine Learning and Knowledge Discovery in Databases*. Lecture Notes in Computer Science. Zv. 7524. Peter A. Flach, Tijl Bie in Nello Cristianini, uredniki. Springer Berlin Heidelberg, 816–819.

[8] Ingo Mierswa, Michael Wurst, Ralf Klinkenberg, Martin Scholz in Timm Euler. 2006. YALE: rapid prototyping for complex data mining tasks. V *Proceedings of the 12th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*. ACM, New York, NY, USA, 935–940.

[9] Tomas Mikolov, Ilya Sutskever, Kai Chen, Greg S Corrado in Jeff Dean. 2013. Distributed representations of words and phrases and their compositionality. V *Advances in Neural Information Processing Systems*, 3111–3119.

[10] Tomas Mikolov, Wen-tau Yih in Geoffrey Zweig. 2013. Linguistic regularities in continuous space word representations. V *Proceedings of the 2013 Conference of the North American Chapter of the ACL: Human Language Technologies*. ACL, 746–751.

[11] Andraž Pelicon, Ravi Shekhar, Matej Martinc, Blaž Škrlj, Matthew Purver in Senja Pollak. 2021. Zero-shot cross-lingual content filtering: offensive language and hate speech detection. V *Proceedings of the EACL Hackashop on News Media Content Analysis and Automated Report Generation*. Association for Computational Linguistics, Online, (apr. 2021), 30–34. https://aclanthology.org/2021.hackashop-1.5.

[12] Matthew Peters, Mark Neumann, Mohit Iyyer, Matt Gardner, Christopher Clark, Kenton Lee in Luke Zettlemoyer. 2018. Deep contextualized word representations. V *Proceedings of the 2018 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies, Volume 1 (Long Papers)*, 2227–2237.

[13] Senja Pollak in Andraž Pelicon. 2022. EMBEDDIA project: cross-lingual embeddings for less- represented languages in European news media. V *Proceedings of the 23rd Annual Conference of the European Association for Machine Translation*. European Association for Machine Translation, Ghent, Belgium, (jun. 2022), 293–294.

[14] Senja Pollak in sod. 2021. EMBEDDIA tools, datasets and challenges: resources and hackathon contributions. V *Proceedings of the EACL Hackashop on News Media Content Analysis and Automated Report Generation*. Association for Computational Linguistics, Online, (apr. 2021), 99–109. https://aclanthology.org/2021.hackashop-1.14.

[15] David De Roure, Carole Goble in Robert Stevens. 2009. The Design and Realisation of the myExperiment Virtual Research Environment for Social Sharing of Workflows. *Future Generation Computer Systems*, 25, (feb. 2009), 561–567.

[16] Matej Ulčar, Aleš Žagar, Carlos S. Armendariz, Andraž Repar, Senja Pollak, Matthew Purver in Marko Robnik-Šikonja. 2021. Evaluation of contextual embeddings on less-resourced languages. (2021). https://arxiv.org/abs/2107.10614.

[17] Joaquin Vanschoren, Jan N Van Rijn, Bernd Bischl in Luis Torgo. 2014. OpenML: networked science in machine learning. *ACM SIGKDD Explorations Newsletter*, 15, 2, 49–60.

[18] Ian H Witten in Eibe Frank. 2005. *Data Mining: Practical Machine Learning Tools and Techniques*. Morgan Kaufmann.

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Toma Strle, Borut Trpin, Olga Markič

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PREDGOVOR

Na tokratni konferenci Kognitivna znanost sodelujejo avtorice in avtorji, ki se raziskovalno ukvarjajo s kognitivno znanostjo, in predstavljajo tako empirične rezultate svojih raziskav kot tudi teoretska raziskovanja z najrazličnejših področij – od psihologije in nevroznanosti do filozofije in umetne inteligence. Poseben poudarek na letošnji konferenci posvečamo kognitivnim vidikom zaupanja v znanost, kar avtorice in avtorji naslavljajo tako z družbenega, političnega, psihološkega in filozofskega vidika.

Upamo, da bo letošnja disciplinarno in metodološko bogata konferenca odprla prostor za povezovanje pronicljivih idej ter povezala domače in tuje, mlade in izkušene znanstvenice in znanstvenike, ki se ukvarjajo z vprašanji kognicije.

Borut Trpin
Toma Strle
Olga Markič

FOREWORD

At this year's Cognitive Science conference, the authors who actively research in scope of cognitive science present their empirical studies as well as theoretical research from a diverse range of disciplinary backgrounds – from psychology and neuroscience to philosophy and artificial intelligence. A special focus of this year's conference is on cognitive aspects of trust in science. The authors address this topic from a social, political, psychological, and philosophical viewpoint.

We hope that this year's cognitive science conference – rich in disciplinary approaches and methodologies – will open space for exchanging intriguing research ideas and will bring together local and international, junior and senior scientists from a diverse range of areas related to the exploration of the human mind.

Borut Trpin
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Into the Constant Now—Comparing DES and micro-phenomenology, two methods for exploring consciousness

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ABSTRACT

Here we compare two methods of examining conscious experience—Descriptive Experience Sampling (DES) and micro-phenomenology. Both look at short episodes of experience. Both have safeguards to limit biases and distortions from first-person reporting. But these methods are still different in terms of how they deal with memory, questioning, and analysis. In this pilot study (n=4), we use both methods in the context of a common task. Participants were interviewed about their experience of a mental imagery task using both methods. DES results focused more on fine-grained details of visual experiences. Micro-phenomenology results focused more on how experience extended over time, and how participants engaged with the task. These differences in results show that the investigated methods differ in scope. To further address this, we encourage a critical methodological pluralism where methods can continue to be improved and tested for validity.

KEYWORDS

Consciousness, inner experience, empirical phenomenology, DES, micro-phenomenology

1 BACKGROUND

The study of first-person experience has had a difficult time. In the early 20th century a prolonged disagreement between two rival introspectionist camps led to the field's essential banishing from psychology [1, 2]. A later influential study by Nisbett and Wilson [3] further solidified the notion that first-person data is flawed and distorted by heuristics, overgeneralizations, and memory problems. People simply don't know what's in their consciousness. To give a pragmatic definition, for a conscious person, there is *something that it is like* to be that person [4]. A conscious person might be sipping coffee noticing the rich smell and hearing birds chirp. An unconscious person could for example be in dreamless sleep.

Conscious experience takes up most of our day (presumably) and influences our identity and understanding of the world. It lies behind our sensations, emotions, and thoughts. It is important. And yet it's often either assumed as trivial, approachable through naive methods, or else unattainable, not worth even seeking to understand. New methods reject both premises–consciousness is neither trivial nor unattainable. These methods attempt to systematize consciousness research, in a field that has been dubbed "empirical phenomenology" [5]. They deal with past critiques and attempt to limit biases. Although validity cannot yet be proven, here we test the limits and constraints of these methods. Specifically, we look at Descriptive Experience Sampling, founded by Russell Hurlburt and refined with the aid of fellow researchers [1]. And we'll look at micro-phenomenology—adapted by Claire Petimengin from Pierre Vermersch's explicitation interview [2].

Descriptive Experience Sampling uses random beeps to direct participants towards specific, concrete episodes of experience. Micro-phenomenology guides participants to a state in which memory becomes immediate and lived.

Both methods then use different means to aim for a common goal, of revealing short episodes of experience. Experience described in the abstract is an amalgamation of warped memory, self-perception, conceptual frames, and fleeting impressions. 'This morning I had breakfast and felt sleepy.' In the concrete, however, experience manifests as a flow of vivid nows. '*Now* I'm watching the cream dissolve in my coffee. *Now* I'm picturing what would happen if gravity reversed overnight and I had to rearrange my furniture on the ceiling.' These *nows*, so vivid when lived, can dissolve in memory like cream in coffee, so that we might forget their original color. Methods of empirical phenomenology aim for that color.

Despite similar intentions, there has been some contention between methods. Akhter and Hurlburt have questioned the validity of micro-phenomenology [6]. Petitmengin has argued about DES that "the beeper is not suitable for observing very brief or very fine subjective events" [7]. Is this disagreement warranted? Do methods really reveal different aspects of experience when used with a common task? And if so, does this call into question the validity of one method or the other? Methods might just have different scopes, yielding different results [8]. To address these questions, we compared methods with a shared task.

2 METHODS

2.1 DES

DES uses random beeps through the day to help participants better grasp their own experience. This can involve a specialized beeper or a smartphone. The participant must have an earpiece directly in their ear throughout the procedure. The beeps are delivered at randomized intervals ranging between five minutes to one hour [9]. Six beeps are delivered a day. This usually takes around three or four hours. In most studies, they occur during the

participant's daily life, not in a lab, to increase ecological validity.

After each beep, the participant jots down notes on their inner experience right before the beep. So not inner experience during the beep (e.g., darn that's annoying!) but right before. The goal is to describe that last uninterrupted moment before the beep. Usually this moment is much shorter than what participants first have in mind, and can last a fraction of a second.

Questioning and training is needed in order to apprehend this moment. At the end of each day of sampling, participants are interviewed about the six beeps they collected. The interviews last an hour and any samples not discussed within that time are discarded. There are always multiple days of sampling, usually around 5 or 6, but occasionally many more. The first day of sampling is always discarded and considered training. Subsequent days are often discarded as well, if they don't hew to validity criteria.

Validity depends primarily on participants' ability to clearly describe specific moments of experience with little hesitation and equivocating language. Questioning aims to lead participants away from generalizations. For example, a participant might first say, "I was driving and kinda nervous I think. I'm always nervous when I drive." The use of the term 'always' may indicate that the participant was generalizing. The use of terms 'kinda' and 'I think' could indicate uncertainty stemming from lack of contact with direct experience. Further questioning may reveal that experience before the beep was something completely different—perhaps a mental image of a fat squirrel with the inner speaking "munchy munch." It is common in DES for results to go against participants' initial expectations [9, 10].

2.2 Micro-phenomenology

Micro-phenomenology aims to guide the participants towards vividly reliving and precisely describing a past conscious episode [7]. This episode is of underdetermined length, ranging from a few minutes to a few seconds. The episode can be in the recent past or have occurred many years ago. For the sake of bringing our methods as close as possible to compare them, here we'll apply micro-phenomenology to the recent past and to short episodes (10 seconds).

Memories can be indistinct, so micro-phenomenology aims to guide the participant to an "evocation state" where past experience is 're-lived' [7]. Participants have direct contact with what they saw, heard, or felt at the time of the target experience. Questions aim to 'stabilize' this evocation state and maintain the participant's contact with their experience. For example, participants are periodically asked to return to the beginning of the episode. If the participant digresses, the interviewer can repeat the participant's earlier descriptions.

As in DES, participants are asked for greater specificity about the elements they reveal. For example, if a participant has a mental image, an interviewer might ask, "Is it in colour or in black and white? Is it detailed or fuzzy? Is it dark or light?" [7].

Micro-phenomenology begins by eliciting the context and sensory modalities of past experience—what participants saw, heard, felt, etc. This helps the participant enter the evocation state. Once in this state, questions can be more open ended. Interviewers can ask about the sequence of experience and how different elements change over time. They then focus on specific elements in turn and ask questions to elicit greater specificity. Micro-phenomenology aims for nuance. Questioning can often focus on subtle emotional shifts of even shifts in body or posture that contribute to experience.

There are no firm guidelines for how long a micro-phenomenology interview lasts. However, it is not uncommon for short segments of experience to elicit hour-long interviews. The aim of micro-phenomenology is to uncover the complexity and nuance of the experiential episode both at a particular moment (synchronic dimension) and its development over time (diachronic dimension),with the focus of the interview depending on the research question of the particular study.

2.3 Main differences

Time - Micro-phenomenology typically deals with longer sections of time. Researchers can observe how elements change. Petitmengin writes, "To enter into contact with one's experience, it is necessary to respect its fluid and dynamic character" [11]. DES does also incorporate time though. Experience is not frozen into a static snapshot. For example, if a person is innerly speaking "I need to call mom" this might extend over time. And a fuzzy feeling in their chest might increase in strength over the moment. The difference here is thus of degree, not of type.

Retrospection - Micro-phenomenology, in general, involves substantially more retrospection. The target experience could be years before the interview [11]. In DES, the target experience is a few seconds before the notetaking and less than 24 hours before the interview. There are still memory demands but they are fewer. However, as mentioned, micro-phenomenology can also be done with the target experience shortly before the interview [12]. This is the case for our comparison study.

Directing attention - Micro-phenomenology aims for an evocation state in which participants re-live the original experience. DES takes a more skeptical approach. DES questions encourage the participant to doubt if reported elements were really part of their direct experience. DES acknowledges that this skepticism might lead it to miss out on elements of experience. But Hurlburt sees this as preferable to reporting elements that weren't there [9]. Micro-phenomenology prefers having as full an impression of experience as possible. It offers participants opportunities to revise and clarify their reports, but in service of maintaining an evocation state, doesn't 'grill' participants to the extent that DES does.

Questioning – Micro-phenomenology questioning is "non-inducive but directive" [7]. DES questioning is non-inducive and non-directive. For example, micro-phenomenology asks about specific sensory modalities in turn, i.e. 'Do you hear anything?' It holds that this is necessary to elicit greater detail since participants may not know where to direct their attention. DES would instead ask, 'Was there anything else in your experience?'.

In general, micro-phenomenology is more trusting of participant reports. DES places a greater emphasis on skepticism, training participants in order to get greater fidelity. For example, the first day of training is always discarded with DES. This is not the case with micro-phenomenology. Training interviews are occasionally used but optional.

Validity - There is agreement between methods about how to judge validity. Both acknowledge that rules and explanations of

the method make their own case for validity. A successful sample/interview then depends on these guidelines being followed, and questions being suitably content-neutral and non-leading. Other points of agreement include situating methods in a net of third-person observables—for example, can first-person data link with behavioral data? Can correlations be found with neuroimaging? No one correlation can address validity but networks of connections can help lead to first- and third- person methods informing each other through "mutual constraints" [13].

Differences include differing methods for judging veracity. Both methods rely on both verbal and non-verbal cues. But DES leans more heavily on verbal cues, like subjunctification [9]. Is the participant saying umm, I think, kindof, maybe, sorta, I guess? Then it's likely they're not describing direct experience. Micro-phenomenology relies more on visual cues—for example a participant's eyes pointing upwards indicating that they're in an evocation state.

Petitmengin also advocates checking a participant's reported experience against the researcher's own experience, calling this the "kingpin of all validation" [7]. Is it similar or at least plausible? Hurlburt and Akhter [6] see this as harmful—a participants' experience may be radically different from the researcher's, and so should be 'bracketed' as much as possible.

3 PROCEDURE

This study involved four participants—a small sample size aimed at highlighting certain method contours rather than generalizing or making claims of statistical significance. All four were female students residing in Slovenia, aged 23 to 26. They are referred to here using pseudonyms. Each participant underwent both the DES and micro-phenomenology procedure. However, two started with micro-phenomenology and two started with DES (to limit biasing). There was a break (at least six days) before switching methods.

To facilitate comparison, the interviews concerned participants' experience of a task. We used a mental imagery elicitation task, in which participants were given descriptive prompts and 10 seconds to form mental images. Examples of prompts include: "A child holds an ice cream cone with three scoops. The ice cream falls onto the hot pavement." "A storm cloud gathers over a city. A lightning bolt strikes."

Before the task came training. For DES, this involved three days of DES sampling during the participant's everyday life—going to class, cafés, etc. Participants received six beeps a day, jotted down their consciousness experience in the moment before the beep, and received hour-long interviews within 24 hours of sample collection [Fig. 1].

For micro-phenomenology, training was much shorter. Participants were given a task shortly before the main task—to spell the word octopus. Participants were then interviewed to give them some practice and familiarity with micro-phenomenology and the interview procedure [Fig. 2].

For the task, the DES portion involved 32 pre-recorded prompts. 10 seconds followed each prompt, allowing for mental imagery formation. Five random beeps were interspersed throughout the task, ranging from 1-10 seconds after the prompt concluded. There was a DES interview after each beep. J.B.-K. conducted these interviews [Fig. 1].

The micro-phenomenology task involved 2 prompts. These were on separate days. Participants again had 10 seconds after the prompt to form mental images. They were interviewed following the guidelines for micro-phenomenological interviews [7] after each prompt. E.W. conducted these interviews [Fig. 2].

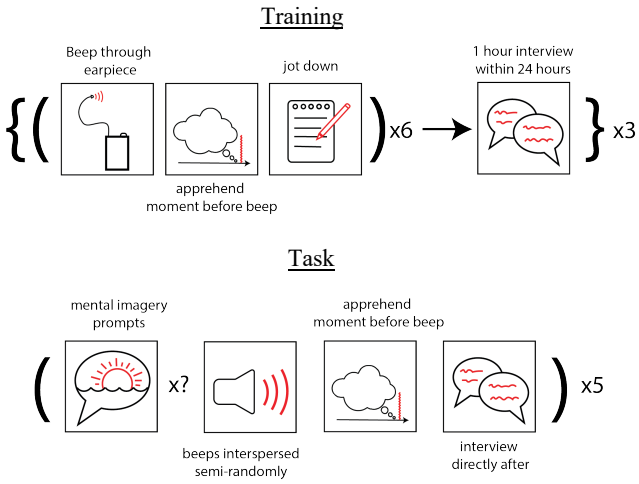

Figure 1: DES training and task

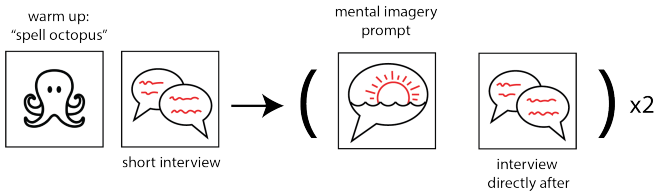

Figure 2: Micro-phenomenology training and task

4 RESULTS

4.1 Similarities

Image characteristics - Both methods uncovered common visual phenomena. One example of this is with GIF-like repetition. This may be something specific to our current digital age. These short, repeating moving images are common on social media. Many older people in DES sampling have mental images in black and white [14]. The technologies of our age may shape our perception and perceptual cognition.

Other commonalities include elements changing over time. For both methods, images didn't always emerge fully formed. And micro-phenomenology further shows how images morphed or how new elements entered. For both methods, images could either be moving or static.

With both methods, mental images had differing levels of detail—inter- and intrasubject. Images were sometimes clear. Sometimes they were fuzzy, indistinct, ghostly, or blurry. Visual elements were sometimes realistic and sometimes cartoonish.

Interactions with other modalities - Inner images could interact with other types of experience. Both methods revealed words and images interacting. Micro-phenomenology revealed participants sometimes innerly repeating words from the prompt. In one case, these words were a distraction from forming images. In another case, they spurred on a new visual perspective.

For DES one participant misheard the word 'chirp' as 'gerb'. At the moment of the beep, she was innerly repeating it, wondering what it meant, and had a visual impression without any visual elements explicitly present—just a large mass.

Images could also interact with feelings. DES found that 1/5 of samples involved feelings. These were sometimes positive in valence ('calm') or sometimes negative ('dislike'). Certain prompts correlated with negative feelings—like the prompt "A family gathers around the dinner table. The father starts serving food."

Micro-phenomenology also found feelings. For example, for a prompt about two children skating on a pond, Jelka added a mother to the scene and projected her own worry onto the mother.

4.2 Differences

Visual differences - While there were similarities concerning mental imagery formation, there were differences as well. With DES, for Jelka, all 5 prompt samples involved imagery with a dual vantage point. She was both looking at the image from a distance but at the same time had another vantage point of being surrounded by the scene. Think of simultaneously watching a movie on a screen and being in the movie as the main character. Since this dual vantage point was found in all of her samples, one might expect it to be a generalizable feature of her mental images. But micro-phenomenology didn't find it. It found instances of 3rd and 1st person inner images for Jelka, but never both at the same time. Perhaps the dual vantage point was present but not apprehended.

DES findings focused more on characteristics of mental images.

—Images can have borders, no borders, or focus can be on the center so the participant is unsure of whether or not the image has edges.

—Images can be in a separate mental space or positioned over the real world, for instance on a "3D screen."

—Mental images can involve aspects that would be impossible in real physical space.

—Two simultaneous visual spaces can be present at the same time. For example, Anna had one visual space of children skating on a frozen pond, and a separate space where she was creating a face to add to the children.

Time – Micro-phenomenology focused more on experience evolving over time. We can see how imagery changes. We can see how participants interact with prompts, referring back to them, and playing with them. We see the broader experience of the task.

—Some elements came naturally, others required concentration.

—Elements could be disproportionate and not fit with the scene. For example, Jelka imagined a tree with birds that didn't fit with the rest of the scene. It was too big, and a different color. We see how new elements enter and how they relate to previous elements.

—The task could involve constrained freedom or constraint. Jelka felt constrained at times. She had to imagine things she wasn't interested in. Anna, especially, felt freedom. She could imagine whatever she wanted. Anna also played with the prompts. For example, given a prompt about a boy with three scoops of ice-cream, Anna imagined three ice-cream scoop tools. We can see how she engaged with the task, lightheartedly testing how far she could push the prompts. DES could not have revealed this entire sequence of trying out different visual components.

5 DISCUSSION

Despite similarities, these methods have different scopes and reveal different results. Micro-phenomenology revealed more temporal dynamics. We saw how images evolved over time, and how participants interacted with the prompts. DES revealed more visual characteristics of images. This is contrary to Petitmengin's comment concerning DES's limited experiential detail: "I doubt whether the beep enables the interviewee to direct his attention from 'what' to 'how', unless by chance" [7]. It also goes against claims from Froese, Seth, and Gould that DES adheres only to a "shallow conception of consciousness" [15].

Note that methods differed in the treatment of fine-grained details. DES revealed dual aspect imagery and micro-phenomenology did not. This could have been the result of differing experience or a product of the research design where training with one method alters reporting with the other method.[1] It could also be a result of one or another method hewing more closely to experience. If this is the case, we need to make sure our methods are faithful. Methods that distort experience may lead to disagreements and stall progression of the study of consciousness. For this reason, issues with retrospection, memory distortion, presuppositions, and biases need to be handled carefully. Practitioners of any method need to question what its intent is, whether its guidelines are coherent, and what research questions it can and can't answer.

Horizons are open for refinement of methods and experimentation. Emerging research is even combining elements from micro-phenomenology and DES [16-19]. Oblak, for example, combined influences from both methods for interviews investigating experience during a visual-spatial memory task [16]. Springinsfeld conducted micro-phenomenology inspired interviews shortly after targeted experience–aiming for interviews on the same day as a bulimic individual's vomiting episodes, to minimize retrospection demands [17]. Caporusso used DES-style beeps with an interview method hewing more closely to micro-phenomenology in order to better understand sense of self and boundaries in daily life and compare this to experiences of boundary dissolution [18]. And Bass-Krueger adapted DES to a slightly wider temporal scope to investigate what is really meant by a 'moment' of experience [19]. Critical methodological pluralism is important going forward. We must acknowledge differing avenues of exploring lived experience, while questioning where exactly these avenues lead us.

[1] Procedurally, there seemed to have been an effect of experience with one method on participants' approach to the other (new) method of investigating experience. For instance, participants who started with DES and then moved on to the micro-phenomenological interviews approached their experience with more skepticism and caution than those who started with micro-phenomenology. Conversely, one participant who started with the micro-phenomenological interviews and then moved on to DES at first found the latter method 'too skeptical' and both required at least as much training as participants with no prior experience with first-person reporting. However, with such a small sample, it is hard to disentangle how experience with one method or the other may have influenced our final results.

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REFERENCES

[1] Russell Hurlburt, 1993. Sampling Inner Experience in Disturbed Affect. Plenum Press.

[2] Pierre Vermersch, 1999. Introspection as practice. *Journal of Consciousness Studies 6,* 2–3, 17–42.

[3] Richard E. Nisbett and Timothy D. Wilson, 1977. Telling more than we can know: Verbal reports on mental processes. *Psychological Review 84 3, 231–259. https://doi.org/10.1037/0033-295x.84.3.231*

[4] Thomas Nagel, 1974. What is it like to be a bat? *The Philosophical Review 84*, 4, 435-450.

[5] Urban Kordeš, 2016. Going beyond theory: Constructivism and empirical phenomenology. *Constructivist Foundations 11*, 2, 375–385.

[6] Russell Hurlburt and Sarah Akhter, 2006. The Descriptive Experience Sampling method. *Phenomenology and the Cognitive Sciences 5*, 271-301. https://doi.org/10.1007/s11097-006-9024-0

[7] Claire Petitmengin, 2006. Describing one's subjective experience in the second person: An interview method for the science of consciousness. *Phenomenology and the Cognitive Sciences 5*, 229-269. https://doi.org/10.1007/s11097-006-9022-2

[8] Urban Kordeš and Ema Demšar, 2021. Horizons of becoming aware: Constructing a pragmatic-epistemological framework for empirical first-person research. *Phenomenology and the Cognitive Sciences*, 1-29. https://doi.org/10.1007/s11097-021-09767-6

[9] Russell Hurlburt and Christopher Heavey, 2006. *Exploring Inner Experience: The Descriptive Experience Sampling Method*. John Benjamins. https://doi.org/10.1075/aicr.64

[10] Russell Hurlburt and Christopher Heavey, 2015. Investigating pristine inner experience: Implications for experience sampling and questionnaires. *Consciousness and Cognition 31*, 148–159. http://doi.org/10.1016/j.concog.2014.11.002

[11] Claire Petitmengin, 2011. Describing the experience of describing? The blindspot of introspection. *Journal of Consciousness Studies 18*, 1, 44-62.

[12] Natalie Depraz, Maria Gyemant, and Thomas Desmidt, 2017. A first-person analysis using third-person data as a generative method: A case study of surprise in depression. *Constructivist Foundations* 12, 2, 191-203.

[13] Francisco Varela, 1996. Neurophenomenology: A Methodological Remedy for the Hard Problem. *Journal of Consciousness Studies* 3, 4, 330-49.

[14] Russell Hurlburt, 2011. Investigating Pristine Inner Experience: Moments of Truth. Cambridge University Press.

[15] Tom Froese, Anil Seth, and Cassandra Gould, 2011. Validating and calibrating first- and second-person methods in the science of consciousness. *Journal of Consciousness Studies 18*, 2, 38-64.

[16] Aleš Oblak, Anka Slana Ozimič, Grega Repovš, and Urban Kordeš, 2022. What Individuals Experience During Visuo-Spatial Working Memory Task Performance: An Exploratory Phenomenological Study. *Frontiers in Psychology* 13. https://doi.org/10.3389/fpsyg.2022.811712

[17] Constanze Springinsfeld [In Review]. Attention, dissociation, and feelings in bulimia nervosa [prospective title]. Mei:CogSci Master's Thesis

[18] Jaya Caporusso, 2022. Dissolution experiences and the experience of the self: An empirical phenomenological investigation. *Mei:CogSci Master's Thesis*. 10.25365/thesis.71694

[19] Julian Bass-Krueger, 2021. Consciousness and Time. *Mei:CogSci Master's Thesis* 10.25365/thesis.70232

LTP and LTD dependence on spontaneous activity in hippocampal and cortical glutamate synapses and the role of anaesthetics in the study of plasticity and learning

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ABSTRACT

The following article is a condensed version of a review paper which was motivated by the hypothesis put forward by Benuskova and her colleagues that an ongoing pre- and postsynaptic spontaneous activity (SA) determines not only the degree of input-specific LTP elicited by various plasticity-inducing protocols, but also the degree of associated LTD in neighbouring non-tetanized inputs. It appears that understanding regularities of spontaneous activity can help us define boundary conditions for both LTP/LTD induction and maintenance. We look into LTP and LTD induction in excitatory glutamate synapses, their interrelatedness and connected non-glutamate plasticity. We then assess the role of SA in plasticity and consider what it means for in vitro studies where SA is limited. We inquire how anaesthetics affect the general capacity for LTP and LTD induction and maintenance and we join this with results on their effects on SA. All of this is taken together in order to suggest protocols of notable ecological validity and to provide an argument in favour of procedure standardization in the field.

KEYWORDS

Hippocampus, Cerebral Cortex, Anaesthesia, Sleep, Spontaneous Activity, Synaptic Long-Term Potentiation (LTP), Synaptic Long-Term Depression (LTD)

INTRODUCTION

In the process of learning, there is both an increase of electrochemical signalling in some synapses and a decrease thereof in others. Potentiation and depression include many physiological changes and are therefore more stable over time in comparison to facilitation and inhibition [1]. The general understanding of NMDA-dependent LTP is as follows: presynaptic stimulation opens postsynaptic NMDA channels which cause a rise in postsynaptic Ca2+. Strong depolarizations displace magnesium ions, which open more NMDA channels in a positive feedback loop manner. The postsynaptic neuron accepts even more Ca2+ ions, and this superfluous concentration of Ca2+ then activates CAMKII, increases cAMP and PKAII concentrations. Activated CAMKII is known to increase the volume of the dendritic spines [2] and stimulate new AMPAr integration [3], with both of these processes being key criteria for successful LTP.

In their seminal work, Abraham and Goddard [4] showed that there is otherwise a notable difference between homosynaptic and heterosynaptic plasticity: *“Homosynaptic plasticity occurs at synapses that were active during the induction. It is also called input-specific or associative, governed by Hebbian-type learning rules. Heterosynaptic plasticity can be induced by episodes of strong postsynaptic activity also at synapses that were not active during the induction, thus making any synapse at a cell a target to heterosynaptic changes. Both forms can be induced by typical protocols and operate on the same time scales but have differential computational properties and play different roles in learning systems. Homosynaptic plasticity mediates associative modifications of synaptic weights. Heterosynaptic plasticity counteracts runaway dynamics introduced by Hebbian-type rules and balances synaptic changes."* [5].

A conceptual shift in our understanding of “activity dependence” in heterosynaptic plasticity occured after the following experiment: Prior to stimulation the medial perforant pathway (MPP) and the lateral perforant path (LPP) were equally weighted. With low-frequency stimulation spontaneous input activity was largely correlated and only simultaneous or closely successive spikes at these two inputs could fire the postsynaptic granule cell. Meanwhile high-frequency stimulation of the MPP decorrelated the activity between LPP and MPP, which lead to lower postsynaptic activity. Notably, there was no heterosynaptic LTD when the presynaptic spontaneous activity was blocked [6]. This became known as the Benuskova-Abraham model which explains "heterosynaptic" LTD as a homosynaptic phenomenon due to presynaptic activity.

Meanwhile, the baseline difference between LTP- and LTD-inducing protocols can most simply be illustrated with a difference in stimulation protocols: "*900 pulses of stimuli induced LTD when applied at lower frequencies (1–3 Hz), and induced LTP when applied at a higher frequency (30 Hz).“* [7]

All of the aforementioned considerations led researchers [8, 9] to investigate the role of background SA in memory formation. It should be noted that any activity which is not

evoked by immediate sensory processing can be considered as spontaneous [10, 11, 12]. The goal of our review was to integrate evaluations of all known processes that affect the animals ability to “create a memory trace”, whether it is the physiological condition of the animal or how the inquiry into physiological change is performed.

METHODS

Data was collected from 232 peer-reviewed studies on excitatory glutamate synapses of granule cells in the dentate gyrus, CA1 neurons of the hippocampus (HPC), and cortical (CTX) networks, including those that dealt with developmental, pathophysiological and behavioural data. We also included computational studies of synaptic plasticity. In the process of integration, various types of methodological differences had to be kept in mind.

RESULTS and DISCUSSION

At the onset of writing we wanted to achieve a sound, precise and conclusive multivariate analysis. Yet this numerical approach proved to be impossible due to overarching disparities in experimental protocols. The differences in methods and materials make these experiments dissimilar to the point of barely studying the same phenomenon at all, not to mention the consideration that plasticity phenomena are not a uniform class to begin with [13]. In the following sections, we are nevertheless able to provide some conclusions about which variables ought to be controlled for so that the experimental work is ecologically valid while also giving results that are available for inferences on subsequent, more complex paradigms within the study of memory.

Firstly, the evidence that SA plays a key role in induction and maintenance of proper strength of LTP and concurring, homeostatic LTD is overwhelming [14, 15, 16]. In order to provide a realistic picture of synaptic plasticity (in which SA is as natural as possible), experiments on intact tissues should be given preference [17], since all nerve ablation limits physiological SA input. For example, when studying the CA1 region, its connections to CA3 [18], the dentate gyrus [19], the entorhinal CTX [20] and the medial prefrontal CTX [21] ought to be maintained. Considering norepinephrine [7] and dopamine [22] modifications on glutamate-synapse plasticity, there is good reason to believe that both the amygdala and nucleus accumbens should remain connected to the HPC area under study. But when it comes to the CTX, the scope of kept projections largely depends on the cortical region in question. Unsurprisingly, and in accordance with many authors referenced in the full paper, a preference for in vivo recordings is advised [17, 23, 24]. Nevertheless, many authors agree that thoughtful attention to in vitro conditions could still prove fruitful.

Secondly, no matter the nature of the preparation, we would do best to also keep track of what is happening on other, non-glutamate synapses – since these signalling chains are extensively interdependent. Along with the previously mentioned norepinephrine and dopamine receptors, endocannabinoid, GABA and various acetylcholine receptors should be accounted for in order for us to be able to interpret and generalize our findings [25]. Surveillance of tyrosine [25], serine [26], adenosine/ATP [27] and Ca2+ secretion [28] whether it be from neighbouring neurons or glial cells also appears to play a vital role in outcomes of synaptic plasticity. Especially in the case of astrocytes, close monitoring of glutamate secretion should not be neglected. As far as the author is aware, all of these recordings are not possible simultaneously - so a full analysis would require iterations of the same paradigm with different permutations of controlled variables. Although genetic similarity of laboratory animals is regular practice, we have found evidence that conditions regarding nutrition, activity, sleep and stress should be matched as closely as possible, as they all play a role in establishing baseline stress levels and ionic/aminoacid signalling [29, 30]. Stress/norepinephrine [31] minimization through ensuring environments that best resemble the ecological niche and allow for natural behaviours is crucial both in terms of deriving inferences on physiological plasticity in humans and ethical concerns. Due to dendrite [32] and button [33] restructuring that occurs in synapses after the process of learning, it would be advised to scan for their baseline structure since an intricate confluence of signalling chains appears to take place at that scale.

Thirdly, we have taken a stance that if we are to study memory itself, we should focus on studies where it is represented as a "fully learned association with practical effects" which can be doubtlessly confirmed only with experiments within behavioural paradigms [34, 35]. This functionalist approach requires multiple-synapse learning with behavioural timescales (seconds-to-minutes). Not only that, but it is also unquestionably dependent on replay during sleep [36], which means that an understanding of phosphorylations [37] and gene expression [38] is an indispensable part of the puzzle. If we are to understand memory, we ought to control for post-learning sleep duration and composition, but also for the quantity of operative gap junction [39] channels that extensively contribute to the plasticity-related signalling in sleep, both through slow oscillations and sharp-wave ripples [40].

In short, there is overwhelming evidence that SA within or outside the region of interest is crucial to synaptic plasticity in a myriad of forms (post-tetanic spiking [41], bursting [42], theta oscillations [43], slow oscillations [44] and sharp wave ripples [45, 46]) and that all of them should be taken into consideration. The more complex the type of learning (declarative vs. nondeclarative, behavioural sequences vs. single behaviours, simple classical conditioning vs. nonassociative learning), the larger the region of interest and the more notable the effect of these sleep phenomena. This compounding of

complexity also applies to most previously mentioned signalling, as the area of messenger perfusion also grows.

Lastly, both in vivo conditions and tissue extraction demand the use of anaesthetics. Due to its equal effect on inhibitory and excitatory receptors, which results in successful plasticity induction while also providing sufficient insentience, application of urethane seems to be the best option for studying plasticity, at least in adult subjects [47]. According to previous research, isoflurane appears to be the second best choice. There is some evidence to believe that sevoflurane is a good option for experiments in the neonatal period [48]. There might be some alternatives to anaesthetic predicaments, e.g. severing some sensory projections, usage of neurotransmitter perfusions that would correct for their effects, such as norepinephrine [36], or a combination of both measures. Nevertheless, a routine use of these remains in the realm of the hypothetical since the bioethical committees might remain sceptical about what lowering the anaesthetic dose would mean in terms of sentience and anguish [49, 50].

At this point in time, we are far from being in possession of any sort of statistical law that could be considered ecologically valid even in simpler types of learning/plasticity. The author is aware that the variables listed in the previous sections taken together are essentially calling for an "ideal experiment" which is entirely unattainable within one laboratory. Yet it appears that a combined effort of multiple institutions could overcome these constraints of time and funding and make greater strides in the integration of experimental results into a cohesive body of knowledge. A collaborative search for a law that could easily generalize across experimental conditions should most likely start with a standardisation of materials and methods and careful coordination of experimental tasks within the in vitro domain of plasticity in order to gradually build up towards the end goal of understanding declarative memory formation.

In conclusion, our research could only show that the spectrum of phenomena contributing to various levels of plasticity is strikingly wide and heavily interconnected - to the point that a comprehensive understanding of learning is apparently not achievable through inherently untransferable results of nonpartisan research.

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REFERENCES

[1] Antonov, I., E. R. Kandel, and R. D. Hawkins. 2010. “Presynaptic and Postsynaptic Mechanisms of Synaptic Plasticity and Metaplasticity during Intermediate-Term Memory Formation in Aplysia.” Journal of Neuroscience 30 (16): 5781–91. https://doi.org/10.1523/jneurosci.4947-09.2010.

[2] Pi, Hyun Jae, Nikolai Otmakhov, Farida El Gaamouch, David Lemelin, Paul De Koninck, and John Lisman. 2010. “CaMKII Control of Spine Size and Synaptic Strength: Role of Phosphorylation States and Nonenzymatic Action.” Proceedings of the National Academy of Sciences 107 (32): 14437–42. https://doi.org/10.1073/pnas.1009268107.

[3] Lu, W., K. Isozaki, K. W. Roche, and R. A. Nicoll. 2010. “Synaptic Targeting of AMPA Receptors Is Regulated by a CaMKII Site in the First Intracellular Loop of GluA1.” Proceedings of the National Academy of Sciences 107 (51): 22266–71. https://doi.org/10.1073/pnas.1016289107.

[4] Abraham, W. C., and G. V. Goddard. 1983. “Asymmetric Relationships between Homosynaptic Long-Term Potentiation and Heterosynaptic Long-Term Depression.” Nature 305 (5936): 717–19. https://doi.org/10.1038/305717a0

[5] Chistiakova, Marina, Nicholas M. Bannon, Maxim Bazhenov, and Maxim Volgushev. 2014. “Heterosynaptic Plasticity: Multiple Mechanisms and Multiple Roles.” The Neuroscientist : A Review Journal Bringing Neurobiology, Neurology and Psychiatry 20 (5): 483–98. https://doi.org/10.1177/1073858414529829.

[6] Benuskova, Lubica, and Wickliffe C. Abraham. 2007. “STDP Rule Endowed with the BCM Sliding Threshold Accounts for Hippocampal Heterosynaptic Plasticity.” Journal of Computational Neuroscience 22 (2): 129–33. https://doi.org/10.1007/s10827-006-0002-x.

[7] Katsuki, Hiroshi, Yukitoshi Izumi, and Charles F. Zorumski. 1997. “Noradrenergic Regulation of Synaptic Plasticity in the Hippocampal CA1 Region.” Journal of Neurophysiology 77 (6): 3013–20. https://doi.org/10.1152/jn.1997.77.6.3013

[8] Beňušková, Ľubica, and Peter Jedlička. 2012. “COMPUTATIONAL MODELING of LONG-TERM DEPRESSION of SYNAPTIC WEIGHTS: INSIGHTS from STDP, METAPLASTICITY and SPONTANEOUS ACTIVITY.” Neural Network World 22 (2): 161–80. https://doi.org/10.14311/nnw.2012.22.010.

[9] Shirrafiardekani, Azam, Lubica Benuskova, and Jörg Frauendiener. 2019. “A Voltage-Based Metaplasticity Rule Applied to the Model Hippocampal Granule Cell Accounts for Homeostatic Heterosynaptic Plasticity,” February. https://doi.org/10.1101/557173.

[10] Vidaurre, Diego, Laurence T. Hunt, Andrew J. Quinn, Benjamin A. E. Hunt, Matthew J. Brookes, Anna C. Nobre, and Mark W. Woolrich. 2018. “Spontaneous Cortical Activity Transiently Organises into Frequency Specific Phase-Coupling Networks.” Nature Communications 9 (1). https://doi.org/10.1038/s41467-018-05316-z.

[11] Sun, W., and Y. Dan. 2009. “Layer-Specific Network Oscillation and Spatiotemporal Receptive Field in the Visual Cortex.” Proceedings of the National Academy of Sciences 106 (42): 17986–91. https://doi.org/10.1073/pnas.0903962106.

[12] Florin, Esther, and Sylvain Baillet. 2015. “The Brain’s Resting-State Activity Is Shaped by Synchronized Cross-Frequency Coupling of Neural Oscillations.” NeuroImage 111 (May): 26–35. https://doi.org/10.1016/j.neuroimage.2015.01.054.

[13] Rc, Malenka, and Bear Mf. 2004. “LTP and LTD: An Embarrassment of Riches.” Neuron. September 30, 2004. https://pubmed.ncbi.nlm.nih.gov/15450156/.

[14] Griffiths, Benjamin J., George Parish, Frederic Roux, Sebastian Michelmann, Mircea van der Plas, Luca D. Kolibius, Ramesh Chelvarajah, et al. 2019. “Directional Coupling of Slow and Fast Hippocampal Gamma with Neocortical Alpha/Beta Oscillations in Human Episodic Memory.” Proceedings of the National Academy of Sciences 116 (43): 21834–42. https://doi.org/10.1073/pnas.1914180116

[15] Umbach, Gray, Pranish Kantak, Joshua Jacobs, Michael Kahana, Brad E. Pfeiffer, Michael Sperling, and Bradley Lega. 2020. “Time Cells in the Human Hippocampus and Entorhinal Cortex Support Episodic Memory.” Proceedings of the National Academy of Sciences 117 (45): 28463–74. https://doi.org/10.1073/pnas.2013250117.

[16] Dehaene, Stanislas, and Jean-Pierre Changeux. 2005. “Ongoing Spontaneous Activity Controls Access to Consciousness: A Neuronal Model for Inattentional Blindness.” Edited by Larry Abbott. PLoS Biology 3 (5): e141. https://doi.org/10.1371/journal.pbio.0030141.

[17] Antkowiak, B. 2002. “In Vitro Networks: Cortical Mechanisms of Anaesthetic Action.” British Journal of Anaesthesia 89 (1): 102–11. https://doi.org/10.1093/bja/aef154.

[18] Lin, Xiaoxiao, Michelle Amalraj, Crisylle Blanton, Brenda Avila, Todd C. Holmes, Douglas A. Nitz, and Xiangmin Xu. 2021. “Noncanonical Projections to the Hippocampal CA3 Regulate Spatial Learning and Memory by Modulating the Feedforward Hippocampal Trisynaptic Pathway.” Edited by Thomas Klausberger. PLOS Biology 19 (12): e3001127. https://doi.org/10.1371/journal.pbio.3001127.

[19] Isomura, Yoshikazu, Anton Sirota, Simal Özen, Sean Montgomery, Kenji Mizuseki, Darrell A. Henze, and György Buzsáki. 2006. “Integration and Segregation of Activity in Entorhinal-Hippocampal Subregions by Neocortical Slow Oscillations.” Neuron 52 (5): 871–82. https://doi.org/10.1016/j.neuron.2006.10.023.

[20] Hahn, Thomas T G, James M McFarland, Sven Berberich, Bert Sakmann, and Mayank R Mehta. 2012. “Spontaneous Persistent Activity in Entorhinal Cortex Modulates Cortico-Hippocampal Interaction in Vivo.” Nature Neuroscience 15 (11): 1531–38. https://doi.org/10.1038/nn.3236.

[21] Lundqvist, Mikael, Jonas Rose, Pawel Herman, Scott L Brincat, Timothy J Buschman, and Earl K Miller. 2016. “Gamma and Beta Bursts Underlie Working Memory.” Neuron 90 (1): 152–64. https://doi.org/10.1016/j.neuron.2016.02.028.

[22] Atherton, Laura A., David Dupret, and Jack R. Mellor. 2015. “Memory Trace Replay: The Shaping of Memory Consolidation by Neuromodulation.” Trends in Neurosciences 38 (9): 560–70. https://doi.org/10.1016/j.tins.2015.07.004.

[23] Whittington, Miles A., Mark O. Cunningham, Fiona E.N. LeBeau, Claudia Racca, and Roger D. Traub. 2010. “Multiple Origins of the Cortical Gamma Rhythm.” Developmental Neurobiology 71 (1): 92–106. https://doi.org/10.1002/dneu.20814.

[24] Pollard, Christopher E., and Anthony Angel. 1990. “Spontaneous Single Cell Discharge in Rat Somatosensory Cortical Slices and Its Relationship to Discharge in the Urethane-Anaesthetized Rat.” Brain Research 518 (1-2): 120–26. https://doi.org/10.1016/0006-8993(90)90962-b.

[25] Bashir, Zafar I. 2003. “On Long-Term Depression Induced by Activation of G-Protein Coupled Receptors.” Neuroscience Research 45 (4): 363–67. https://doi.org/10.1016/s0168-0102(03)00002-6.

[26] Nishiyama, Makoto, Kyonsoo Hong, Katsuhiko Mikoshiba, Mu-ming Poo, and Kunio Kato. 2000. “Calcium Stores Regulate the Polarity and Input Specificity of Synaptic Modification.” Nature 408 (6812): 584–88. https://doi.org/10.1038/35046067.

[27] Chen, Jiadong, Zhibing Tan, Li Zeng, Xiaoxing Zhang, You He, Wei Gao, Xiumei Wu, et al. 2012. “Heterosynaptic Long-Term Depression Mediated by ATP Released from Astrocytes.” Glia 61 (2): 178–91. https://doi.org/10.1002/glia.22425.

[28] SUL, JAI-YOON, GEORGE OROSZ, RICHARD S. GIVENS, and PHILIP G. HAYDON. 2004. “Astrocytic Connectivity in the Hippocampus.” Neuron Glia Biology 1 (1): 3–11. https://doi.org/10.1017/s1740925x04000031.

[29] Roth, Richard H., Robert H. Cudmore, Han L. Tan, Ingie Hong, Yong Zhang, and Richard L. Huganir. 2020. “Cortical Synaptic AMPA Receptor Plasticity during Motor Learning.” Neuron 105 (5): 895-908.e5. https://doi.org/10.1016/j.neuron.2019.12.005.

[30] Dittman, Jeremy S., Anatol C. Kreitzer, and Wade G. Regehr. 2000. “Interplay between Facilitation, Depression, and Residual Calcium at Three Presynaptic Terminals.” The Journal of Neuroscience 20 (4): 1374–85. https://doi.org/10.1523/jneurosci.20-04-01374.200

[31] Tomar, Anupratap, Denis Polygalov, Sumantra Chattarji, and Thomas J. McHugh. 2021. “Stress Enhances Hippocampal Neuronal Synchrony and Alters Ripple-Spike Interaction.” Neurobiology of Stress 14 (May): 100327. https://doi.org/10.1016/j.ynstr.2021.100327.

[32] Ohtsuki, Gen. 2019. “Modification of Synaptic-Input Clustering by Intrinsic Excitability Plasticity on Cerebellar Purkinje Cell Dendrites.” The Journal of Neuroscience 40 (2): 267–82. https://doi.org/10.1523/jneurosci.3211-18.2019.

[33] Emptage, Nigel J., Christopher A. Reid, and Alan Fine. 2001. “Calcium Stores in Hippocampal Synaptic Boutons Mediate Short-Term Plasticity, Store-Operated Ca2+ Entry, and Spontaneous Transmitter Release.” Neuron 29 (1): 197–208. https://doi.org/10.1016/s0896-6273(01)00190-8.

[34] Cone, Ian, and Harel Z. Shouval. 2021. “Behavioral Time Scale Plasticity of Place Fields: Mathematical Analysis.” Frontiers in Computational Neuroscience 15 (March). https://doi.org/10.3389/fncom.2021.640235.

[35] Cao, Jun, Nanhui Chen, Tianle Xu, and Lin Xu. 2004. “Stress-Facilitated LTD Induces Output Plasticity through Synchronized-Spikes and Spontaneous Unitary Discharges in the CA1 Region of the Hippocampus.” Neuroscience Research 49 (2): 229–39. https://doi.org/10.1016/j.neures.2004.03.001.

[36] Reasor, Jonathan D., and Gina R. Poe. 2008. “Learning and Memory during Sleep and Anesthesia.” International Anesthesiology Clinics 46 (3): 105–29. https://doi.org/10.1097/aia.0b013e318181e513.

[37] Brüning, Franziska, Sara B. Noya, Tanja Bange, Stella Koutsouli, Jan D. Rudolph, Shiva K. Tyagarajan, Jürgen Cox, Matthias Mann, Steven A. Brown, and Maria S. Robles. 2019. “Sleep-Wake Cycles Drive Daily Dynamics of Synaptic Phosphorylation.” Science 366 (6462). https://doi.org/10.1126/science.aav3617.

[38] PEKNY, T., D. ANDERSSON, U. WILHELMSSON, M. PEKNA, and M. PEKNY. 2014. “Short General Anaesthesia Induces Prolonged Changes in Gene Expression in the Mouse Hippocampus.” Acta Anaesthesiologica Scandinavica 58 (9): 1127–33. https://doi.org/10.1111/aas.12369.

[39] Ross, F.M, P Gwyn, D Spanswick, and S.N Davies. 2000. “Carbenoxolone Depresses Spontaneous Epileptiform Activity in the CA1 Region of Rat Hippocampal Slices.” Neuroscience 100 (4): 789–96.https://doi.org/10.1016/s0306-4522(00)00346-8.

[40] Yuste, Rafael, Alejandro Peinado, and Lawrence C. Katz. 1992. “Neuronal Domains in Developing Neocortex.” Science 257 (5070): 665–69. https://doi.org/10.1126/science.1496379.

[41] Vandael, David, Yuji Okamoto, and Peter Jonas. 2021. “Transsynaptic Modulation of Presynaptic Short-Term Plasticity in Hippocampal Mossy Fiber Synapses.” Nature Communications 12 (1). https://doi.org/10.1038/s41467-021-23153-5.

[42] Goodman, Corey S., and Carla J. Shatz. 1993. “Developmental Mechanisms That Generate Precise Patterns of Neuronal Connectivity.” Cell 72 (January): 77–98. https://doi.org/10.1016/s0092-8674(05)80030-3.

[43] Wang, Mengni, David J. Foster, and Brad E. Pfeiffer. 2020. “Alternating Sequences of Future and Past Behavior Encoded within Hippocampal Theta Oscillations.” Science 370 (6513): 247–50. https://doi.org/10.1126/science.abb4151.

[44] Kim, Jaekyung, Tanuj Gulati, and Karunesh Ganguly. 2019. “Competing Roles of Slow Oscillations and Delta Waves in Memory Consolidation versus Forgetting.” Cell 179 (2): 514-526.e13. https://doi.org/10.1016/j.cell.2019.08.040.

[45] Farooq, U., and G. Dragoi. 2019. “Emergence of Preconfigured and Plastic Time-Compressed Sequences in Early Postnatal Development.” Science 363 (6423): 168–73. https://doi.org/10.1126/science.aav0502.

[46] Fernández-Ruiz, Antonio, Azahara Oliva, Eliezyer Fermino de Oliveira, Florbela Rocha-Almeida, David Tingley, and György Buzsáki. 2019. “Long-Duration Hippocampal Sharp Wave Ripples Improve Memory.” Science 364 (6445): 1082–86. https://doi.org/10.1126/science.aax0758.

[47] Hara, Koji, and R. Adron Harris. 2002. “The Anesthetic Mechanism of Urethane: The Effects on Neurotransmitter-Gated Ion Channels.” Anesthesia & Analgesia 94 (2): 313–18. https://doi.org/10.1097/00000539-200202000-00015.

[48] Feng, X., J.J. Liu, X. Zhou, F.H. Song, X.Y. Yang, X.S. Chen, W.Q. Huang, L.H. Zhou, and J.H. Ye. 2012. “Single Sevoflurane Exposure Decreases Neuronal Nitric Oxide Synthase Levels in the Hippocampus of Developing Rats.” British Journal of Anaesthesia 109 (2): 225–33. https://doi.org/10.1093/bja/aes121.

[49] Vahle-Hinz, C, and O Detsch. 2002. “What Can in Vivo Electrophysiology in Animal Models Tell Us about Mechanisms of Anaesthesia?” British Journal of Anaesthesia 89 (1): 123–42. https://doi.org/10.1093/bja/aef166.

[50] Hentschke, H., A. Raz, B.M. Krause, C.A. Murphy, and M.I. Banks. 2017. “Disruption of Cortical Network Activity by the General Anaesthetic Isoflurane.” British Journal of Anaesthesia 119 (4): 685–96. https://doi.org/10.1093/bja/aex199.

[51] Bratuša, M. 2022. “LTP and LTD dependence on spontaneous activity in glutamate synapses of the HPC and CTX and the role of anaesthetics.” exchange semester project MEi:CogSci. https://www.academia.edu/80928790/LTP_and_LTD_dependence_on_spontaneous_activity_in_glutamate_synapses_of_the_HPC_and_CTX_and_the_role_of_anaesthetics

Trusted sources and disinformation: studying the limits of science*

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ABSTRACT

During the Covid-19 pandemic, the spread of disinformation became more apparent. Much of that disinformation focused on health-related topics and the current health crisis, often claiming to be scientific information. Trusting scientists became crucial to counter the pandemic effectively as a society; however, science-related disinformation and so-called pseudoscience provided new challenges for societies. These beliefs often overlap with other types of disinformation and conspirational thinking, making them very attractive to human cognition. Twenty semi-structured interviews were done in 2020 to investigate individuals' trust in science, governments, and media. The interviews focused on information sources and the conclusions drawn from the situation to determine how individuals estimate information sources' trustworthiness.

KEYWORDS

Pseudoscience, disinformation, Covid-19, trust

1 DISINFORMATION AND PSEUDOSCIENCE

1.1 Dimensions of disinformation

Disinformation is most commonly defined as false information that is deliberately propagated and distributed [1, 2, 3, 4]. The concept of disinformation includes various dimensions and aspects, which often overlap and influence each other [1, 3]. Kapantai et al. (2020) developed a taxonomical framework to include important types of disinformation, including the motive (profit, ideological, psychological, and unclear), facticity, and verifiability as dimensions. That resulted in eleven kinds of disinformation, including, for instance, conspiracy theories, pseudoscience, hoaxes, trolling, or clickbait. Disinformation can also be partly true to make it more credible [5].

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Disinformation often speaks to human emotions and touches upon controversial or ideologically charged topics [5] as "people have a taste, a predisposition even, for it" [5, p. 57], and virality helps content to be distributed widely [6]. As soon as such topics are concerned, the content is often not that important to be empirically correct and reasonable. However, a social identity is afforded by believing that content is valuable [7]. Making certain beliefs their identity does not only lead to an ignorance of facts (ibid.), but it also enables people to think along ideologically polarised lines with affective disdain for outgroup beliefs [8]. Therefore, believing, for instance, that the earth is flat goes beyond holding a belief but is used to form identities. Around these identities, movements are formed, and, in the case of flat earthers, for instance, people are willing to lose their jobs, friends, and family relations to be part of the group [7].
A kind of disinformation that has become crucial, especially during the Covid-19 pandemic, has been dubbed *pseudoscience*.

1.2 What is pseudoscience?

Distinguishing science from pseudoscience is not a simple endeavour. Some paradigmatic cases might exist where philosophers and scientists agree, but other examples remain undecided or on the fringes of science. Ultimately, the question of defining science and delimitating it from non-science comes down to a fundamental question of philosophy, mainly what knowledge is and how we attain it [9]. Pseudoscience can be understood as a discourse about a specific subject matter, and what is considered pseudoscience, like science, changes [10]. Defining pseudoscience often "involves subjects that are either on the margins or borderlands of science and are not yet proven, or have been disproved, or make claims that sound scientific but in fact have no relationship to science" [11, p. 203]. Several characteristics can be identified to designate the likelihood of adherence to pseudoscientific or non-scientific claims. For example, the language used to describe the phenomenon or research results often indicates the credibility of the reported results or evidence. The excessive use of technical terms and scientifically sounding language, for instance, in press releases, might lead to trust and acceptance of the presented results due to the impression of smart people doing important work. These are, however, not doing a great job in communicating science, and

more importantly, some elements of good scientific practice can be commonly understood [12]. Pseudoscientific theories often use language full of epithets and refer to emotions and religion or use ideological markers.The presentations often include theses and evaluations presented as unequivocal [13]. The method used might not be scientifically sound. For instance, anecdotal evidence and not controlling for other variables, very small or unrepresentative sample sizes in establishing causal relationships, lack of control groups, or blind testing might indicate unsound methods. Moreover, many pseudoscientific studies tend to select parts of their evidence, which allows for a very charitable interpretation of studies to support a predefined conclusion [12]. As there is not one comprehensive definition of pseudoscience, issues fall more or less under its spectrum. I will consider the above-outlined characteristics during my empirical investigation. Pseudoscience and science are historical phenomena that inform the decisions societies make about what is considered the truth. Attempting to define pseudoscience involves making claims about the nature of science. Overall, no methodology has been developed that allows for a general and comprehensive distinction [10], with Popper's principle of falsifiability [14] not solving the problem satisfactorily [15]. In a culture that highly values science, other domains such as religion, politics, or literature are often closely associated with science and seem to borrow scientific language, theories, or methods [11]. Later, theories might be reevaluated and reclassified as science or pseudoscience [10]. Pseudoscientific beliefs are not a marginal phenomenon and influence public policies [9, 16]. For example, during the Covid- 19 pandemic, pseudoscientific explanations for the causes and cures of the virus surged [17]. Therefore, these beliefs, especially in crises, when public policies might be more crucial to follow, and such beliefs could be detrimental to society. However, belief acquisition is not always easy, as human beings are prone to biases and faulty conclusions.

2 STUDYING THE LIMITS OF SCIENCE

2.1 Method and participants

Twenty semi-structured [18] and problem-centred qualitative interviews [19] were conducted in November and December 2020 with Austrian volunteers (N=20, 16 female, age 19-65, SD = 13.8). Interviews were led in German, and the author translated quotes. Interview participants were volunteers. Therefore, the researcher did not have much influence on their gender. However, gender was determined not to be a crucial influence on the study. The discussions included several topics. However, only one part focusing on trust and attitude towards the government, scientists and media is contained in this paper. Some limitations must be outlined when doing qualitative interviews online. Conducting interviews online limits the information transmission compared to real life interviewing face-to-face. The qualitative study was done at a specific moment of the pandemic and thus only reflects participants' attitudes during that time. Furthermore, participants might be hesitant to share pseudoscientific beliefs or denial of science with a researcher. Therefore, no outright questions about such ideas were asked.

2.2 Results: "I don't know what to believe anymore": doubt and trust in times of crises

Participants used various sources of information about the Covid-19 pandemic, including online sources, TV, radio and conversations with friends and family. When asked about the sources participants considered trustworthy or not to provide information about the Covid-19 pandemic, various categories were mentioned, including the media, social media, social contacts, and the government. However, the trust did not seem to be easily acquired or granted among participants. Social aspects were considered influential in attributing trustworthiness (P3, P6). Therefore, a reason to trust a source would be that people from an individual's social circle would also trust it (P3, P6, P19). Furthermore, authenticity and "thinking outside the box" (P13) were considered trustworthy traits of people. Some said they would trust family members, doctors or journalists they knew personally (P2, P11).

Participants trust media if they provide sources with more information about the topic in question (P3), including links to other trusted websites (P4). Furthermore, if the information could be cross-referenced with scientific sources (P14), and if scientists, experts, or studies are included (P20), the trust in media sources is increased. Furthermore, including various opinions was considered a sign of trustworthiness (P6, P1). These opinions permit looking at a subject from multiple viewpoints (P3) and discussions by different people (P3, P14). The content would not be considered trustworthy if a personal opinion were presented as objective truth (P3). Furthermore, the presentation of information in the media and on the internet influences the attribution of trustworthiness. Accordingly, the way people post something, specifically the language (P14), if they write whole sentences and if they explain the context of an article (P4) or if something is not formulated blatantly (P18) and frequently based on emotion (P5) it is considered more trustworthy. However, trust was not attributed without reservation for many participants as they perceived the media as having their agenda (P8, P13) and being prejudiced (P14), but still more trustworthy than social media (P8). On the other hand, some did not consider the media "a source to find out what is really happening" (P13), and one participant mentioned that they "don't believe anything anymore" because "[...] it is not explained what the numbers mean at all or put into a context from which area the numbers come from and how they were created at all" (P16). Social media was not considered trustworthy because a lot of information originates from private individuals (P19). Moreover, assessing the trustworthiness of information on social media is challenging (P1), even though most participants considered some people they were friends with on Facebook trustworthy (P3, P4, P15). Some participants based their trust on intuition and how they felt regarding the media and online information. One participant described it as follows: "When I open that, how does it 'feel' if I move towards a platform, then I read how the information is structured, and I read the first paragraphs, and when something is in there that seems a bit strange to me, then I would get out of there and look it up somewhere else. So, it depends on how it is in a textual sense and how the information lies in front of me"

(P15). More specific descriptions of that feeling included if something seemed "out of touch with reality" (P5), what sounds reasonable (P3), to use one's common sense or if it appears strange (P18). Participants furthermore attributed trustworthiness to sources or information that would confirm a worldview. Accordingly, a participant described that other people with differing worldviews would find different information trustworthy and objective (P6). Additionally, reputation was a source of trustworthiness, especially in the media (P10, P19). Some participants mentioned the government and ministries as trustworthy sources of information. One participant said, "in the last months, I have experienced things where I was not sure in the moment can I trust anyone, and this is now a purely emotional thing because you cannot know anything anyway" (P8). Furthermore, a participant claimed that "somebody is telling me, I cannot go to university anymore, that I cannot see people anymore, who is that somebody who would permit that, who decides about me, that I cannot do that anymore" (P5). Some participants showed understanding of the difficult decisions the government needs to take right now, claiming as they would not want to be in their position or get involved, they would need to comply with measures (P11).

Furthermore, some participants claimed that everybody would need to find their way of dealing with the situation and meet as many people as they would think appropriate (P14), emphasizing the responsibility of individuals (P5, P14). Many participants mentioned the adverse consequences of the measures. Some agreed that these consequences, including the dangers of a lockdown (P1), were not discussed enough (P1, P2, P16, P17). Some were worried about restricting civil rights during the lockdown and possible dangers to democracy (P9, P1), claiming that the government could not implement a curfew as it violated human rights (P1). Participants wished that people were given more credit (P20, P13), which included telling them to take care of their immune system and take vitamins (P13). Another participant would have wanted different perspectives on the transformation happening in 2020, as communication is changing and more telepathy will be possible due to that change (P5). According to participant 13, not discussing alternative ways of handling the pandemic can be attributed to international pressure (P13).

The plurality of opinions is generally valued highly among participants as it is essential that everybody can share their standpoint and how they arrive at their conclusions because everybody has a good reason to think as they do (P2, P1). However, according to some participants, not all opinions and standpoints were listened to somewhat during the pandemic. For instance, the questions "masks yes or no these questions are not allowed to be asked because we are being beaten down by all these numbers" (P13), and they should listen to people who have other methods (P14). Some observed that a division between opinions and people was taking place in the general society. In that regard, only two contrary camps seemed to exist, and only to "be for Corona or against, a middle course or a differentiated account was not possible" (P17). That means, participants were worried that a nuanced debate about issues regarding the pandemic was more difficult.

Moreover, participants observed how people changed and suddenly believed entirely different things (P16, P2, P8). According to participants, everybody should state their opinion but has the responsibility to do it respectfully (P15). An individual's history is crucial to consider to make respectful interaction easier (P2). Participants elaborated more in detail on how they formed their own opinions about the measures, the communication, and the pandemic in general. Some attributed the decision to believe the information from a source to intuition (P12) or if it seems strange (P20), as highlighted previously in section 6.4.1. Furthermore, they highlighted the influence of social factors, such as the influence of people they would talk to (P5), for instance, in their workplace or people who had the illness (P14), even if they disagreed with them (P5). They would like to discuss these issues among their circle of friends as some would be more active and critical and might introduce other perspectives (P14). If some- thing seems strange, however, they would try to find other opinions (P20), and online they would follow links from friends (P9) or try and consume contrary opinions (P5). Overall, participants would form their opinions by combining various other opinions (P8), questioning their worldview, and staying open for new information (P14), and reflect on it (P5). Participants highlighted difficulties with opinion formation about the Covid-19 pandemic, as one participant summarized: "I believe a big problem is that there are so many people, where it is claimed, ok, I am a doctor in that area, and I say this and that. And the doctor then says that and you don't know, is that person really a doctor, do they really know about that. I mean, probably they are doctors but did they actually engage with that issue, or are they just saying anything? There are so many doctors that have different areas of expertise and, of course, various experiences and a different level of knowledge, so you don't know where the information is coming from" (P16).

3 DISCUSSION AND CONCLUSION

Participants highlighted some specific topics as instilling the most significant doubts about trustworthy sources considering the Covid-19 pandemic. Science was considered a trusted source, but various indications showed that participants had significant doubts regarding the scientific consensus about Covid-19, for instance, that they would not know what it really was (P1) and that it was the flu, which is unpleasant but not particularly dangerous (P13). Tests to determine infections were doubted in their validity and efficacy (P16) and are considered inaccurate (P13). Even though the interviews were led before Covid-19 vaccinations were widely available, mandatory vaccinations were already a big concern for some participants, which are thought to change society (P11) and should be well prepared to take people's fears about the vaccinations (P20) as chaos might ensue if vaccinations become mandatory (P12). Furthermore, the topic of not being told everything was present regarding the issue of vaccinations. Participants worried about what would happen to the Austrian culture and the country if vaccinations were mandatory (P11). An electronic compulsory vaccination certificate was mentioned as a source of worry for a functioning peaceful democracy (P9). Various conspirational elements seemed to be present during interviews. For example, some participants were worried about democracy and the rule of law in

Austria. One mentioned that a friend who is a doctor told them that now with the pandemic, the government can achieve things they could never have done without the pandemic (P13), which happens behind the scenes and might endanger our democracy (P9). In that regard, with the climate of fear, the government "is trying out how far it can tighten the thumbscrews" (P9), and the government lies, meaning something changed in a significant and sustainable way without people knowing (P9). In that regard, a participant stated the government was "catholic, dishonest and tendentious" (P11) and that it "actually does not have a plan [...] only false numbers, false facts, false something" (P17). Some doubted the democratic nature of the situation, as not everything is communicated (P18) in our "so-called democracy" (P12). One participant summarised the situation as follows:

"Honestly, it is a bit authoritarian because the information comes from above. Kurz [the Austrian chancellor] speaks from the microphone, and everyone listens, sits in front of the TV or channel, listens to him, and then it is done. I don't think that's democracy. How that has now developed individually that certain events were then possible, these self-initiatives that have then taken place in conformity with measures I find again thanks to people with whom I live together that we are democratic. These two perspectives in my social environment where you get together and ask if it's okay if you can hug someone or sing with each other even though choirs are not allowed to practice so that in agreement with the others, of course, works because we are not in the snitch system and the Biedermeier maybe it seems so but not quite." (P5).

All participants seemed to struggle with doubts regarding handling the pandemic in 2020. These doubts focused either on the government or on science. The media seemed to be the most trusted. However, some would argue that they would only report uncritically. If doubts focused on the government, they seemed to lean more towards a conspirational mindset. Doubts regarding scientific consensus about Covid-19 are mostly deemed to adhere to pseudoscientific beliefs such as Covid-19 is the same as the flu or tests/masks do not work. However, a mix of pseudoscience (vaccines do not work) and conspirational tendencies (there is some more extensive agenda) could be observed when discussing vaccinations. In conclusion, the frequency of social media use and the content consumed should not be overestimated, as an individuals' immediate social environment (i.e. friends and family) seems to have a more significant influence on their beliefs.

REFERENCES

[1] J. Möller, M. Hameleers and F. Ferreau, "Verschiedene Formen von Desinformation und ihre Verbreitung aus kommunikationswissenschaftlicher und rechtswissenschaftlicher Perpektive. Ein Gutachten im Auftrag der Gremienvorsitzendenkonferenz der Landesmedienanstalten (GVK).," die medeinanstalten - ALM GbR, Berlin, 2020.

[2] E. Humprecht, F. Esser and P. Van Aelst, "Resilience to Online Disinformation: A Framework for Cross-National Comparative Research," *The INternational Journal of Press/Politics,* vol. 25, no. 3, pp. 493-516, 2020.

[3] E. Kapantai, A. Christopoulou, C. Berberidis and V. Peristeras, "A Systematic Literature Review on Disinformation: Toward a Unified Taxonomical Framework," *New Media & Society,* vol. 23, no. 5, pp. 1301-1326, 2021.

[4] K. Shu, S. Wang, D. Lee and H. Liu, "Mining Disinformation and Fake News: Concepts, Methods, and Recent Advancements," in *Disinformation, Misinformation, and Fake News in Social Media: Emerging Research Challenges and Opportunities*, Cham, Springer International Publishing, 2020, pp. 1-20.

[5] N. O'Shaughnessy, "From Disinformation to Fake News: Forwards into the Past," in *The Sage Handbook of Propaganda*, Thousand Oaks (CA), Sage, 2019, pp. 55-71.

[6] S. Vosoughi, D. Roy and S. Aral, "The Spread of True and False News Online," *Science,* vol. 359, no. 6380, pp. 1146-1151, 2018.

[7] L. McIntyre, How to Talk to a Science Denier. Conversations with Flat Earthers, Climate Deniers, and Others Who Defy Reason, Cambridge (MA): MIT Press, 2021.

[8] L. Mason, "Ideologues without Issues: Polarizing Consequences of Ideological Identities," *Public Opinion Quarterly,* vol. 82, no. S1, pp. 866-887, 2018.

[9] M. Pigliucci and M. Boudry, "Introduction: Why the Demarcation Problem Matters," in *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*, London, The University of Chicao Press, 2013, pp. 1-9.

[10] D. K. Hecht, "Pseudoscience and the Pursuit of Truth," in *Pseudoscience. The Conspiracy Against Science*, Cambridge (MA), MIT Press, 2018, pp. 3-20.

[11] M. Shermer, "Science and Pseudoscience. The Difference in Practice and the Difference It Makes," in *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem.*, London, The University of Chicago Press, 2013, pp. 203-223.

[12] C. W. Lack and J. Rousseau, Critical Thinking, Science, and Pseudoscience, New York: Springer, 2016.

[13] M. Szynkiewicz, "May you live in interesting times. Science vs. pseudoscience in the era of the internet," *Ethics in Progress,* vol. 11, no. 1, pp. 85-98, 2020.

[14] K. Popper, The logic of scientific discovery, London and New York: Routledge, 2002.

[15] M. Pigliucci, "The Demarcation Problem. A (Belated) Response to Laudan.," in *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*, London, The University of Chicago Press, 2013, pp. 9-29.

[16] J. H. Taylor, R. A. Eve and F. B. Harrold, "Why creationists don't go to psychic fairs: differential sources of pseudoscientific beliefs," *Skeptical Inquirer,* vol. 19, no. 6, pp. 23-28, 1995.

[17] T. T. Desta and T. Mulugeta, "Living with COVID-19 triggered pseudoscience and conspiracies," *International journal of Public Health,* vol. 65, no. 6, pp. 713-714, 2020.

[18] G. D. McCracken, The long interview, Newbury Park (CA): Sage, 1988.

[19] U. Flick, An introduction to qualitative research, London: Sage, 2009.

[20] R. Armitage and C. Vaccari, "Misinformation and Disinfomration," in *The Routledge Companion to Media Disinformation and Populism*, London and New York, Routledge, 2021, pp. 38-49.

[21] P. Carrillo-Santisteve and P. Lopalco, "Measles still spread in Europe: Who is responsible for the failure to vaccinate?," *Clinical Microbiology and Infection,* vol. 18, no. 5, pp. 50-56, 2012.

[22] J. M. Berman, Anti vaxxers: How to Challenge a Misinformed Movement, Cambridge (MA): Teh MIT Press, 2020.

[23] D. Kahneman, "A perspective on judgement and choice: Mapping bounded rationality," *American Psychologist,* vol. 58, no. 9, pp. 697-720, 2003.

[24] H. A. Simon, "Rational Decision Making in Business Organizations," *The American Economic Review,* vol. 69, no. 4, pp. 493-513, 1979.

[25] A. Tversky and D. Kahneman, "Judgment under uncertainty: Heuristics and biases," in *Judgment under uncertainty: Heuritsics and biases*, Cambridge (MA), Cambridge Unviersity Press, 1982, pp. 3-23.

[26] A. Tversky, "Elimination by Aspects: A Theory of Choice," *Psychological Review,,* vol. 79, no. 4, pp. 281-299, 1972.

Opacity and understanding in artificial neural networks: a philosophical perspective

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ABSTRACT

In the paper, I review some of the emerging philosophical literature on the problem of using artificial neural networks (ANNs) and deep learning in science. Specifically, I focus on the problem of opacity in such systems and argue that although using deep neural networks in cognitive science can produce better results, it can also acts as a barrier to gaining new understanding of cognitive processes.

KEYWORDS

explanation, understanding, scientific discovery, artificial neural networks, black-box problem

1 INTRODUCTION

Early on in their inception, connectionist approaches in cognitive science faced challenges from proponents of competing approaches. One of the leading theorists of the classical symbolic approach, J. Fodor and Z. Pylyshyn [7], for example, argued that connectionism could not account for four essential properties of cognition – i.e., productivity, systematicity, compositionality, and coherence – and thus was not a sufficient theory of the mind. We now have good reasons to believe that their argument does not hold [11]. Indeed, in their demonstration of the supposed inadequacy of connectionist models, Fodor and Pylyshyn only considered very simple models with local representations. But it turns out that more complex models with distributed representations can satisfactorily solve the explanatory task. Contrary to what Fodor and Pylyshyn claimed, we can therefore show that even connectionist cognitive models are powerful enough to exhibit the required properties.

Fast forward forty or so years in the future, scientists using artificial neural networks (ANNs) and deep learning to study cognitive functions now face a different problem. One of the key advantages of present day ANNs that use deep learning is their increased complexity and depth [4]. But because of their increased complexity, such systems can become opaque in a way that even the researchers developing them do not understand some key aspects of how they work [10]. Present day ANNs can thus be used to model cognitive functions much more successfully than before, but because of their opaqueness, it is unclear what new insights such successes are generating [5].[1] If researchers in the 1980s talked about an explanatory task, the problem scientists' face today could be called an explanatory barrier.

In this paper, I will review some of the emerging philosophical literature on the problem of using ANNs in science. First, I will briefly introduce the problem of opaqueness or the so-called black-box problem. Then, I will present a paper by Erasmus et al. [6] which provides a detailed analysis of the notions of explanation and understanding that are central to thinking about the problem. After that, I will present Florian J. Boge's [3] argument that we can talk about two distinct dimensions of opacity in ANNs. In the last section, Mazviita Chimirmuuta's [5] argument about the implications of the trade-off between predictive accuracy and opacity for research in computational neuroscience will be presented.

2 BLACK BOX PROBLEM

Let us first turn to the problem of opaqueness. Authors of one of the review papers [10] from the field of explainable AI (XAI) note that the "predictive accuracy [of machine learning systems] has often been achieved through increased model complexity." This increased complexity, "combined with the fact that vast amounts of data are used to train and develops such complex systems" has inherently reduced researches' ability to "explain the inner workings and mechanisms" of these systems. As a result, "the rationale behind decisions [of these systems] becomes quite hard to understand and, therefore, their predictions hard to interpret." Therefore, they say that "there is clear trade-off between the performance of a machine learning model and its ability to produce explainable and interpretable predictions." The authors of anther review paper [1] reached a similar conclusion: "Indeed, there are algorithms that are more interpretable than others are, and there is often a tradeoff between accuracy and interpretability: the most accurate AI/ML models usually are not very explainable (for example, deep neural nets, boosted trees, random forests, and support vector machines), and the most interpretable models usually are less accurate (for example, linear or logistic regression)."

Authors of [10] thus distinguish between "black-box" models, which have state-of-the-art performance but are opaque, and "white-box" or "glass-box" models, which are more easily interpretable, but not as powerful. In her paper, Chirmuuta [5] also specifies which aspects of deep neural networks suffer from opaqueness. She argues that scientists have a good understanding of "internal architecture and workings" of the systems, i.e., they know the activation values of the units, the learning rule, the depth of the network and the connectivity between the layers. But they do not know exactly how an already trained network arrives at a prediction or classification.

[1] In contrast to this, Sullivan [14] argues that the problem of contemporary ANNs is not their opacity, but "a lack of scientific and empirical evidence supporting the link that connects a model to the target phenomenon." But see Räz and Breisbart [13] for an argument that her point rests on a weak and thus undesirable notion of understanding.

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3 EXPLANATION AND UNDERSTANDING

The black box problem or the problem of opaqueness has resulted in increased attention to research in explainable AI. But one salient feature of the literature on explainable AI is the imprecise or even interchangeable use of the concepts of explainability, intelligibility and interpretability. This is also recognized by the researchers themselves. For example, the authors [10] observe that there is "no concrete mathematical definition of the concepts of explainability and interpretability." Nevertheless, they make a conceptual distinction between these two terms. Interpretability, on the one hand, is understood in connection to the ability of researchers to intuitively understand the relationship between inputs and outputs of a system. Explainability, on the other hand, is understood in relation to the ability to understand the inner workings of a system. In contrast, authors of a different similar study [9] define explainability as possibility to provide a satisfactory answer to the "why" question regarding the functioning of a system. They also make a difference between two levels of explanation, connected to two different questions scientists can ask about a system. Namely, "why does this particular input lead to that particular output?" i.e., a question about the relationship between inputs and outputs, and "what information does the network contain?" i.e., a question about the internal workings of a system.

In their paper, Erasmus et al. [6] point to this shortcoming of the literature on explainable AI and argue that this imprecise use of the terms leads to a misunderstanding of the trade-off between performance and explainability of AI systems. Their argument proceeds in three steps. First, they offer a more precise analysis of the notions of explanation and understanding. Second, they show that the increased complexity of systems affects their undersandability rather than their explainability.[2] And third, they offer a typology of possible explanatory methods that could also increase the intelligibility of systems. Here, I will be interested mainly in the first and the second step. Therefore, in the remainder of this section I will first present (a) their definition of explanation, (b) their arguments that the possibility of explanation is independent of the complexity of the phenomenon itself, and (c) the argument that ANNs can be explained. Then I will present (d) their definition of understanding and (e) their argument that complexity affects the ability to understand.

Let us start with (a). In defining the notion of explanation, Erasmus et al. [6] draw on a longer tradition in philosophy of science which holds that explanation consists of three elements: (1) the *explanandum*, i.e., what we want to explain, (2) the *explanans*, i.e., with what we are explaining, and (3) *the process of explanation.* Different models of explanations differ in one or more of these elements. Four such models feature prominently in the literature. (I) Deductive Nomological model, in which the explanans includes empirical content plus a law-like preposition, and the process of explanation takes the form of deductive reasoning. (II) Inductive Statistical model, in which the explanans includes a statistical law about behavior of the variables, and the process of explanation takes the form of inductive or probabilistic reasoning. (III) Causal Mechanical model which aims to show "how the explanandum fits into the causal structure of the world", and thus involves giving information about the causal process and the causal interaction that leads to the emergence of the explanandum. (IV) New Mechanist model which takes as explanans the entities and their activities that are responsible for the emergence of the explanandum.[3]

Erasmus et al. [6] then argue (b) that the increased complexity of the phenomenon we are trying to explain (or of the concepts and data we use to explain it) does not affect our ability to offer an explanation for the phenomenon. And (c) that deep neural networks can be explained in all four of the ways described above. The argument for (b) is quite simple: Deductive Nomological explanation, for example, requires only that the explanans contains a law, and that the process of explanation takes the form of deductive reasoning. It does not matter how complex the two elements are. Thus, an explanation that contains a more complex explanans and requires more complex reasoning may be less desirable, but it is no less an explanation.

The argument for (c) is a bit more technical. To demonstrate this point, the authors provide an example of an explanation of how an ANN, trained to identify dense breast tissue on X-ray images, classify these images [6]. Let us see how a Deductive Nomological explanations of such ANN could work. As the empirical content of the explanans, we could use all the information about the activation values of the individual units in the network and about the weights between them, as well as the numerical values of the input data. We could also form a law-like proposition of the form "outputs with such and such numerical value are classified as such and such." In this way, the explanandum, i.e., the classification of the photograph F into the class r, would be explained using an explanans consisting of a law-like preposition and empirical content. In other words, we would have a Deductive Nomological explanation. Although the arguments for (b) and (c) were presented only for the case of Deductive Nomological explanation, authors argue they apply *mutatis mutandis* to other models of explanation as well.

Let us now turn to (d), the definition of understanding. As Erasmus et al. [6] point out, authors who study understanding do not, of course, entirely agree on its exact definition, but they commonly observe that, while explanation is necessary for understanding, it is not sufficient for it. So to gain understanding of a phenomenon, some other conditions besides having an explanation must be met. There are several candidates for these additional conditions in the literature, but, as Erasmus et al. argue, they all have in common that they are "psychological traits of the user of the explanation." One such condition is the criterion of intelligibility. It states that a theory T is intelligible to a scientist in a context C if the scientist is able to recognize the qualitatively distinct consequences of T without doing the exact calculations [5, 6].[4] Given this, it is obvious that increased complexity of an explanation or a phenomenon makes it less intelligible and thus less understandable. Thus, it can be concluded that (e) complexity affects the ability to understand.

4 TWO DIMENSIONS OF OPACITY

Erasmus et al. [6] argue that while the workings of deep neural networks are explainable, they are often not understandable for

[2] See Beisbart and Räz [2] for a critique of this point. They say that "the distinction that Erasmus et al. draw between interpretability and explainability in this way seems rather stipulative." In contrast, they argue that we should use these terms as synonyms. Nevertheless, I think that Erasmus et al. [6] point to an important and well established concetpual distinction between these two terms which should not be so easily dismissed.

[3] Woodword and Ross [17] present a slightly different typology. In particular, they add Salmon's statistical relevance model and pragmatic models of explanation.

[4] Chirimuuta [5] also lists four properties of a theory (or an explanation) that affect its intelligibility. Those are: (1) the possibility of visualization, (2) the simplicity of included theoretical assumptions, (3) the linearity of mathematical operations, and (4) functional transparency.

human users. In other words, they conclude that we should talk about a trade-off between the performance of AI systems and their understandability or intelligibility, not their explainability. Nevertheless, they seem to overlook another important aspect of the trade-off. As it is apparent from the definitions of explainability and understandability in Gilpin et al. [9] and Linardatos et al. [10], there seem to be different ways in which ANNs can be opaque to humans.

This point is explicated and extended upon by Boge [3]. In his paper, he presents the following three theses: (1) deep neural networks are instrumental, and their instrumentality is distinct from that of other mathematical models; (2) deep neural networks are opaque in two different ways; and (3) the combination of (1) and (2) means that in the future, we may not be able to understand potential new discoveries made by deep neural networks. In the rest of this section, I will be primarily interested in (2).

Boge [3] begins his exposition of the two aspects of opacity by defining opacity. He defines it as follows: "a process P is epistemologically opaque to a subject X at time t if and only if X does not know all the epistemically relevant elements of the process P at time t." He then distinguishes between two aspects of the opacity of deep neural networks. First, he describes h-opacity. It concerns the operation of a system: a system is h-opaque if it is the process of its operation that is not not intelligible to its human users. This is the opacity that results from the complexity of deep neural networks and hiders the understanding of the connection between input and output data. But as Boge notes, this type of opacity is not qualitatively different from, say, the opacity of other complex computational simulations, e.g., climate simulations. He therefore identifies another aspect of opacity that is specific to deep neural networks. This is w-opacity, which concerns the representational content of the system (what was learned). According to Boge, in deep neural networks, not just the process that takes a neural network from an input to an output, but also the properties of the input data that guide this process are opaque.

This difference is important as it points to a specific problem that the use of deep neural networks introduces to scientific research. H-opacity only hinders the understanding of the computational model itself, as it prevents researchers from seeing how it gets from input to output data. Such opacity can thus be problematic form an ethical point of view, as it makes it harder to justify the decisions made on the basis of a recommendation by an AI system. In contrast to this, w-opacity reduces the potential of deep neural networks to bring new understanding to the processes studied by the scientists. Even in the case where promising results would suggest that an ANN represents a given problem space in a better way than existing theories, w-opacity would leave this representation incomprehensible to scientists. Thus, w-opacity has important implications for the use of neural networks in scientific research.

5 PREDICTION VERSUS UNDERSTANDING

The implications of w-opacity for research in computational neuroscience are convincingly presented by Chirimuuta [5]. In this section, I will summarize her findings. I will do this in the following steps: (a) first, I will briefly outline the research program of computational neuroscience; (b) then, I will present examples of two studies from the field, one in which scientists approached their problem using a transparent mathematical model, and another in which they approached a very similar problem using a w-opaque deep neural network; (c) finally, I will present Chirimuuta's version of the trade-off between performance and understanding that arises when using ANNs in science.

Let us start with (a). Chirimuuta [5] defines computational neuroscience as "a tradition of research that builds mathematical models of neurons' response profiles, aiming both at predictive accuracy and at theoretical understanding of the computations performed by classes of neurons." It is based on the assumption that information about the external world is 'encoded' in the electrical and chemical signals of the neurons. It attempts to solve the so-called 'decoding problem', i.e., it tries to find a mathematical function that could successfully link neuron spikes to outside information. Specifically, according to Chirimuuta, scientists try to devise a theory of how neurons encode information about the outside world and then write a program, called an encoder, that performs the translation operation between the stimuli and the neural activity.

Thus, as Chirimuuta [5] points out, computational neuroscience pursues two separate epistemic goals. On the one hand, it aims at accurately predicting the relations between neural activity and external stimuli (e.g., to predict how neurons will fire if we show a picture of a square to a primate). On the other hand, it tries to understand how this translation takes place. Chirimuuta thus argues that in the past, when even very simple linear models have proved surprisingly accurate in certain contexts, there has been a convergence between these two goals. However, with the development of deep neural networks, which are much more accurate but w-opaque, these two goals started to diverge.

Chirimuuta [5] presents two examples of such divergence, one from modeling the functioning of the motor cortex and another from modeling the visual perception system. I will limit my presentation to the former, i.e., to her comparison between two studies that tried to model motor cortex activity, Georgopoulos et al. [8] and Sussillo et al. [15]. In both of these two experiments, researchers measured the activity of individual neurons in non-human primates while the primates were performing given tasks. Georgopoulos et al. [8] present an experiment in which a monkey was surrounded by eight buttons, with another button straight ahead. In the experiment, first the button in front of the monkey lit up. After the monkey held it for one second, one of the other eight buttons lit up, and the monkey had to press it with the same hand. Meanwhile, the scientists measured the activity of a population of neurons in her motor cortex, and tried to establish a correlation between this activity and the direction of her arm movement. They did this by simply converting the activity of a neuron into a vector in three-dimensional space according to a formula they devised, and then summing the vectors of the individual neuronal cells to obtain one vector that represented the whole neuron population. They found out that the direction of this vector quite closely matched the direction of arm movement. Because of the fairly simple math they used, their model was completely transparent. In addition, the researchers themselves determined which information about the neural activity is important and should be used to calculate the movement vector. The accuracy achieved by the model can thus be seen as a partial confirmation that these features of neural activity are indeed important for directing arm movement.

The experiment reported by Sussillo et al. [15] is a bit different. They also had non-human primates, this time two, implanted with electrodes that measured the activity of individual neurons in their motor cortex. But the monkeys did not press buttons; rather, they had to move a cursor on a screen from a central

position to a marked position in one of the corners of the screen. Each monkey performed three series of experiments. First, they moved the cursor by moving their hand. Then, they moved the cursor using a brain-machine interface (BMI) that used a encoder, based on a mathematical model, similar to the one described in the previous example. In the last series, they used a BMI that encoded information using a trained neural network. Each monkey performed each of the three experiments hundreds of times. The researchers found that using this ANN based encoder significanty improved monkey's performance *vis-à-vis* the older model. This suggests that the BMI with an ANN was more successful in translating between neuronal activation and information about the outside world. We can thus assume that the ANN either approximated the mathematical function linking neuronal activation and external stimuli more accurately or it 'discovered' new properties of the input data that play an important role in the translation. But the ANN used was both h-opaque and w-opaque so despite its improved performance, it did not provide scientists with a better understanding of how the motor cortex works.

Turning to point (c), it should now be clear what Chirimuuta [5] is getting at when she says that the use of ANNs creates a divergence between the goals of predictive accuracy and understanding of neurological processes. Chirimuuta calls this divergence a trade-off between understanding and accuracy. The trade-off arises because a problem can either be tackled with models that are not the most accurate, but can be interpreted and can thus provide us with new understanding of the problem. Or it can be tackled with ANNs, which, although they achieve greater accuracy, are opaque and therefore do not bring new understanding to scientists.

In addition to presenting a dilemma from the point of view of epistemic goals of science, the trade-off also has some practical implications. For example, increasing reliance on ANNs to analyze data may be linked to issues related to trust in scientific findings. In his influential analysis of epistemic trust, T. Wilholt [16] argued that the reliance between the members of a scientific community is based on the "assumption that the results [the scientists are] relying upon were arrived at by means of professional methods suitably employed". Given the opacity of ANNs using deep learning, this assumption might be difficult to test. Furthermore, some researchers speculated that "hyping" scientific results (especially in the more directly applicative fields, such as biotechnology) can ultimately result in a loss of public trust in science. Although this connection between hype and public trust have not yet been empirically established [12], it is not hard to see how focusing on predictive accuracy, rather than understanding, could further increase the unwanted hype surrounding scientific research.

6 CONCLUSION

In this paper, I reviewed some of the emerging literature on the epistemological aspects of the problem of opaqueness in deep neural networks. First, I used Erasmus et al. [6] to point out that we need to distinguish between explainability and understandability of AI systems. I also presented their argument that the increasing complexity of these systems has a particular impact on our ability to understand them, not on their inherent explanaibility. Then, with the help of Boge [3], I distinguished between two dimensions of opacity of these systems. Finally, following Chirimuuta [5], I presented this problem using a concrete example of two studies in computational neuroscience. In this way, I have shown in more detail what philosophers mean when they talk about the trade-off between performance and intelligibility (or understandability) of AI systems in science.

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REFERENCES

[1] Amina Adadi and Mohammed Berrada. 2018. Peeking Inside the Black-Box: A Survey on Explainable Artificial Intelligence (XAI). *IEEE Access*, 6, 52138–52160. DOI: 10.1109/ACCESS.2018.2870052.

[2] Claus Beisbart and Tim Räz. 2022. Philosophy of science at sea: Clarifying the interpretability of machine learning. *Philosophy Compass*, 17, 6, (June 2022). DOI: 10.1111/phc3.12830.

[3] Florian J. Boge. 2021. Two Dimensions of Opacity and the Deep Learning Predicament. *Minds and Machines*, (Sept. 2021). DOI: 10.1007/s11023-021-09569-4.

[4] Cameron Buckner. 2019. Deep learning: A philosophical introduction. *Philosophy Compass*, 14, 10, (Oct. 2019). DOI: 10.1111/phc3.12625.

[5] M. Chirimuuta. 2021. Prediction versus understanding in computationally enhanced neuroscience. *Synthese*, 199, 1-2, (Dec. 2021), 767–790. DOI: 10.1007/s11229-020-02713-0.

[6] Adrian Erasmus, Tyler D. P. Brunet, and Eyal Fisher. 2021. What is Interpretability? *Philosophy & Technology*, 34, 4, (Dec. 2021), 833–862. DOI: 10.1007/s13347-020-00435-2.

[7] Jerry A. Fodor and Zenon W. Pylyshyn. 1988. Connectionism and cognitive architecture: A critical analysis. *Cognition*, 28, 1-2, (Mar. 1988), 3–71. DOI: 10.1016/0010-0277(88)90031-5.

[8] Apostolos P. Georgopoulos, Andrew B. Schwartz, and Ronald E. Kettner. 1986. Neuronal Population Coding of Movement Direction. *Science*, 233, 4771, 1416–1419.

[9] Leilani H. Gilpin, David Bau, Ben Z. Yuan, Ayesha Bajwa, Michael Specter, and Lalana Kagal. 2018. Explaining Explanations: An Overview of Interpretability of Machine Learning. In *2018 IEEE 5th International Conference on Data Science and Advanced Analytics (DSAA)*. IEEE, (Oct. 2018), 80–89. ISBN: 978-1-5386-5090-5. DOI: 10.1109/DSAA.2018.00018.

[10] Pantelis Linardatos, Vasilis Papastefanopoulos, and Sotiris Kotsiantis. 2020. Explainable AI: A Review of Machine Learning Interpretability Methods. *Entropy*, 23, 1, (Dec. 2020), 18. DOI: 10.3390/e23010018.

[11] Olga Markič. 2011. *Kognitivna znanost: filozofska vprašanja*. Aristej, Maribor.

[12] Zubin Master and David B. Resnik. 2013. Hype and Public Trust in Science. *Science and Engineering Ethics*, 19, 2, (June 2013), 321–335. DOI: 10.1007/s11948-011-9327-6.

[13] Tim Räz and Claus Beisbart. 2022. The Importance of Understanding Deep Learning. *Erkenntnis*, (Aug. 2022). DOI: 10.1007/s10670-022-00605-y.

[14] Emily Sullivan. 2022. Understanding from Machine Learning Models. *The British Journal for the Philosophy of Science*, 73, 1, (Mar. 2022), 109–133. DOI: 10.1093/bjps/axz035.

[15] David Sussillo, Paul Nuyujukian, Joline M Fan, Jonathan C Kao, Sergey D Stavisky, Stephen Ryu, and Krishna Shenoy. 2012. A recurrent neural network for closed-loop intracortical brain–machine interface decoders. *Journal of Neural Engineering*, 9, 2, (Apr. 2012), 026027. DOI: 10.1088/1741-2560/9/2/026027.

[16] Torsten Wilholt. 2013. Epistemic Trust in Science. *The British Journal for the Philosophy of Science*, 64, 2, (June 2013), 233–253. DOI: 10.1093/bjps/axs007.

[17] James Woodward and Lauren Ross. 2021. Scientific Explanation. (2021). Retrieved Jan. 29, 2022 from https://plato.stanford.edu/entries/scientific-explanation/.

Politizirana znanost in zaupanje v znanost kot politična uniforma

Politicized science and trust in science as a political uniform

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POVZETEK

Zaupanje v znanost je dandanes, sploh po dveh letih pandemije Covida-19, posebej družbeno relevanten problem. Izraz pa je nekoliko dvoumen, saj lahko znanost razumemo na več načinov, med drugim kot raziskovalni proces in kot institucije, na katerih se ta proces odvija. Zato je izraz zaupanje v znanost lebdeči označevalec, oznaka brez jasnega referentnega objekta.. Težava lebdečih označevalcev se pokaže, ko postanejo tarča politizacije. V tem primeru zaradi nejasnosti semantičnega pomena sociopolitične konotacije izraza postanejo njegov primarni pomen. V politizirani znanosti bi zato "zaupati v znanost" v resnici pomenilo podpirati obstoječi politični režim, izražanje tega zaupanja (ali njegovega pomanjkanja) pa bi služilo kot politična uniforma, ki izraža pripadnost enemu ali drugemu političnemu polu. V prispevku analiziram znanstveni diskurz zadnjih dveh let z namenom ugotavljanja, kaj je bil v tem obdobju družbeni pomen zaupanja v znanost – podpora procesa znanstvenega raziskovanja ali izraz politične konformnosti?

KLJUČNE BESEDE

Politizacija znanosti, Covid-19, zaupanje v znanost, socialno presojanje, psihološka inokulacija

ABSTRACT

Trust in science is especially relevant in today's society, given that we are living in the wake of the 2-year Covid-19 pandemic. The term itself is somewhat vague, as science has multiple definitions, mainly the process of scientific research as well as the institutions that engage in said process. Thus, trust in science is a floating signifier, a label without a clear referent. Such labels can be problematic if targeted by politicization. The vagueness of the floating signifier's semantic meaning allows the socio-political connotations to acquire primacy. In times of politicized science, "trusting in science" would then actually mean to endorse the established political regime. As for actions that signal this trust (or lack thereof), they would act as a political uniform – an expression of political allegiance to one's chosen side. This article analyses the state of scientific discourse during the pandemic, with the goal of establishing the precise meaning of trust in science in practice – endorsement of the process of scientific research, or an expression of political conformity?

KEYWORDS

Politicization of science, Covid-19, trust in science, social reasoning, psychological inoculation

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1 Kaj pomeni zaupati v znanost?

Vse večjo relevantnost pojma "zaupanja v znanost" v sodobni družbi lahko jemljemo kot posledico *poznanstvenjenja družbe in družbenih praks* – vse večjega soodvisnost znanstveno-tehnološkega razvoja in vodenja sodobnih družbenh praks [22]. Še posebej pomemben pa je postal v zadnjih dveh letih, odkar se je svet soočil s pandemijo Covida-19. Narodne, mednarodne ali celo globalne zdravstvene krize, kamor spadajo tudi pandemije, so pogosto zaznamovane z določeno mero vključevanja medicinske znanosti v vodenje družbe in usmerjanje družabnega življenja in Covid kriza je bila še posebej izrazit primer tega. Tako smo bili priča vsesplošni uporabi slogana "zaupajmo v znanost" (včasih "zaupajmo znanosti"), v angleščini "trust the science" z namenom upravičevanja in izpostavljanja znanstveno podprtega značaja uradno sprejetih ukrepov za spopadanje s Covid epidemijo.

Kaj natanko pomeni zaupati v znanost? Drugače povedano, *kateri* znanosti naj bi se zaupalo? Znanost lahko razumemo kot metodo (znanstvena metoda), proces (znanstveno-raziskovalni proces), socialni sistem (skupnost znanstvenikov) ali institucijo (skupek akademskih institucij, kjer se izvaja znanstveno raziskovanje). Vidimo torej, da pojem zaupanja v znanost nima enoznačnega pomena – lahko pomeni zaupati kateri koli kombinaciji zgoraj naštetih vidikov znanosti – zato ga je tudi težko enoznačno vrednotiti in proučevati. Zaupanje v znanost je Hackingova *človeška vrsta*, je posplošitev oziroma klasifikacija neke človeške lastnosti oziroma vedenjske tendence, ki v svoji prisotnosti ali odsotnosti definira posebno kategorijo človeka [10]. Človeške vrste so podvržene učinku zanke, zaradi refleksije in samo-refleksije identifikacija neke socialne entitete z določeno človeško vrsto vpliva na lastnosti te socialne entitete, kar posledično vpliva tudi na pomen človeške vrste – oznake, s katero jo poimenujemo. Pomen besede "znanost" je relativen in dinamičen tudi v odsotnosti zankanja, zato to velja tudi za "zaupanje v znanost" – ko se spreminja pomen znanosti, se spreminja tudi pojem »zaupanje v znanost«.

Zato lahko trdimo, da je zaupanje v znanost *lebdeči označevalec* (ang. *floating signifier*), oznaka brez točnega ali splošno-sprejetega pomena, torej brez točnega referentnega

objekta [13]. Ravno v tej značilnosti se skriva moč lebdečih označevalcev – nejasnost njegovega pomena dopušča individualno konstrukcijo pomena. Tako je točen pomen lebdečega označevalca relativen – za eno osebo ali skupino ljudi pomeni nekaj, za drugo nekaj drugega.

Zaupanje v znanost torej nima enoznačnega pomena, kljub temu pa lahko to idejo ovrednotimo na podlagi različnih možnih definicij. Najprej si zamislimo dva ekstrema, znanstveni dogmatizem in radikalni skepticizem do znanosti. Dogmatik bo najverjetneje trdil, da *smo dolžni* zaupati vsem aspektom znanosti – v uporabnost znanstvene metode, zanesljivost znanstveno-raziskovalnega procesa pri odgovarjanju na raziskovalna vprašanja, verodostojnost znanstvenikov in nevtralnost oziroma apolitičnost znanstvenih institucij. Radikalni skeptik, v kolikor njegova pozicija ne temelji na a-priornem zavračanju, pa se bo najbrž skliceval na uvide Foucaulta [8] in Lyotarda [14], ki sta izpostavljala neko mero relativnosti znanstvenega spoznanja. Posledično bo trdil, da znanstvene institucije niso apolitične, znanstveniki niso racionalni in zato niti verodostojni, znanstveno-raziskovalni proces in znanstvena metoda pa nista univerzalno orodje za dostopanje do resnice, temveč orodje za perpetuacijo specifične jezikovne igre.

Na srečo lahko uberemo vmesno pot, ki ustreza klasični koncepciji razsvetljenske znanosti in temelji na egalitarnem odnosu do znanja in zavračanju dolžnosti laika, da zaupa intelektualni avtoriteti. To stališče dobro povzame izjava Richarda Feynmana, da je znanost *verjetje v nevednost strokovnjakov* [7]. Potemtakem "zaupanje v znanost" pomeni priznavanje uporabnosti znanstvene metode in zanesljivosti raziskovalnega procesa, hkrati pa ohranitev zdravega dvoma v verodostojnost znanstvenikov in institucij. Če strokovnjak ali institucija trdi da *p*, ni potrebno da temu slepo verjamemo, temveč lahko zahtevamo argumentacijo in vpogled v raziskovalni proces.

2 Politična znanost

Zagovarjam stališče, da bi "zaupanje v znanost" moralo pomeniti zaupanje v znanost kot proces in metodo, ne pa v njen človeški element (znanstveniki in institucije), ki je dovzeten za razne pristranosti in konflikte interesa, zaradi katerih trpi verodostojnost znanstvenih zaključkov. Znanstvenega procesa v praksi seveda ni brez človeškega elementa, ki ta proces izvaja, vendar človeški element v tej izvedbi tudi ni nezmotljiv. Zato velja zaupati v process, v človeški element pa ne povsem. Posledično moramo ugotoviti, ali se uporaba tega slogana v zahodni družbi sklada s tovrstnim razumevanjem ali ne. V kolikor se ne, in za tem stoji pričakovanje slepega zaupanja znanstvenikom in institucijam, je to znak dogmatizma in institucionalizacje znanosti, ki sta močno povezani s politizacijo.

Carl Schmit je znan po svoji definiciji politike kot presojanju na podlagi dihotomije prijatelj/sovražnik, pri čemer je prijatelj nekdo s komer si delim interese, sovražnikovim interesom pa nasprotujem [18]. Politično vrednotenje dogajanj in dejanj torej ne temelji na splošnih načelih, temveč poteka na podlagi identitete udeleženih subjektov in uporabnosti njegovih posledic za osebo, ki presoja. Če je politika razločevanje med prijatelji in sovražniki, potem je znanost politična kadarkoli primarni kriterij za razločanje med znanstveno in neznanstveno trditvijo ni kvaliteta argumentacije in podprtost z dokazi, temveč status njenega sporočevalca. Z drugimi besedami, dihotomija prijatelj/sovražnik se v znanosti odraža, ko je "kdo je to rekel?" pomembnejše vprašanje od "kako je bila izjava argumentirana?". V podrobnosti argumentacije se morda ne moremo popolnoma spustiti, lahko pa vsaj presodimo ali je argumentacija formalno-logično ustrezna.

Lebdeči označevalci so zaradi svoje nejasnosti in dvoumnosti idealna tarča za politizacijo. Politizirana oznaka poleg svojega semantičnega pomena dobi še sociopolitični pomen – prisotnost referentnega objekta označuje prijatelja ali sovražnika (režima) oziroma pripadnika ingrupe ali outgrupe. Ravno zaradi nejasnosti semantičnega pomena (oznaka pomeni različne stvari različnim skupinam) sociopolitični pomen nadvlada semantičnega in postane primarni. Tako potem lebdeči označevalec postane univerzalna oznaka za sovražnika režima – točen semantični pomen besede sicer vsak razume po svoje, njena čustvena in moralna valenca pa sta enoznačni. Znanost je v naši družbi pozitivna, torej bi primeru politizacije "zaupanje v znanost" v svoji lebdeči obliki označevalo pripadnike ingrupe oziroma prijatelje režima, njegova odsotnost pa njegove sovražnike oziroma pripadnike outgrupe.

S tega vidika je bila Covid kriza zelo zanimiva. Moja analiza se bo sicer osredotočala predvsem na dogajanje v mednarodni in ameriški znanosti, vendar so bili enaki ali podobni vzorci prisotni tudi v Sloveniji. Ekipa znanstvenikov iz MIT-ja je leta 2021 objavila pre-print študije *Viral Visualizations: How Coronavirus Skeptics Use Orthodox Data Practices to Promote Unorthodox Science Online*, ki je poročala o navadah, značilnostih, stališčih in vrednotah spletnih skupnosti *Covid-skeptikov* oziroma *anti-maskerjev*, ljudi, ki so tako ali drugače nasprotovali uradnim Covid ukrepom [12]. Intuitivno bi se nam zdelo, da so to skupine, ki ne "zaupajo znanosti", avtorji uporabijo termin "anti-znanost" (anti-science), obstaja tudi variacija "zanikalec znanosti" (science-denier). Vendar se je izkazalo, da ti ljudje niso klasični oziroma stereotipni zanikalci znanosti, v resnici sploh ne nasprotujejo znanosti kot taki in da so nadpovprečno znanstveno pismeni. Nasprotovali so *uradni* (politično podprti) znanosti, razlikovanju med uradno in neuradno znanostjo ter avtoritarnemu odnosu stroke do laikov. Zagovarjali so torej egalitarno znanost, kjer ima vsakdo dostop do podatkov in možnost oblikovanja svojih zaključkov [12].

Avtorji študije se s tem niso strinjali in so trdili, da Covid-skeptiki "spodkopavajo uradne znanosti s spretno manipulacijo podatkov". Ta trditev se mi zdi bizarna – kako lahko želja po intersubjektivnem preverjanju s strani visoko znanstveno pismenih posameznikov, ki želijo nepristransko ovrednotiti podatke [1] "spodkopava uradno znanost"? Ni to kvečjemu koristno, saj je po Popperju [2] ravno falsifikacija gonilo znanstvenega napredka, ki je v času pandemije še toliko bolj ključen? Rekel bi, da načeloma je, vendar ne v institucionalizirani znanosti, kjer akademske institucije želijo obdržati monopol nad produkcijo znanja. Institucionalizacijo

[1] Lee et al (2021): "These users want to understand and analyze the information for themselves, free from biased, external intervention.", str. 12

[2] Popperjev model falsifikacije ima sicer svoje težave, vsekakor pa gonilo znanstvenega napredka ni izogibanje možnostim falsifikacije.

sicer lahko razumemo kot mehko obliko politizacije, vendar to še ni indikator politizacije v pravem pomenu besede.

Žal pa je med Covid krizo prišlo tudi do slednje. V institucionalizirani znanosti vlada kredencializem – merilo ideje je znanstveni in akademski prestiž znanstvenika, ki jo predlaga. Vendar med Covid krizo niti znanstveni prestiž avtorja ni bil zadosten pogoj za sprejemanje neke ideje. Tako se je npr. dr. Robert Malone moral soočiti z deplatformiranjem zaradi "širjenja dezinformacij" – Twitter mu je deaktiviral račun [15] po nastopu na Roganovem podcastu, kjer je izrazil nestrinjanje z uradnim konsenzom glede Covida in zajezitvenih ukrepov, ter svoje stališče znanstveno argumentiral [3]. Malone je sicer znanstvenik – mednarodnega renomeja [4] – vendar očitno ni izpolnjeval kriterijev za "zaupanje znanosti". Kaj je torej znanost, na katero se je med Covid krizo nanašal slogan "zaupajmo znanosti"? Ugotovili smo, da se ne nanaša na proces znanstvenega raziskovanja in niti na individualne znanstvenike z dovoljšno mero prestiža. Moja teza je torej, da se je beseda "znanost" nanašala na uradno, torej politično-podprto znanost oziroma *znanost režima*. Tukaj se lahko navežem na Foucaltov režim resnice, kjer je ideja resnice politično in ideološko umeščena – diskurz in metode produkcije resnice so omejeni, hkrati obstaja skupina ljudi, ki ima monopol nad razglašanjem družbene resnice [8].

Med Covid krizo so vlogo razsodnika resnice prevzeli *znanstveniki režima* – uradni Covid komentatorji (kot npr. dr. Fauci v Ameriki, dr. Krek in dr. Beović v Sloveniji), vlogo "čuvaja" resnice pa mediji in socialni mediji, ki so tako ali drugače utišali znanstvenike, ki so želeli izraziti kakršno koli nestrinjanje z uradnim konsenzom. Covid krizo je torej zaznamovala močna politizacija znanosti, saj je pravico do širjenja (znanstvenih) resnic nudila predvsem podpora (prijateljstvo) režima, ki se je odražala v podpori uradnega konsenza glede spopadanja s pandemijo. Posledično trdim, da slogan "zaupajmo znanosti" ni predstavljal klica k epistemski racionalnosti in sistematičnemu presojanju znanstvenih izjav, temveč ravno nasprotno – emocionalno in politično prežet sklic na avtoriteto. Cilj je bil sprejemanje stališč intelektualnih avtoritet režima, ne pa samostojni razmislek.

3 Socialno presojanje

Tematika letošnje konference je "kognitivni vidiki zaupanja v znanost". Moj cilj je pokazati, da je zaradi politizacije znanosti in zaupanja v znanost večina teh kognitivnih vidikov pod vplivom socialnih pritiskov.

V socialni psihologiji obstaja veliko raziskav in teorij na temo oblikovanja in spremembe stališč ter presojanja novih informacij. Giner-Sorolila in Chaiken sta poimenovala koncept motiviranega sklepanja, kjer sistematično sklepamo z namenom potrditi točno določeno stališče [9]. Caccioppo in Petty sta postavila dvoprocesni model spremembe stališč, kjer centralno procesiranje upošteva predvsem vsebino sporočila, periferno pa lastnosti sporočevalca in socialni kontekst [2]. Festinger pa je postavil teorijo kognitivne disonance – ljudje se držimo očitno neresničnih stališč, ker težimo k ujemanju stališč, vedenja in samopodobe [6]. Za naštete fenomene predlagam nadpomenko *socialnega presojanja in sklepanja*[5] – presojanja in sklepanja v skladu s svojo skupinsko identiteto, konsenzom ingrupe ali stališčem ingrupne intelektualne avtoritete, kar pogosto vodi do fenomena, ki ga Perkins (po navedbi Barona) poimenuje *myside bias* [1]. Socialnega presojanja se po mojem mnenju poslužujemo na vseh družbeno-relevantnih področjih, kjer nimamo motivacije, sposobnosti ali predznanja za sistematično oblikovanje lastnega stališča.

V to kategorijo zaradi svoje kompleksnosti spada večina znanstvenih tem, še posebej tistih, ki so družbeno oziroma politično relevantne, vključno s pandemijo Covida-19 in z njo povezanimi ukrepi. Pinker govori o fokusnih točkah, javno vidnih in relevantnih dogodkih in dogajanjih, ki jih vidi posameznik in se hkrati zaveda, da so vidni tudi drugim prebivalcem družbe [17]. Fokusne točke, oziroma spektakli, pogosto postanejo politizirane – to so močno družbeno relevantna dogajanja, do katerih se je potrebno opredeliti. Že sama potreba po opredelitvi je političnega značaja, ker ne dopušča nevtralnosti, zgolj izbiro enega izmed dveh polov. Ko je prisotna binarna polarizacija, pa je prisotna tudi dihotomija prijatelja (podpornika uradnih ukrepov) in sovražnika (nasprotnika uradnih ukrepov). Fokusne točke torej aktivirajo in okrepijo vrojeno tendenco človeka po socialnem presojanju, v tem primeru o vsebini same fokusne točke. Ko je zaupanje znanosti postalo fokusna točka, kar se je zgodilo med Covid krizo (če ne še prej), se je torej navzelo političnih konotacij in postalo označevalec za prijatelje in sovražnike režima – definirane kot zaupnike in zanikalce znanosti (včasih teoretike zarote). Zaupanje v znanost je torej družbenopolitični problem. Stran, na kateri se nekdo nahaja, je prej merilo politične opredeljenosti kot samega zaupanja v znanost v klasičnem pomenu izraza, ali odraz globljih filozofskih načel. Drugače povedano, izražanje (ne)zaupanja v znanost v kakršnem koli socialnem kontekstu je *politična uniforma,* zato je to prej signal privrženosti ustaljeni politiki kot pokazatelj odnosa do raziskovalne dejavnosti, ki ji pravimo znanost.

4 Politični in spoznavni razhod

V obdobju politične polarizacije zaradi socialnega presojanja in politizacije znanosti pogosto pride do spoznavnega razhoda – na eni strani imamo množico ljudi, ki takorekoč zaupa znanosti oziroma uradnim virom in zgodbam, na drugi pa množico ljudi, ki "zanika znanost" – torej zavrača uradne vire in zgodbe, ter oblikuje svoja stališča s pomočjo alternativnih virov.

Pojavita se vsaj dve različni "socialni resničnosti", dve različni interpretaciji vsebine fokusne točke. Imamo torej ljudi, ki v grobem sprejemajo uradno zgodbo in ljudi, ki jo v grobem zavračajo (seveda pa sta to sprejemanje in zavračanje kontinuum), v primeru Covida se to nanaša na stališča do mask, cepljenja in drugih uradnih ukrepov. To je v veliki meri posledica

[3] https://open.spotify.com/episode/3SCsueX2bZdbEzRtKOCEyT

[4] Malone na https://www.rwmalonemd.com: "I am an internationally recognized scientist/physician and the original inventor of mRNA vaccination as a technology- I have approximately 100 scientific publications with over 12,000 citations of my work (per Google Scholar with an "outstanding" impact factor rating committees)."

[5] Ta koncept sem podrobneje razdelal v članku *Social Reasoning and the Politicization of Science During the Covid Pandemic*, ki bo objavljen Decembra v reviji Mankind Quarterly [16].

razlik v zaznavanju zaupanja vrednih oziroma verodostojnih virov v obeh (ali vseh) skupinah ljudi. Vir, ki je verodostojen za eno skupino nikakor ni verodostojen za drugo, to presojanje o verodostojnosti pa je politične narave. Torej, spoznavni razhod je posledica političnega razhoda, ne obratno. Oziroma, kot bi rekel Foucault, znanje izvira iz moči. In šele nato spoznavni razhod perpetuira političnega – sprejemanje ene ali druge interpretacije (označeno kot zaupanje znanosti ali teoriziranje zarote) je politična uniforma, ki signalizira pripadnost enemu od političnih polov.

Kljub temu pa pomanjkljivo znanje, do katerega pride v primeru cenzure nasprotujočih stališč, nosi svoje posledice – pogosto negativne. V zadnjih mesecih prihaja vedno več raziskav in medijskih objav, ki izpostavljajo destruktivne posledice določenih Covid ukrepov – ekonomska škoda, ki so jo povzročili lockdowni [20], zaviranje razvoja otrok zaradi obveznega nošenja mask [23] in njihova splošna neučinkovitost [19], neučinkovitost cepiv pri zaščiti pred okužbo s Covidom [5] in možnost nevarnih stranskih učinkov pri določenih demografskih skupinah, npr. nosečnicah [4]. Ameriški CDC je sicer pred kratkim spremenil svoje smernice za spopadnje s Covidom – zdaj so enake za cepljene in necepljene posameznike, kar implicira enako stopnjo tveganosti obeh skupin [3]. Vendar se moramo vprašati, zakaj šele zdaj? Različni ljudje in institucije po svetu so tako ali drugače opozarjali na morebitne negativne posledice uradnih Covid ukrepov, vendar so bili tako ali drugače utišani. Tukaj torej vidimo, da imata politizacija znanosti in dogmatični odnos do tako-imenovanega "strokovnega konsenza" v naši poznanstvenjeni družbi obsežne negativne posledice.

V svetu, kjer se zdi, da lahko motiviran laik z dovoljšno mero znanstvene pismenosti v enem tednu iskanja člankov na Google Scholar doseže osnovno razumevanje (ali vsaj aproksimacijo le-tega) nekega znanstvenega področja, uradne znanstvene institucije niso več edini možni vir znanja. In v skladu s tem se moramo tudi ravnati in priznavati veljavnost izvenkonsenzualnih stališč, v kolikor so podprta z argumenti in dokazi.

Na žalost pa Googlov think tank Jigsaw in Svet za družboslovno raziskovanje (Social Science Research Council, SSRC), tako kot Lee in kolegi povlečeta ravno obraten zaključek. Laikom ne želita prepustiti, da si sami ustvarijo stališče in sami presojajo med informacijami in dezinformacijami, oziroma med znanjem in lažnimi novicami. Nasprotno, Jigsaw predstavlja koncept "pre-bunkinga" oziroma *psihološke inokulacije*, vnaprejšnjega zavračanja možnih heterodoksnih stališč v obliki kratkih sporočil, ki predstavijo protiargumente in poslušalcu olajšajo zavračanje tega stališča v prihodnosti [11]. SSRC pa skuša ugotoviti kako maksimizirati povpraševanje po Covid cepivih – tako da dijake in študente nauči prepoznavati "dezinformacije o cepivih". sporočevalce opremi z ustreznimi "sporazumevalnimi strategijami" in na družbenih omrežjih oblikuje "(demografsko in geografsko) prilagojena sporočila" [21].

Spet se moramo vprašati, kdo razlikuje med informacijo in dezinformacijo, med ortodoksnimi in heterodoksnimi stališči. Je to znanost, politika ali politizirana znanost? In nadalje, ne bi to morala biti pravica in dolžnost vsakega odraslega državljana v demokratični in egalitarni državi? Če si posameznik ne more, oziroma *ne sme* sam ustvariti mnenja, čemu potem služi demokracija?

Odgovor je, seveda, režim in "znanost" režima. Vidimo torej, da je spoznavni razhod med podporniki uradne narative in kontranarative posledica aktivno ustvarjenega političnega razhoda s strani režima in njegovih ideoloških aparatov, ki v interakciji z javnostjo ustvarjajo koncept zaupanja znanosti, zanikanja znanosti in teorij zarote. Akademiki in drugi raziskovalci imamo edinstveno možnost izpostavljanja napak režima, ampak lahko to dosežemo zgolj, če znanost zaščitimo pred politizacijo. Prvi korak k depolitizaciji znanosti pa je po mojem mnenju prepoznavanje koncepta zaupanja v znanost kot politične uniforme in posledično zavračanje vseh dihotomij, ki jih ustvari.

LITERATURA

[1] Baron, J. (2000), Thinking and deciding (3rd ed.), New York: Cambridge University Press

[2] Cacioppo, J.T. in Petty, R.E. (1984). The Elaboration Likelihood Model of Persuasion. NA - Advances in Consumer Research, 11, 673-675.

[3] CDC (2022). CDC streamlines COVID-19 guidance to help the public better protect themselves and understand their risk. Sneto iz https://www.cdc.gov/media/releases/2022/p0811-covid-guidance.html

[4] Clark County Today (2022). FDA knew huge percentage of women in Pfizer trial suffered miscarriages. Sneto iz: https://www.clarkcountytoday.com/news/fda-knew-huge-percentage-of-women-in-pfizer-trial-suffered-miscarriages/

[5] Comber, J. in Madhava, S. (2022). After Data Show Vaccinated at Higher Risk of Dying from COVID, Canadian Province Ends Monthly Reports. Global Research. Sneto iz: https://www.globalresearch.ca/after-data-show-vaccinated-higher-risk-dying-from-covid-canadian-province-ends-monthly-reports/5790795

[6] Festinger, L. (2022). *A Theory of Cognitive Dissonance (Anniversary ed.)*. Stanford University Press.

[7] Feynman, R. (n.d.). What is Science? Sneto iz: http://www.feynman.com/science/what-is-science/

[8] Fontana A. & Pasquino, P. (n.d.) *Truth and Power (interview with Foucault)*. Sneto iz https://www2.southeastern.edu/Academics/Faculty/jbell/foucaulttruthpower.pdf

[9] Giner-Sorolila, R., & Chaiken, S. (1997). Selective Use of Heuristic and Systematic Processing Under Defense Motivation. Personality and Social Psychology Bulletin, 23(1), 84–97. doi:10.1177/0146167297231009

[10] Hacking, I. (1995). The looping effects of human kinds. In D. Sperber, D. Premack, & A. J. Premack (Eds.), *Causal cognition: A multidisciplinary debate* (pp. 351–394). Clarendon Press/Oxford University Press.

[11] Jigsaw (2021). Psychological Inoculation: New Techniques for Fighting Online Extremism. Medium. Sneto iz: https://medium.com/jigsaw/psychological-inoculation-new-techniques-for-fighting-online-extremism-b156e439af23

[12] Lee, C., Yang, T., Inchoco, G. D., Jones, G. M., & Satyanarayan, A. (2021). *Viral Visualizations: How Coronavirus Skeptics Use Orthodox Data Practices to Promote Unorthodox Science Online.* Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. *https://doi.org/10.1145/3411764.3445211*

[13] Lévi-Strauss, C. (1987). *Introduction to Marcel Mauss*. Routledge.

[14] Lyotard, J.-F. (1984). *The Postmodern Condition: A Report on Knowledge*. University of Minnesota Press.

[15] Malone, R. (2021). Permanently suspended on Twitter. Who is Robert Malone. Sneto iz: https://rwmalonemd.substack.com/p/permanently-suspended-on-twitter

[16] Marušič, J. Ž. (2022). Social Reasoning and the Politicization of Science During the Covid Pandemic. Mankind Quarterly. Sprejeto v objavo.

[17] Pinker, S. (2021). Rationality: What Is It, Why It Seems Scarce, Why It Matters. Viking Press.

[18] Schmitt, C. (2007) *The Concept of the Political.* University of Chicago Press.

[19] Spira B (April 19, 2022) Correlation Between Mask Compliance and COVID-19 Outcomes in Europe. Cureus 14(4): e24268. doi:10.7759/cureus.24268

[20] Sumption, J. (2022). Little by little the truth of lockdown is being admitted: it was a disaster. The Times. Sneto iz: https://www.thetimes.co.uk/article/little-by-little-the-truth-of-lockdown-is-being-admitted-it-was-a-disaster-5b5lrlgwk

[21] The Rockefeller Foundation. Mercury Project to Boost Covid-19 Vaccination Rates and Counter Public Health Mis- and Disinformation in 17 Countries Worldwide. Sneto iz: https://www.rockefellerfoundation.org/news/mercury-project-to-boost-

covid-19-vaccination-rates-and-counter-public-health-mis-and-disinformation-in-17-countries-worldwide/
[22] Ule, A. (2006). Znanost, družba, vrednote. Aristej.
[23] Watson, S. (2022). CNN Medical Analyst Who Fiercely Advocated Masking Now Admits It 'Harmed' Her Own Son's Development. Summit News. Sneto iz: https://summit.news/2022/08/24/cnn-medical-analyst-who-fiercely-advocated-masking-now-admits-it-harmed-her-own-sons-development/

Filozofski in psihološki vidiki človeške racionalnosti

Philosophical and psychological aspects of human rationality

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POVZETEK

Človeška racionalnost je kompleksen pojem, ki se nanaša na široko paleto našega spoznavanja in delovanja. Obstajajo številne opredelitve racionalnosti; Ronald de Sousa razlikuje med kategorično in normativno racionalnostjo, govorimo lahko o instrumentalni ali široki racionalnosti ali o racionalnosti kot logičnem sklepanju. Vprašanja o racionalnosti so tesno prepletena s preučevanjem odločanja. Normativne teorije odločanja racionalno vedenje opredelijo kot tisto, ki vodi do izida z največjo pričakovano koristnostjo, deskriptivne teorije pa preučujejo, kako se odločanje v vsakdanjem življenju dejansko poteka. K odmiku od idealiziranega pogleda na racionalnost so pripomogli program hevristik in pristranosti, ki sta ga osnovala Daniel Kahneman in Amos Tversky, koncept omejene racionalnosti, ki ga je predstavil Herbert A. Simon, ter delo Gerda Gigerenzerja in sodelavcev, ki preučujejo ekološko racionalnost. Poleg racionalnosti dejanj lahko govorimo tudi o racionalnosti prepričanj, kar preučevanje racionalnosti poveže s temeljnimi vprašanji s področja epistemologije.

KLJUČNE BESEDE

omejena racionalnost, ekološka racionalnost, racionalnost prepričanj, hevristike in pristranosti

ABSTRACT

Human rationality is a complex topic that encompasses a wide range of cognitive processes and behavior. Many definitions of rationality exist, one of them being Ronald de Sousa's notion of categorical and normative rationality. Some authors distinguish between instrumental and broad conception of rationality, while others define rationality in terms of logical reasoning. The study of rationality is intertwined with research in the field of decision making. Normative theories define rationality as behavior that leads to the outcome with the greatest expected utility, while descriptive theories examine how people actually make decisions in everyday life. Kahneman and Tversky's heuristics and biases program, Herbert A. Simon's concept of bounded rationality and Gerd Gigerenzer's study of ecological rationality all contributed to the shift from the idealized view of human rationality to a more moderate one. In addition to research on rational action, study of rational beliefs is another field of inquiry that connects investigation of rationality with fundamental questions in epistemology.

KEYWORDS

bounded rationality, ecological rationality, rationality of belief, heuristics and biases

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1 UVOD

Vprašanje, ali smo ljudje racionalna bitja, še zdaleč ni enostavno. Odgovor se že stoletja izmika znanstvenikom različnih disciplin od ekonomije in psihologije do filozofije in kognitivne znanosti. Človeška racionalnost je tema, ki se je lahko lotevamo iz številnih vidikov in z uporabo različnih metod, zato ni nenavadno, da danes na tem področju obstaja ogromno polje razprav in raziskav. V veliki razpravi o racionalnosti, kot so to poimenovali v kognitivni znanosti, obstajata dva nasprotujoča si pogleda. Na enem polu so avtorji, ki zagovarjajo, da so človeško sklepanje, presojanje in odločanje, ki so del racionalnega vedenja, polni pomanjkljivosti in pristranosti ter da jih je mogoče izboljšati; zagovorniki takšnega pogleda v veliki meri izhajajo iz programa hevristik in pristranosti, ki sta ga osnovala psihologa Daniel Kahneman in Amos Tversky. Raziskovalci na drugem polu pa takšnemu pogledu na racionalnost nasprotujejo in trdijo, da so kriteriji normativnih teorij racionalnosti neustrezni ter da izsledki empiričnih raziskav, ki pričajo o sistematičnih odklonih od omenjenih kriterijev, še ne zadostujejo za sklep, da smo ljudje iracionalni [1, 2, 3].

Namen prispevka je podati pregled izbranih pogledov na človeško racionalnost. Začela bom z definicijo filozofa Ronalda de Sousa, nadaljevala pa z dvema opredelitvama racionalnosti, med katerima se v literaturi pogosto razlikuje: instrumentalno in široko. Na primeru Wasonove naloge izbire kart – ene najbolj uporabljenih nalog pri empiričnem preučevanju sklepanja – bom opisala pogled, ki racionalnost povezuje z logičnim sklepanjem ter je še vedno vpliven zlasti na področju filozofije. Poleg logike je področje, ki je prav tako prepleteno s preučevanjem racionalnosti, odločanje. Opisala bom, kakšno sliko racionalnosti prikazujejo normativne teorije odločanja ter kako se je kot kritika takšnega pogleda izoblikoval program hevristik in pristranosti, ki je še danes eden najvplivnejših okvirjev za preučevanje odločanja in presojanja. Nato bom predstavila koncept omejene racionalnosti, ki ga je oblikoval Herbert A. Simon in je

pomembno vplival na razumevanje in pojmovanje racionalnosti, ter koncept ekološke racionalnosti, ki ga preučujejo Gerd Gigerenzer in sodelavci ter se naslanja na Simonovo delo. V zadnjem delu se bom odmaknila od empiričnih raziskav odločanja in presojanja ter opisala nekatera vprašanja, ki jih odpira raziskovanje racionalnosti prepričanj – teme na presečišču preučevanja racionalnosti in epistemologije.

2 DE SOUSOVA OPREDELITEV RACIONALNOSTI

Filozof Ronald de Sousa najprej razlikuje med kategorično in normativno racionalnostjo. Pri kategorični racionalnosti je nasprotje racionalnega aracionalno vedenje. Racionalno je takšno vedenje, ki ga vodijo določeni razlogi, aracionalno pa takšno, ki ga ne vodi mišljenje ali izbira. Pri kamnu, ki ga vržemo skozi okno, ali človeku, ki se spotakne in pade v grm kopriv, ne govorimo o (i)racionalnosti – pri prvem gre namreč za pojav, ki uboga zakone fizike, pri drugem pa za dejanje, ki ga ni vodila izbira. Pri normativni racionalnosti pa razlikujemo med racionalnim in iracionalnim vedenjem. Racionalno vedenje je tisto, ki je ustrezno utemeljeno z določenimi razlogi, normami ali vrednotami, iracionalno pa tisto, ki se od temu pogoju na tak ali drugačen način ne zadostuje. De Sousa pravi, da lahko o ljudeh kot o racionalnih živalih govorimo samo, če sprejmemo, da smo ljudje racionalni v kategoričnem smislu in kot taki tudi sposobni iracionalnega vedenja [4].

Če kategorične racionalnosti ne pripisujemo dogodkom, ki jih lahko zadostno razložimo z naravnimi zakoni, ali to pomeni, da z njimi ne moremo razložiti človeškega vedenja? Zmernejša interpretacija pravi, da je človeško vedenje podvrženo naravnim zakonom, vendar ti ne ponujajo zadostne razlage. Kot primer de Sousa navaja igro šaha, ki ga moramo razložiti s pravili igre – in ta niso naravni zakoni. Močnejša interpretacija pa pravi, da vedenje racionalnih bitij, vključno s človekom, na nek način presega zakone narave. De Sousa meni, da je tako stališče absurdno, saj bi predpostavljalo čudež ali pa vsaj to, da zakonov narave ne razumemo pravilno. Zagovarja, da moramo človeka obravnavati kot bitje, ki je kot vsa ostala podvržen zakonom narave; razliko med človekom in ostalimi bitji je potrebno iskati v zakonih narave in ne v lastnostih, ki bi le-te na nek način presegale. Če privzamemo, da se racionalnost nanaša na misli in dejanja, lahko razlikujemo med dvema ključnima spremembama tako na nivoju evolucije kot razvoja posameznika: prva je razvoj od golega zaznavanja objektov do zmožnosti tvorbe reprezentacij, druga pa razvoj od avtomatskih vedenjskih odzivov do zmožnosti oblikovanja namer ter želja ter vedenja na podlagi le-teh [4].

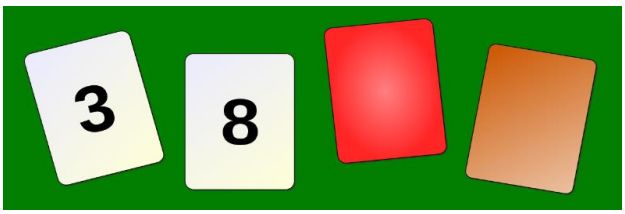
3 INSTRUMENTALNA IN ŠIROKA RACIONALNOST

V literaturi se pogosto pojavlja razlikovanje med ožjim, instrumentalnim in širokim pojmovanjem racionalnosti [1, 4]. Instrumentalno racionalnost opredelimo kot vedenje, ki nas približa doseganju zastavljenega cilja glede na mentalne in fizične vire, ki so nam na voljo. Povedano drugače, racionalno je tisto vedenje, ki optimizira doseganje ciljev, pri čemer se ne ukvarjamo s tem, kakšni ti cilji so in kako si jih posameznik postavlja. Prednost takšnega pristopa je v tem, da lahko postavimo norme, ki služijo kot kriterij racionalnosti, ter spremljamo, v kolikšni meri in pod kakšnimi pogoji ljudje od njih odstopamo. Po drugi strani pa se zdi preučevanje racionalnosti le iz instrumentalnega vidika preozko – če se osredotočamo samo na ciljno usmerjeno vedenje, izpustimo pa vprašanja o ciljih, normah in vrednotah, zanemarimo velik in pomemben del človeškega delovanja [1]. John Searle v svoji knjigi o racionalnosti navaja primer znanih raziskav o inteligentnosti opic, ki jih je psiholog Wolfgang Köhler izvajal na Tenerifih. V eksperimentih se je izkazalo, da so opice sposobne reševanja problemov z vpogledom; da bi dosegle na strop obešene banane, do katerih niso mogle priti s skakanjem, so uporabile škatle in palico [6]. Iz intrumentalnega vidika so se opice torej vedle racionalno in Searle meni, da tudi racionalnost človeka še vedno presojamo na podoben način. V klasičnih modelih racionalnosti je človeška racionalnost pravzaprav le kompleksnejša verzija šimpanzje. Searle v nadaljevanju opozarja na pomanjkljivosti takšnega pojmovanja racionalnosti in opozarja na pomembnost ločevanja vedenja na podlagi želja in na podlagi razlogov [7].

V odgovor na pomanjkljivosti instrumentalnega pristopa so se pojavila širša pojmovanja racionalnosti, ki upoštevajo tudi cilje, prepričanja, norme in vrednote, ki usmerjajo naše vedenje. Te teorije se med drugim ukvarjajo z vprašanji o racionalnosti samih ciljev [5] ter o vedenju, ki nima samo instrumentalne funkcije [1]. Filozof Robert Nozick na primer govori o konceptu simbolne koristnosti in pravi, da imajo naša dejanja neodvisno od instrumentalne tudi simbolno vrednost, ki bi jo morale vključevati vse formalne teorije racionalnosti in odločanja. Ker živimo v socialno in simbolno kompleksnem okolju, naša dejanja služijo tudi namenom, ki presegajo doseganje ozko zastavljenih ciljev, na primer temu, da sebi in drugim sporočamo, kakšne osebe smo [8]. Podobno ekonomist Shaun H. Heap kot protipol instrumentalni racionalnosti postavlja ekspresivno racionalnost. Ko izvajamo dejanja, ki so ekspresivno racionalna, opredeljujemo in raziskujemo lastna prepričanja in vrednote. Ne gre torej za enosmerno povezavo med vrednotami in delovanjem, temveč za povratno zanko, kjer z dejanji vrednote tudi konstruiramo, spremljamo in prilagajamo [9].

4 RACIONALNOST IN LOGIČNO MIŠLJENJE

Najbrž eden od najstarejših kriterijev racionalnosti je sledenje pravilom logičnega sklepanja in verjetnostnega računa [1]. Ena od najbolj preučevanih nalog, ki se uporablja v empiričnih raziskavah sklepanja, je Wasonova naloga izbire kart [10, 11], ki ima naslednjo obliko: »Na mizi so štiri karte. Vsaka ima na eni strani številko, na drugi pa barvo. Katere karte je potrebno obrniti, da testiraš pravilo: če je na eni strani sodo število, je na drugi strani rdeča barva?«



Slika 1: Primer Wasonove naloge izbire kart.

V zgoraj navedenem primeru je pravilni odgovor, da je potrebno obrniti karto s številko 8, s čimer preverimo modus ponens, in karto rjave barve, s čimer preverimo modus tollens. Večina udeležencev pri takšni nalogi poda odgovor, da je potrebno obrniti karto s številko 8 in karto z rdečo barvo, vendar gre pri slednjem za napako zatrjenega konsekvensa. V več kot petdesetih letih od izvirne objave je bila naloga uporabljena v ogromnem številu raziskav, kjer so avtorji manipulirali z različnimi spremenljivkami, ki bi lahko vplivale na izvedbo naloge, še danes pa ni enotne razlage za majhen delež pravilnih rešitev; ena od interpretacij je, da se večinoma osredotočamo na potrjevanje hipoteze, manj pa preverjanje pogojev, ki bi hipotezo ovrgli [12, 13, 14]. Še ena ugotovitev je, da so udeleženci pogosto nagnjeni k izbiri kart, ki so eksplicitno omenjene v navodilu [15]. Eno od opažanj je, da se delež pravilnih rešitev poveča, če namesto abstraktnih uporabimo konkretne primere, kar nakazuje na to, da se pri logičnem sklepanju oz. tesitranju hipotez ne zanašamo le na obliko argumentov, temveč tudi na vsebino [16]. Delež pravilnih rešitev je še večji, če uporabimo deontična pravila. Če morajo udeleženci na primer preverjati pravilo »Če piješ alkohol, moraš biti starejši od 18 let«, na mizi pa imajo karte s številkami 16 in 25 ter z napisi »pivo« in »kokakola«, večina pravilno izbere karti s številko 16 in napisom »pivo«. Testiranje hipotez nam gre očitno torej bolje, ko moramo preverjati morebitne kršitve socialnih pravil [17]. Ena od interpretacij, ki temelji na evolucijski psihologiji, je, da sklepanje ni le splošen, od vsebine neodvisen proces, temveč je v ozadju več specializiranih procesov, eden izmed katerih je namenjen reševanju problemov v kontekstu socialnih izmenjav in kršitev socialnih pogodb [17]; ta interpretacija je deležna številnih kritik [18]. Nekateri avtorji pa menijo, da je logično pravilna rešitev Wasonove naloge v konfliktu z načinom, kako v vsakdanjem življenju testiramo hipoteze, ter zagovarjajo, da je način, kako se udeleženci lotijo reševanja, v resničnem življenju adaptiven. Po njihovem neuspešno reševanje naloge torej ne služi kot dokaz iracionalnosti [19, 20]. To se sklada s pogledom, da logičnega mišljenja ne gre vedno in apriori enačiti z racionalnostjo, temveč je ustreznost takšnega mišljenja odvisna tudi od konteksta [1].

5 RACIONALNOST IN ODLOČANJE

Pojem racionalnosti je tesno prepleten s preučevanjem odločanja in presojanja. Znotraj vedenjskega preučevanja odločanja ločimo med normativnimi, deskriptivnimi in preskriptivnimi pristopi. Normativne teorije se osredotočajo na to, kako bi se ljudje morali odločati, da bi prišli do izida, ki ima zanje največjo koristnost, deskriptivne teorije preučujejo, kako človeško odločanje v resničnem življenju dejansko poteka, preskriptivne pa želijo zmanjšati vrzel med prvima dvema in osnovati predloge za izboljšanje odločanja [21].

Prevladujoč model normativnega odločanja pod pogojem tveganja je bila dolgo časa teorija pričakovane koristnosti, ki sta jo v knjigi Theory of Games and Economic Behaviour leta 1944 predstavila John von Neumann in Oskar Morgenstern. Teorija temelji na aksiomih, ki se nanašajo na odločevalčeve preference. Med drugim predpostavljajo, da ima posameznik popoln, urejen in tranzitiven nabor preferenc; to pomeni, da lahko za vsak par alternativ določi, v kakšnem odnosu sta, velja pa tudi, da v primeru, ko posameznik preferira alternativo A pred B in B pred C, preferira tudi A pred C. Če aksiomi držijo, lahko vsaki alternativi pripišemo določeno koristnost in racionalno odločanje je tisto, ki privede do izida z najvišjo koristnostjo [22].

Normativne teorije pred odločevalce torej postavljajo stroge zahteve in kmalu so se začela pojavljati vprašanja, če se ljudje v vsakdanjem življenju resnično odločamo na tak način. Kahneman in Tversky sta leta 1979 objavila članek, v katerem sta pokazala, da ljudje sistematično kršimo aksiome racionalnosti, na katerih slonijo normativne teorije. Svoje ugotovitve sta strnila v teorijo obetov, ki nadgrajuje teorijo pričakovane koristnosti in razlaga, kako se ljudje odločamo pod pogojem tveganja [23].

Kahneman in Tversky sta dolga leta preučevala presojanje in odločanje in osnovala raziskovalni okvir, ki ga poznamo pod imenom »program hevristik in pristranosti«. V številnih raziskavah sta pokazala, da ljudje v negotovih pogojih pogosto uporabljamo hevristike – miselne bližnjice, ki olajšujejo reševanje problemov, so hitre, varčne in zahtevajo manj napora – kar vodi do sistematičnih napak v presojanju in odločanju, ki sta jih poimenovala kognitivne pristranosti. Ljudje pogosto ne upoštevamo pravil logike in verjetnostnega računa, smo slabi intuitivni statistiki, zaključujemo brez ustreznih dokazov, slabo napovedujemo lastne prihodnje preference in smo podvrženi številnim dejavnikom, ki na tak ali drugačen način »neupravičeno« vplivajo na naše presoje. Doprinos programa hevristik in pristranosti je ravno v poudarjanju tega, da ljudje nismo racionalni v okviru normativnih teorij, temveč da odločanje in presojanje v vsakdanjem življenju potekata drugače [24, 25, 26].

Delo Kahnemana in Tverskyja je bilo skozi leta deležno različnih kritik. Če smo ljudje resnično tako podvrženi sistematičnim napakam v presojanju in odločanju, kako je sploh mogoče, da se dovolj učinkovito odzivamo na okolje, da preživimo? Različni avtorji so ponudili alternativne interpretacije izsledkov, ki naj bi izražali pristranosti v mišljenju. Ena vrsta interpretacij se ukvarja z razlago odgovorov na naloge znotraj laboratorijskih pogojev, druga pa z vprašanjem, kaj nam ti odgovori povedo o sklepanju, presojanju, odločanju in reševanju problemov v vsakdanjem življenju. Že znotraj laboratorijskega konteksta ni vedno enoznačno, ali je določen odgovor na nalogo pravilen ali napačen. Primer tega so različne interpretacije že omenjene Wasonove naloge izbire kart. Oaksford in Chater na primer menita, da naloga ne ocenjuje deduktivnega sklepanja, temveč verjetnostno. Če privzamemo, da kriterij za pravilne odgovore ni upoštevanje pravila falsifikacije, temveč izbira najbolj informativnih kart v skladu s teorijo optimalne selekcije podatkov (ang. *optimal data selection*), lahko nekatere odgovore udeležecev smatramo kot pravilne, tudi če ne sledijo pravilom formalne logike [19, 20]. Zagovorniki druge vrste interpretacij pa segajo izven laboratorija in menijo, da so »napačni« odgovori udeležencev iz evolucijskega, adaptivnega vidika pravzaprav smiselni. Odgovori, ki jih v umetno ustvarjenih problemih v laboratorijskem eksperimentiranju razlagamo kot napake, imajo v vsakdanjem življenju prilagoditveno vlogo in zato morda ni upravičeno, da jih jemljemo kot dokaz človeške iracionalnosti [27, 28, 29].

6 OMEJENA RACIONALNOST

Še en koncept, ki je pomembno vplival na odmik od idealiziranih, normativnih teorij odločanja, je bil koncept omejene racionalnosti, ki ga je v 50. letih prejšnjega stoletja predstavil Herbert A. Simon. Simon je menil, da je pojem globalne racionalnosti, ki naj bi jo posedoval človek v ekonomskih teorijah odločanja, potrebno nadomestiti s pojmom racionalnega vedenja, ki je kompatibilno z računskimi sposobnostmi in dostopnostjo do informacij, kot jo ima človek v lastnem okolju v resnici. Racionalnost po njegovem ne pomeni iskanje najboljše možne, temveč zgolj dovolj dobre rešitve, kar je poimenoval *satisficing*. Uporabil je prispodobo škarij, kjer eno rezilo ponazarja računske zmožnosti akterja, drugo pa strukturo okolja; zagovarjal je, da je pri preučevanju človeške racionalnosti pomembno upoštevanje in razumevanje obeh »rezil« [30, 31, 32, 33].

Simon je v svojih delih podrobno razdelal tako omejitve človekovega kognitivnega sistema kot značilnosti okolja. Menil je, da ni dokazov, ki bi pričali v prid temu, da človeško odločanje poteka na način, kot to predpostavljajo normativne teorije, in da ljudje v kompleksnih odločitvenih situacijah uporabljamo poenostavitve. Ena od njih je, da ne iščemo najboljše možne, optimalne rešitve, temveč si postavimo kriterij in izide nad njim obravnavamo kot zadovoljive, pod njim pa kot nezadovoljive. Seveda se ob tem poraja vprašanje, na kakšen način si postavljamo kriterij. Poleg tega pogosto nimamo popolnih informacij o tem, do kakšnih izidov bodo privedle različne alternative. Simon je zagovarjal, da v samem procesu odločanja postopoma pridobivamo informacije o tem in posodabljamo naše poznavanje odnosa med alternativami in izidi. Vrednotenje alternativ po njegovem mnenju poteka postopoma, zaporedno, in odločevalec lahko preprosto izbere prvo zadovoljivo. Kriterij za to, kaj je zadovoljiva rešitev, lahko po potrebi prilagajamo – če je previsok, ga znižamo in obratno, s čimer zagotovimo, da bomo v vsakem primeru prišli vsaj do ene rešitve [30].

Poleg zmožnosti organizma je za razumevanje racionalnosti potrebno upoštevati tudi strukturo okolja. Simon je menil, da se moramo osredotočiti na lastnosti okolja, ki so za odločevalca pomembne in ki predstavljajo njegov življenjski prostor. Ne gre torej preprosto za preučevanje fizičnih lastnosti sveta, ki nas obdaja; to, kaj smatramo kot okolje, je odvisno od zaznavnih sposobnosti, želja, potreb in ciljev organizma. Po Simonovem mnenju odločevalci nimajo le enega, temveč več različnih mehanizmov odločanja, ki so hierarhično urejeni, in vprašanje, ki si ga moramo zastaviti, je, katere procese odločanja bomo v posameznih situacijah še lahko označili za prilagoditvene [31].

Vprašanje, kaj pomeni racionalno obnašanje, je torej drugačno, če ga zastavimo z upoštevanjem omejitev odločevalca in njegovega okolja ali pa iz perspektive normativnih teorij racionalnosti. Ob upoštevanju vseh omejitev človeka, zlasti glede računskih in napovednih sposobnosti, je dejanska, človeška racionalnost lahko v najboljšem primeru le poenostavljen približek t. i. globalne racionalnosti, na kateri slonijo npr. modeli teorije iger [30].

Koncept omejene racionalnosti se je od izvirnih Simonovih del do danes razvijal in nadgrajeval ter še vedno močno vpliva na preučevanje odločanja in racionalnosti [34]. Na njem temelji tudi delo psihologa Gerda Gigerenzerja in sodelavcev, ki so osnovali raziskovalni program hitrih in varčnih hevristik ter so ostri kritiki programa hevristik in pristranosti. Zagovarjajo, da so hevristike lahko učinkovita orodja mišljenja in da poseganje po njih v nekaterih situacijah, sploh takšnih z visoko stopnjo negotovosti, lahko pojmujemo kot racionalno. Ukvarjajo se s tako imenovano ekološko racionalnostjo, kjer je poglavitno vprašanje, katera strategija v določeni situaciji vodi do boljših izidov kot druge. Boljše kot je ujemanje med strategijo, na primer določeno hevristiko, in strukturo naloge, bolj ekološko racionalni smo [35, 36].

7 RACIONALNOST PREPRIČANJ

Poleg racionalnosti dejanj lahko govorimo tudi o racionalnosti prepričanj. Prepričanje je eden od temeljnih pojmov v epistemologiji in je del klasične tripartitne definicije znanja, ki le-tega opredeli kot upravičeno resnično prepričanje. Eno od osrednjih vprašanj epistemologije je, kako priti do resničnih prepričanj. Vprašanje je neločljivo povezano s preučevanjem racionalnosti. Kakšen je odnos med racionalnostjo, upravičenostjo in resničnostjo prepričanj ter znanjem? So racionalna prepričanja tista, ki so upravičena, ali gre za ločena pojma? Kako ljudje oblikujemo svoja prepričanja in kako bi jih morali [37, 38]?

Tradicionalni pogled je, da je vprašanje, kako bi ljudje morali oblikovati prepričanja, v domeni epistemologije, vprašanje, kako dejansko jih, pa v domeni psihologije, in da naj bi disciplini delovali ločeno ena od druge. Do neke mere drži, da so normativna vprašanja epistemologije ločena od deskriptivnih vprašanj psihologije - če bi določena psihološka spoznanja na primer pričala o tem, da je proces oblikovanja prepričanj pretežno nezaveden in da ljudje večinoma stremimo k tem, da sprejmemo prepričanja, ki spadajo v že obstoječo mrežo prepričanj, to samo po sebi ne daje dodatne teže koherentistični teoriji upravičenja v epistemologiji. Vprašanji sta se začeli povezovati v 60. letih prejšnjega stoletja, ko je Willard V. O. Quine predstavil program naturalistične epistemologije, ki poudarja, da so pri preučevanju prepričanj in znanja potrebne tudi metode, izsledki in teorije empiričnih znanosti [38].

V literaturi se pogosto pojavlja izraz epistemska racionalnost. Pritchard jo opredeli kot obliko racionalnosti, katere cilj je pridobivanje resničnih prepričanj [37]. Po njegovem lahko človek, ki stremi k epistemski racionalnosti, privzame različne strategije. Ena od njih je maksimizacija števila resničnih prepričanj, druga pa minimizacija števila napačnih prepričanj, vendar pri obeh naletimo na težave: najboljši način za maksimizacijo števila resničnih prepričanj je, da verjamemo kar koli, s čimer neizogibno pridobivamo tudi napačna prepričanja, najboljši način za minimizacijo števila napačnih prepričanj pa, da ne verjamemo skoraj ničesar. Zdi se, da bi bilo najbolj smiselno privzeti vmesen, uravnotežen pristop med verjetjem vsemu in radikalnim skepticizmom [37]. Cilj epistemske racionalnosti pa ni postavljen v prihodnost, temveč v sedanjost – večino epistemologov zanima, kakšno je stanje naših resničnih prepričanj v tem trenutku, ne pa na primer čez eno leto. Za primer lahko vzamemo osebo, ki je brez ustreznih dokazov prepričana, da je dobra v matematiki. To prepričanje vodi v obiskovanje dodatnih ur matematike in zvišuje motivacijo ter količno učenja, kar na dolgi rok dejansko pripomore k večjemu številu resničnih prepričanj o matematiki. Kljub temu bi večina epistemologov

zavrnila idejo, da je posedovanje prvega prepričanja epistemsko racionalno [38].

Do zdaj omenjeni pogled prepričanja pojmuje kategorično, pri čemer imamo le tri možnosti: lahko smo prepričani, da p, prepričani, da ne-p, ali pa se prepričanja vzdržimo. Nekatera področja epistemologije, na primer bayesovska epistemologija, pa prepričanja obravnavajo kot stopenjska – prepričanje torej ni več propozicionalno stanje v smislu »vse ali nič«, temveč smo lahko v neko propozicijo prepričani bolj ali manj. V tem primeru se odpirajo številna nova vprašanja, na primer kakšen je odnos med dokazi za določeno propozicijo in našo stopnjo prepričanja vanjo ter kakšno stopnjo prepričanja potrebujemo, da lahko trdimo, da je posedovanje nekega prepričanja epistemsko racionalno [39, 40, 41]. S tem povezana so tudi vprašanja o tem, kako prepričanja posodabljamo ali spreminjamo, ko pridobivamo nove informacije. Obstajajo različni modeli, ki opisujejo te procese, na primer AGM model revizije prepričanj [42] in teorija rangiranja [43, 44].

Nadaljnja vprašanja, povezana z epistemsko racionalnostjo, se dotikajo epistemskih norm in odgovornosti. Pravila, ki nam narekujejo, kako oblikovati prepričanja, se imenujejo epistemske norme. Poraja se vprašanje, ali lahko agenta, ki prepričanja oblikuje v skladu z napačnimi epistemskimi normami, še vedno smatramo za epistemsko racionalnega. Šibkejši, deontični pogled na epistemsko racionalnost pravi, da ja – agentova prepričanja so epistemsko racionalna, če so v skladu z epistemskimi normami, ki jim agent sledi. V hipotetični situaciji, kjer bi bil agent sistematično zaveden glede epistemskih norm, ni odgovoren za morebitna napačna prepričanja; nasprotno pa v situaciji, kjer je bil seznanjen s pravimi epistemskimi normami, pa vseeno sledi napačnim, odgovornosti za napačna prepričanja ni razrešen. Močnejši, ne-deontični pogled pa kot kriterij za epistemsko racionalnosti postavlja, da agent sledi pravim epistemskim normam, torej tistim, ki dejansko vodijo do resnice. Težava ne-deontičnega pogleda je v tem, da agent nikoli ni odgovoren za napačna prepričanja – če sledi napačnim epistemskim normam, sicer ni epistemsko racionalen, vendar tudi ni odgovoren za svoje zmote [37].

Predmet razprave je tudi vprašanje o odnosu med epistemsko racionalnostjo in upravičenjem. Nekateri izraza »epistemsko racionalna prepričanja« in »epistemsko upravičena prepričanja« uporabljajo kot sinonima, drugi ju ločujejo. V drugem primeru ni jasno, kakšen je odnos med epistemsko racionalnim prepričanjem in znanjem. Ena od možnih pozicij je, da tudi če sprejmemo upravičenje vsaj kot nujen, če ne že zadosten pogoj za znanje, za epistemsko racionalnost to ne velja. Epistemsko racionalna prepričanja torej z znanjem niso povezana na enak način kot upravičena prepričanja. Če prekinemo povezavo med znanjem in epistemsko racionalnostjo, nam to omogoča, da slednjo preučujemo tudi izven okvirja epistemologije in jo povežemo z drugimi vidiki racionalnosti, na primer racionalnostjo odločitev in dejanj. Foley predlaga, da je odločitev (načrt, strategija) za osebo racionalna, če lahko oseba epistemsko racionalno verjame, da bo odločitev v zadovoljivi meri vodila v izpolnitev njenih ciljev [38].

Namen tega dela prispevka je bil nakazati le nekatera izmed številnih vprašanj, ki se odpirajo na presečišču preučevanja racionalnosti in epistemologije. Racionalnost prepričanj ali teoretsko racionalnost se pogosto prikazuje kot protipol praktični, instrumentalni racionalnosti in menim, da je za razumevanje celotne slike pomembno poznavanje obeh pogledov ali »vrst« racionalnosti. Osredotočila sem se predvsem na odnos med racionalnostjo in različnimi temeljnimi pojmi epistemologije, zlasti upravičenjem, ter na povezavo med racionalnostjo in epistemskimi normami. Seveda pa na področju racionalnosti prepričanj obstajajo še številna druga vprašanja in pogledi, opis katerih presega namen prispevka.

8 ZAKLJUČEK

Racionalnost je kompleksen pojem, ki zajema široko paleto človeškega spoznavanja in delovanja. Opredelitve racionalnosti, kriteriji zanjo in metode, s katerimi jo preučujemo, so tako številne in raznolike, da kategoričnega odgovora na vprašanje, ali smo ljudje racionalni, ni pričakovati. Hkrati so praktično vsa področja našega življenja prepredena vsaj z implicitnimi prepostavkami o lastni (i)racionalnosti in tako je preučevanje lete pomembno ne le iz teoretskega, ampak tudi iz aplikativnega vidika. Preučevanje racionalnosti kot optimalnega doseganja ciljev lahko služi kot podlaga za oblikovanje spodbud in strategij, ki bi tako posameznikom v vsakdanjem življenju kot strokovnjakom z različnih področij, kot so zdravstvo, gospodarstvo in pravo, pomagale pri učinkovitem sprejemanju dobrih odločitev. Tu pa pridemo do naslednjega vprašanja, ki se odpre, ko presežemo instrumentalno pojmovanje racionalnosti – kaj so »dobre« odločitve ali »racionalni« cilji? In nenazadnje, zakaj bi si pravzaprav želeli biti racionalni – ker menimo, da je tako prav, ker racionalno delovanje izboljšuje naše možnosti za preživetje in uspeh, ker vodi v srečo in blagostanje? Tudi pri racionalnosti prepričanj se odpirajo podobna vprašanja; eno od njih je, ali je doseganje resnice vedno primarni epistemski cilj.

Pojmovanje racionalnosti je pomembno tudi pri razmislekih o različnih vidikih zaupanja v znanost. Na kakšen način je znanje, ki ga pridobivamo z znanstveno metodo, drugačno od znanja, ki ga pridobivajo laiki v vsakdanjem življenju? Koliko prostora za napake in kolikšno stopnjo negotovosti je smiselno dovoliti, ko preverjamo hipoteze? Kakšni dokazi so dovolj dobri, da bomo neko trditev sprejeli ali ovrgli? Odgovori na ta in podobna vprašanja so deloma odvisni od tega, kakšen pogled na racionalnost privzamemo.

Menim, da sta pri preučevanju racionalnosti pomembni tako filozofska analiza kot metode empiričnih znanosti, ki nam dajejo vpogled v procese in mehanizme v ozadju človeškega oblikovanja prepričanj, sklepanja, presojanja in odločanja. Integracija spoznanj različnih disciplin lahko pripomore k zmanjševanju vrzeli med normativnimi in deskriptivnimi teorijami ter pripomore k oblikovanju karseda celostne slike človeške racionalnosti.

VIRI

[1] Keith E. Stanovich. 2010. *Decision making and rationality in the modern world*. Oxford University Press, New York

[2] Phillip E. Tetlock and Barb Mellers, 2002. The great rationality debate. *Psychol Sci* 13, 1 (Jan, 2002), 94–99. DOI: 10.1111/1467-9280.00418

[3] Edward Stein. 1996. *Without good reason: the rationality debate in philosophy and cognitive science*. Clarendon Press, Oxford

[4] Ronald de Sousa. 2007. *Why Think?: Evolution and the Rational Mind*. Oxford University Press, New York

[5] Jon Elster. 1983. *Sour Grapes: studies in the subversion of rationality*. Cambridge University Press, New York

[6] Wolfgang Köhler. 1925. *The Mentality of Apes*. Percy Lund, Humphries & Co, London

[7] John R. Searle. 2001. *Rationality in Action*. MIT Press, London

[8] Robert Nozick. 1981. *The Nature of Rationality*. Princeton University Press, New Yersey

[9] Shaun H. Heap. 1989. *Rationality in economics*. Blackwell Publishing, London

[10] Peter C. Wason. 1966. Reasoning. In *New horizons in psychology*, Pelican, Harmondsworth

[11] Peter C. Wason, 1968. Reasoning about a rule. *Q J Exp Psychol*. 20, 3 (Apr, 1968), 273–281. DOI: 10.1080/14640746808400161

[12] Richard A. Griggs and James R. Cox, 1982. The elusive thematic-materials effect in Wason's selection task. *Br J Psychol* (July, 1982) 73, 407–420. DOI:10.1111/j.2044-8295.1982.tb01823.x

[13] Marco Ragni, Ilir Kola and Phillip N. Johnson-Laird. The Wason selection task: A meta-analysis. In *Proc 32nd Annu Conf Cogn Sci Soc* (July, 2017). Curran Assciates Inc., New York, 980–985

[14] Phillip N. Johnson-Laird and Peter C. Wason, 1970. A theoretical analysis of insight into a reasoning task. *Cogn Psychol* 1, 2 (Feb, 1970), 134–148. DOI:10.1016/0010-0285(70)90009-5

[15] Valerie A. Thompson, Jonathan St. B. T. Evans and Jamie I. D. Campbell, 2013. Matching bias on the selection task: It's fast and feels good. *Think Reason* (Oct, 2013), 19, 3–4, 431–452. DOI:10.1080/13546783.2013.820220

[16] Paul Pollard and Jonathan St. B. T. Evans, 1987. Content and context effects in reasoning. *AJP* 100, 1 (Spring, 1987), 41–60. DOI: 10.2307/1422641

[17] Leda Cosmides and John Tooby, 1992. Cognitive adaptations for social exchange. In *The adapted mind: Evolutionary psychology and the generation of culture*. Oxford University Press, New York, 163–228

[18] Paul S. Davies, James H. Fetzer and Thomas R. Foster, 1995. Logical reasoning and domain specificity - A critique of the social exchange theory of reasoning. *Biol Philos* 10 (Jan, 1995), 1–37. DOI:10.1007/BF00851985

[19] Mike Oaksford and Nick Chater, 1994. A rational analysis of the selection task as optimal data selection. *Psychol Rev* 101, 4 (Oct, 1994), 608–631. DOI:10.1037/0033-295X.101.4.608

[20] Mike Oaksford and Nick Chater, 2003. Optimal data selection: Revision, review, and reevaluation. *Psychon Bull Rev* 10, 2 (May, 2003), 289–318. DOI: 10.3758/BF03196492

[21] Baruch Fischhoff, 2010. Judgment and decision making. *Wiley Interdiscip Rev Cogn Sci* 1, 5 (Sept/Oct, 2010), 724–735. DOI: 10.1002/wcs.65

[22] John von Neumann and Oskar Morgenstern. 1944. *Theory of games and economic behavior*. Princeton University Press, New Yersey

[23] Daniel Kahneman and Amos Tversky, 1979. Prospect theory: An analysis of decision under risk. *Econometrica* 47 (Mar, 1979), 263–291. DOI: 10.2307/1914185

[24] Daniel Kahneman, Amos Tversky and Paul Slovic. 1982. *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge University Press, Cambridge

[25] Daniel Kahneman and Amos Tversky. 2000. *Choices, values and frames*. Cambridge University Press, Cambridge

[26] Daniel Kahneman. 2011. *Thinking, fast and slow*. Farrar, Straus and Giroux, New York

[27] Aron K. Barbey and Steven A. Sloman, 2007. Base-rate respect: From ecological rationality to dual processes. *Behav Brain Sci* 30, 3 (Jun, 2007), 255–297. DOI: 10.1017/S0140525X07001653

[28] Gerd Gigerenzer, 1996. The psychology of good judgment: Frequency formats and simple algorithms. *Med Decis Mak* 16, 3 (Jul–Sept, 1996), 273–280. DOI: 10.1177/0272989X9601600312

[29] Gerd Gigerenzer, 1991. How to make cognitive illusions disappear: Beyond "heuristics and biases."*Eur Rev Soc Psychol.* 2, 1 (1991), 83–115. DOI: 10.1080/14792779143000033

[30] Herbert A. Simon, 1955. A behavioral model of rational choice. *Q J Econ* 69, 1 (Feb, 1955), 99–118. DOI: 10.2307/1884852

[31] Hebert A. Simon, 1956. Rational choice and the structure of the environment. *Psychol Rev* 63, 2 (Mar, 1956) 129–138. DOI: 10.1037/h0042769

[32] Herbert A. Simon, 1990. Invariants of human behavior. *Annu Rev Psychol* 41 (Feb, 1990), 1–19. DOI:10.1146/annurev.ps.41.020190.000245

[33] Herbert A. Simon, 1992. What is an explanation of behavior? *Psychol Sci* 3, 3 (May, 1992), 150–161. DOI: 10.1111/j.1467-9280.1992.tb00017.x

[34] Riccardo Viale (ur.). 2021. *Routledge handbook of bounded rationality*. Routledge, New York

[35] Gerd Gigerenzer and Peter M. Todd. 1999. *Simple heuristics that make us smart*. Oxford University Press, New York

[36] Gerd Gigerenzer, Ralph Hertwig and Thorsten Pachur (ur.). 2011. *Heuristics: the foundations of adaptive behavior*. Oxford University Press, New York

[37] Duncan Pritchard. 2018. *What Is This Thing Called Knowledge?* (4th edition.) Routledge: New York

[38] Sven Bernecker and Duncan Pritchard (Ed). 2011. *The Routledge Companion to epistemology*. Routledge, New York

[39] Richard Foley, 1992. The epistemology of belief and the epistemology of degrees of belief. *Am Philos Q* 29, 2 (Apr, 1992), 111–124

[40] Stephen Hartmann and Jan Sprenger, 2011. Bayesian epistemology. In *The routledge companion to epistemology*. Routledge, New York, 636–648

[41] Elizabeth G. Jackson, 2020. Relationship between belief and credence. *Philos Compass* 15, 6 (Mar, 2020), 1–13. DOI: 10.1111/phc3.12668

[42] Carlos E. Alchourrón, Peter Gärdenfors and David C. Makinson (1985). On the logic of theory change: Partial meet contraction and revision functions. *J Symb Log* 50, 2 (June, 1985), 510–530, DOI: 10.2307/2274239

[43] Wolfgang Spohn, 1988. Ordinal conditional functions: A dynamic theory of epistemic states. In *Causation in decision, belief change, and statistics II*. Dordrecht: Kluwer, 105–134

[44] Franz Huber, 2019. Ranking theory. In *The open handbook of formal epistemology*. PhilPapers Foundation, 397–437

Joint history of play provides means for coordination

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ABSTRACT

In this study we investigate how joint history shapes strategic decisions for solving coordination problems. We show that coordinating partners use the history of their past interactions to select their strategies. More precisely, people accurately predict that a winning strategy used in the past is mutually salient and can be successfully used again in similar situations. Thus, joint history helps players form accurate mutual expectations about each others' choices and increase the rate of successful coordination.

We demonstrate that precedence is strongly relied upon and provides insights into the psychological bases of the social processes through which conventions emerge. By investigating the path dependence of the individual behaviour in the context of coordination, we experimentally confirm that conventions emerge because people systematically rely on their past interactions in order to coordinate successfully.

KEYWORDS

coordination games, path dependence, Schelling salience

1. INTRODUCTION

Coordination is the process of tacit convergence on a mutual strategy in the context of interdependent decisions. Coordinating partners can choose to do exactly same thing (drive on the right side of the road), exactly the opposite thing (wait while another person is calling back after the line is cut) or complement each other's actions to produce a common outcome (division of the household chores). In many everyday cases coordination is achieved by following an existing convention, by making an explicit verbal agreement or by performing actions in sequence, when the person initiating the interaction has the opportunity to make the first choice and express their preference. However, even in the absence of communication, successful coordination can be accomplished with the probability much higher than chance. Thomas Schelling first draw attention to this apparent paradox of coordination with his informal experiments [1], that were later successfully replicated in the controlled settings [2, 3].

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In pure coordination games (Schelling games) participants are asked to choose the same option from the set of equally attractive ones. Surprisingly, people tend to converge on one particular option at a rate significantly higher than chance. For example, choosing between «heads» or «tails» reveals consistent preference for «heads», much higher than mathematically implied equiprobability. Such recognisable prominence of one alternative over another, that results in a stable solution, is called a focal point or salience.

Pure coordination games therefore pose a question how to identify a unique solution to avoid coordination failure [4]. Although the exact reasoning behind the coordination process is open for debate [5, 6, 7, 8], Schelling's suggestion is to look for such selection rule among many, which can single out a successful coordination strategy. This rule should be mutually recognised by the interacting parties to be able to provide reliable means for coordination [1]. A focal point, emerged by applying such selection rule, is called Schelling salience.

Building on the logic of coordination games, David Lewis convincingly argued for the emergence of (linguistic) conventions [9]. According to his account, observed behavioural regularities that are commonly known among the population, create accurate mutual expectations that facilitate coordination by providing unambiguous solution to social coordination problems, resulting in stable equilibria.

We hypothesise that these behavioural regularities become salient by virtue of repeating precedence, which is used as Schelling salience, once the agents are confronted with the coordination problem.

The goal of the study is to show how the joint history of interactions in coordination problems shapes the choice of coordination strategies. At the cognitive level, this means that joint history is used by people as relevant information for choosing their strategy for coordination.

The following hypotheses were tested:

H1: Joint history facilitates accurate mutual expectations.

Players choose a coordination strategy in view of what they expect their partner to do. These expectations are informed by the knowledge they have of their joint history, which makes their prediction more accurate.

H2: Joint history determines coordination strategies.

When the situation does not provide any unambiguous clues for coordination, players choose a specific strategy that resulted in successful coordination in the past to resolve the ambiguity and avoid coordination failure.

2. METHOD

This research is based on the empirical methodology of experimental game theory. The economic game chosen for the experiment is pure coordination game [1, 2, 3].

In the experiment, participants were presented with various layouts of coloured tokens and asked to coordinate on the token of the same colour. Both sets of tokens were visible to both partners and the choice was simultaneous. The result of every interaction and individual players' choices were logged online in real time. The analysis was carried out for the particular type of rounds (at individual or dyadic level) with the condition as an independent variable.

2.1. Participants

One hundred and thirty-three participants took part in the "Mobile Coordination Games" experiment, which was conducted online in two parts. Game sessions for the baseline condition were organised during June and July, 2021 with a total of 51 participants (mean age = 26.2 years; 16 females and 35 males). Game sessions for the experimental conditions took place in January, 2022 with a total of 82 participants (mean age = 24.1 years; 24 females and 58 males). Participants were recruited online via the Sona Research Participation System of Central European University. There were no restrictions on participation for the adult participants, who needed basic English skills for understanding the instructions and a mobile device for accessing the Coordy research application. All the participants received compensation based on their performance level (average amount = 4,9 euros) in the form of an online voucher of their preference, either Amazon or PayPal.

2.2. Materials

To enable empirical investigation of the real-time coordination between the pairs of participants, a proprietary mobile research application named Coordy has been developed for both Android and iOS based mobile devices. Coordy was officially released and became available for download on Google PlayMarket and AppStore.

In the experiment, we used two different kinds of experimental scenarios:

- 30 single rounds of various difficulty in the baseline condition:

A. easy rounds with the symmetrical clues for coordination;
B. hard rounds with the clashing clues;
C. equiprobable rounds with no coordination clues;

- 46 games of five rounds (experimental conditions).

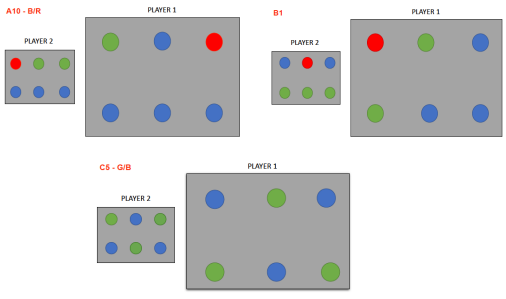

Figure 1: Examples of A, B and C rounds.

2.2. Experimental conditions

We used a between-subject design to examine the research hypotheses. Participants were presented with the experimental scenarios under the following three conditions:

(1) no joint history (baseline condition)

Baseline data reveals the rate of coordination in the absence of joint history of play. The baseline condition also helps to empirically differentiate various types of rounds that are used to construct scenarios in the experimental conditions. Rounds that reveal preference for one particular colour will become history rounds. Rounds, where the colour choices are equally distributed, will become test rounds. Coordination index [2, 3] is calculated to show the hypothetical coordination rate of the unpaired participants based on their individual responses.

Experimental setting: Participants play single rounds in pairs with their player IDs hidden. They connect with the new partner after each round and are aware of this. The participants pool is set to 2 players to allow random pairing.

Experimental stimuli: 30 individual rounds of various difficulty. Each round could be played for up to 2 times by any player (but not in sequence).

(2) random joint history (experimental condition)

Participants have the opportunity to build a joint history of play, consisting of randomly assigned rounds. This history of mutual interactions can provide them with the clues for successful coordination in the test round. Its coordination rate will be compared to the corresponding baseline rate and the coordination index.

Experimental setting: Participants play games, consisting of four random rounds and a test round, in dyads with their player IDs shown. They change their game partner after each game. The participants pool is set to 8 players to allow fixed pairing in order to avoid repetitions.

Experimental stimuli: 36 games of 5 rounds from the baseline condition (6 unique histories of four rounds combined with each of the 6 test rounds). Each game was played just once during the game session.

(3) specified joint history (experimental condition)

Joint history, provided by the designed scenario, increases the probability that a certain strategy is used during this history and, subsequently, in the test round. Individual player's strategy, operationalised as a choice of the specific colour, will be compared between different histories that end up with the same test round.

Experimental setting: Participants play games, consisting of four predefined rounds and a test round, in dyads with their player IDs shown. They change their game partner after each game. The participants pool is set to 8 players to allow fixed pairing in order to avoid repetitions.

Experimental stimuli: 10 games of 5 rounds (5 unique histories of four rounds combined with the corresponding test rounds). Each game was played twice during the game session.

All the scenarios (both single round and games of five rounds) appeared during the game sessions in the randomised order to avoid order effects. The order of rounds within a particular game was fixed. Both experimental conditions were tested together during the same game sessions.

3. RESULTS

Before reporting the results of the study, we would like to clarify the issue of the players' expertise and its potential influence on the outcome of coordination. In both conditions, all the participants would start playing without any prior experience (match number 0). We analysed the outcome of the coordination in the last round (success or failure) for match numbers below and above 7 (half of the experimental game sessions) and found no evidence for the improvement of the coordination success at the dyadic level. Coordination in the last round was successful in about half of the games irrespective of the participants' level of experience with the task.

3.1. Baseline results

A chi-square test of goodness-of-fit was performed to determine whether each of the three colours were equally chosen by the participants in the particular round.

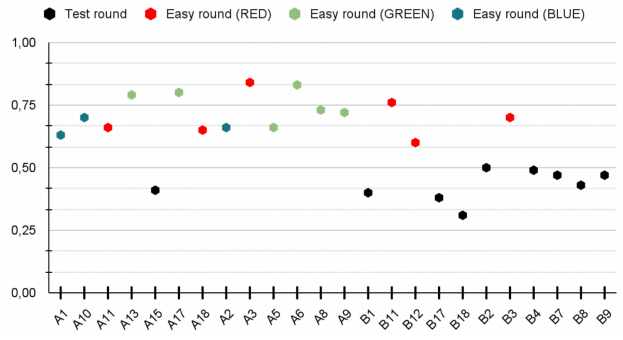

Figure 2: Baseline coordination rates for the A, B rounds.

A preference for a specific colour was found in the majority of A rounds (except for A15) and some B rounds (B3, B11, B12). The corresponding dots on the graph are coloured with the colour that was chosen the most (over ⅔ of the individual choices) in the particular round. Also the coordination rates (CRs) for those rounds were very high (mean CR = 0.72). These rounds were used to constitute history rounds.

A preference for the specific colour was not found in the four B rounds (B1, B8, B17, B18) and one A round (A15). While the choices for the three colours were not equally distributed in the rounds B2, B4, B7 and B9, the proportion of any particular colour did not exceed 60%. Their corresponding dots on the graph are therefore coloured in black. Also their CRs were significantly lower (mean CR = 0.43) than in the previous group of rounds with the focal points. These rounds were used as test rounds in the random history condition.

For the majority of C rounds (C1, C3, C4, C6) a colour preference was not established. Also the CRs for C rounds were not significantly higher than chance (mean CR = 0.57). Hence they are not depicted on the graph. These rounds were used as test round in the specified history condition.

3.2. Random history results

A chi-square test of independence was performed to examine the relation between the coordination rate in the test rounds (at the group level) and the history of previous interactions. The relation between these variables was significant, X^2 (1, N = 592) = 8.39, $p < .01$; $r = .12$.

Participants were more likely to successfully coordinate in the test rounds after the joint history of play than without it.

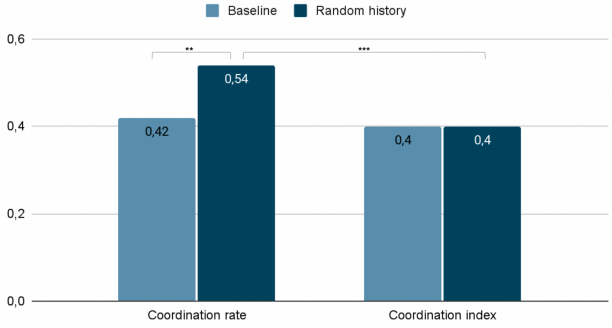

Figure 3: Change in the coordination rate and coordination index across conditions (group-level). Levels of significance: **: p < .01, ***: p < .001.

A two-proportion z-test was conducted to calculate the difference between the CR and coordination index (CI) in the last round of the games with random history. For the group of test B rounds CR was found to be significantly higher than CI after the joint history of play z (N = 1029) = 4.26, $p < .001$; $r = .13$.

Therefore the actual coordination rate exceeds the rate of the expected coordination, when the choices are made by the randomly paired participants.

3.3. Specified history results

A chi-square test of independence was performed to examine the relation between the individual player's choice in the same test round and the specific history preceding that round.

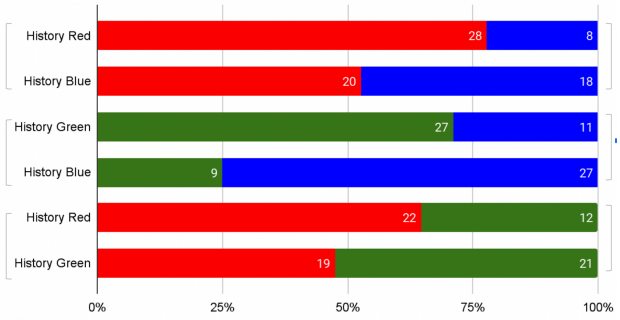

Figure 4: Individual player's choice of colour for coordination in the last round after the specified history.

For some pairs of histories, the relation between these variables was significant:

- for the test round C4 after the histories Red and Blue X^2 (1, N = 74) = 7.29, $p < .01$; $r = .3$;
- for the test round C2 after the histories Green and Blue X^2 (1, N = 74) = 15.69, $p < .0001$; $r = .45$.

In the same test round, participants were more likely to choose the modal colour of the history rounds (e.g. in the test round C4 participants were more likely to choose red colour after the history Red and blue colour after the history Blue).

For the histories Red and Green the relation between these variables was statistically insignificant.

4. DISCUSSION

In this study we aimed to investigate how previous interactions can influence the outcome of coordination for the pair of players. First, we let the participants play single rounds anonymously. Even though the participants played several rounds, they could not constitute joint history of interaction because they were — knowingly — paired with a new random participants for each round. This set-up helped us identify rounds with the «natural» focal points, i.e. colours that appealed to the participants as obvious to coordinate upon due to the specific layout of the scenario, irrespective of other factors.

We noticed that in the absence of communication and any explicit coordination rules, participants did manage to coordinate more than rational choice theory would predict. This is in line with previous results showing that people are able to rely on Schelling salience in order to coordinate successfully.

In our experiment participants converged on a tacit rule for coordination, which was «choose colour with the most tokens present on both players' layouts»**.** Those rounds, where this rule could not be unmistakably applied, demonstrated lower coordination rates and were chosen to be the test rounds for the subsequent experimental conditions. We wanted to explore the possibility that the history of interactions itself would provide Schelling salience and thus determine the choice of colour to increase the coordination rate.

We then created games with five rounds, which were played by the participants in dyads with their IDs shown and mutually known, thus letting them build the history of mutual interactions. In the games, which histories did not suggest a choice of any specific colour, we observed a significant improvement coordination in the last round. Interestingly, the coordination index for this round did not significantly changed between the conditions with and without joint history. It is only the actual coordination rate that changed. In other words, had the participants been paired randomly for the last round, no improvement would have occurred.

This suggests that the increase in coordination rate is due to players tracking what they have played with their own partner and using this information to make their future choices. This findings confirm our hypothesis that joint history of play facilitates coordination. When the game partners are aware of each other's previous choices, they tend to choose the focal point for coordination more accurately. However, the effect size of the observed differences remained small. One possible explanation is that randomness and variety of the history rounds created clashing focal points to converge on.

In the games from the third condition, where a history of rounds nudged the choice of a given colour, we observed that this same colour tended to be chosen in the last round. More precisely, participants had to select one of two colours in the last round of their joint history. They tended to select the same colour, on which they coordinated during their joint history. They did so significantly more than the participants, who were given a joint history that nudged towards another colour. We documented that effect for two test rounds with a moderate effect size. We did not observe a significant effect for the third test round.

Our post-hoc hypothesis is that the salience of the red colour overshadowed the salience shaped by the history of past interactions. This mixed result calls for the replication study with the different set of stimuli.

Overall, in our experiment we managed to observe how participants make use of the precedence by applying the following rule for coordination: «choose the colour that brought us successful coordination before». Though studying path dependence in the lab setting poses certain challenges [10], some researchers found the way to address them using the economic games [11]. In the future, it could be fruitful to empirically investigate the robustness of the coordination rules and the amount of common knowledge required for their emergence [12, 13, 14, 15].

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REFERENCES

1. Thomas Schelling. 1960. *The strategy of conflict* (1st. ed.). Harvard University Press, Cambridge, MA.
2. Judith Mehta, Chris Starmer, and Robert Sugden, 1994. The Nature of Salience: An Experimental Investigation of Pure Coordination Games. *The American Economic Review* 84, 3 (Jun, 1994), 658–73. JSTOR: http://www.jstor.org/stable/2118074.
3. Nicholas Bardsley, Judith Mehta, Chris Starmer and Robert Sugden, 2010. Explaining Focal Points: Cognitive Hierarchy Theory *versus* Team Reasoning, *The Economic Journal* 120, 543 (Mar, 2010), 40–79. DOI:https://https://doi.org/10.1111/j.1468-0297.2009.02304.x.
4. Giovanna Devetag and Andreas Ortmann, 2007. When and why? A critical survey on coordination failure in the laboratory. *Experimental economics* 10 (Aug, 2007), 331-344. DOI:https://doi.org/10.1007/s10683-007-9178-9.
5. Robert Sugden. The logic of team reasoning, 2003. *Philosophical explorations* 6, 3 (Sep, 2003), 165-181. DOI:https://doi.org/10.1080/10002003098538748.
6. Colin F. Camerer, Teck-Hua Ho and Juin-Kuan Chong, 2004. A Cognitive Hierarchy Model of Games, *The Quarterly Journal of Economics* 119, 3 (Aug, 2004), 861–898. DOI:https://doi.org/10.1162/0033553041502225.
7. Nicholas Bardsley and Aljaž Ule, 2017. Focal points revisited: Team reasoning, the principle of insufficient reason and cognitive hierarchy theory. *Journal of Economic Behavior & Organization* 133 (Jan, 2017), 74-86. DOI:https://doi.org/10.1016/j.jebo.2016.10.004.
8. Francesco Guala, 2018. Coordination, Team Reasoning, and Solution Thinking. *Revue d'économie politique* 128, 3, 355-372. DOI:https://doi.org/10.3917/redp.283.0355.
9. David Lewis. 1969. *Conventions: A Philosophical Study* (1st. ed.). Harvard University Press, Cambridge, MA.
10. Jean-Philippe Vergne and Rodolphe Durand, 2010. The missing link between the theory and empirics of path dependence: conceptual clarification, testability issue, and methodological implications, *Journal of Management Studies* 47, 4 (Aug, 2010), 736-759. DOI:https://doi.org/10.1111/j.1467-6486.2009.00913.x
11. Marc Knez and Colin Camerer, 2000. Increasing cooperation in prisoner's dilemmas by establishing a precedent of efficiency in coordination games, *Organizational Behavior and Human Decision Processes* 82, 2 (Jul, 200), 194-216. DOI:https://doi.org/10.1006/obhd.2000.2882
12. Margaret Gilbert, 1983. Agreements, conventions, and language. *Synthese* 54, 3 (Mar, 1983), 375-407. JSTOR: http://www.jstor.org/stable/20115846.
13. Ken Binmore, 2008. Do conventions need to be common knowledge? *Topoi* 27 (Jul, 2008), 17-27. DOI:https://doi.org/10.1007/s11245-008-9033-4.
14. Giacomo Sillari, 2008. Common Knowledge and Convention. *Topoi* 27 (Jul, 2008), 29-39. DOI:https://doi.org/10.1007/s11245-008-9030-7.
15. Kyle A. Thomas, Peter DeScioli, Omar Sultan Haque, and Steven Pinker, 2014. The Psychology of Coordination and Common Knowledge, *Journal of Personality and Social Psychology* 107, 4, 657–676. DOI:https://doi:10.1037/a0037037.

Predicting Trust in Science in the Context of COVID-19 Pandemic: The Role of Sociodemographics and Social Media Use

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ABSTRACT

Research in the context of COVID-19 pandemic has consistently shown that scientific distrust adversely affects health-related behavior. Therefore, the aim of our study was to identify the risk factors for the development of scientific distrust, with emphasis on the role of sociodemographic variables and social media use. A convenience sample of 490 Slovene speaking individuals was used to perform hierarchical linear regression analysis. In line with our hypotheses, the results showed that trust in science was negatively correlated with age, religiosity and use of social media as an information source about COVID-19, while it was positively correlated with male gender and total years of formal education. When only sociodemographic variables were entered into the prediction model, each of them explained a significant proportion of the variance in trust in science. However, after the inclusion of social media use, religiosity was no longer a significant predictor. In contrast to our expectations, the results also showed no significant interaction between education and social media use when predicting trust in science. Our findings are further discussed and additional implications are provided.

KEYWORDS

COVID-19, trust in science, social media use, education, religiosity

1 INTRODUCTION

When the new coronavirus (Sars-CoV-2) started to spread in 2020 it has quickly become evident that the world as we knew it was about to change. Ever increasing number of infections led to health system overloads, high mortality rates, mental health difficulties and great economic burden [1]. As adoption of social distancing measures and newly developed vaccines was crucial for reducing the spread of the new coronavirus and its adverse consequences, identification of factors influencing health-related behavior became of utmost importance. One of the variables that has been consistently found to predict preventive behavior as well as vaccine acceptance is trust in science [2].

According to Barber [3] public trust in science depends on the perceptions of scientists' compliance with technical and moral norms. Technical norms consist of expectations that the scientists will perform an assigned task with a certain level of competence and expertise, while moral norms are related to the anticipation that by doing so, they will also act in a way that puts the interest of the community before their personal advances. Similarly, Wintterlin et al. [4] argue that trust in science is rooted in expectations that scientists' claims are epistemically sound and that science has a prosocial stance. Overall, perhaps the most comprehensive definition of trust in science has been provided by Nadelson et al. [5], describing it as a multifaceted construct, which includes affective components, credibility and trustworthiness perceptions, knowledge and epistemic beliefs.

Since scientists were the main source of information on COVID-19 and its adverse consequences, and also the ones that helped governments develop preventive measures and vaccines, the findings that low trust in science negatively impacts health-related behavior [2] should not come as a complete surprise. However, not much has been researched about the predictors of trust in science in the context of the pandemic. As we believe this kind of knowledge is crucial to implement communication changes, which could accurately address those who are particularly prone to developing scientific mistrust, we conducted a study focusing on the sociodemographic predictors of trust in science as well as its connection to social media use.

1.1 Predictors of Trust in Science

Previous research on the relationship between trust in science and age has shown somewhat mixed results. For example, some researchers reported on non-significant correlations [6], while others found that scientists were more likely to be trusted by those who are younger [7]. The latter result could in part be explained by higher average levels of education among younger individuals, however age remained an important predictor even when education was accounted for [7].

Regarding gender, previous research has consistently shown that men generally have more positive attitudes towards science than women [6][8]. However, when possible reasons for these results were examined, other sociodemographic variables, such as education, religiosity and work status were found to explain this gender gap [8].

Throughout history, religion and science were often seen as epistemologically conflicted [9], which may have resulted in lower trust in science by those who are more religious. Indeed, previous research has shown that religiosity was associated with negative attitudes towards science as well as lower science literacy [5][10].

Another sociodemographic factor that has been consistently shown to predict trust in science is education [6]. One of the most prevalent explanations for the described relationship was that

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education indirectly influences positive attitudes towards science by increasing scientific knowledge [11]. However, further research showed that education remained an important predictor of trust even when controlling for scientific knowledge [12].

Although previous research has indicated that social media use positively predicts trust in science [13], we believe that the results might be different in the times of COVID-19 pandemic. Since social platforms enabled rapid misinformation dispersion [14], extensive social media use could lower trust in science by increasing conspiracy beliefs about scientists' involvement in the pandemic. Indeed, our previous research [15] showed that the extent of using social media as an information source predicted COVID-19 conspiracy beliefs, which were also highly inversely correlated with trust in science.

1.2 The Present Research

The aim of our study was to examine the importance of several sociodemographic variables and social media use in predicting trust in science. Based on the previous findings we hypothesized that trust in science will be higher among younger individuals (H1), men (H2), those who are less religious (H3), more educated (H4) and those who obtained less information about the coronavirus from the social media (H5). Additionally, we hypothesized that education would have a moderating role in the relationship between social media use and trust in science (H6). Since critical thinking has been found to develop through education [16], we assumed that even extensive social media use would not reflect in high levels of scientific distrust as long as individuals would be capable to critically evaluate the quality of obtained information. Furthermore, we also aimed to investigate the amount of the variance in trust in science that a combination of these variables could explain as well as their relative importance when entered into a multivariate prediction model.

2 METHOD

2.1 Sample

Data collection took place between March 29 and April 7, 2021, using an online survey. Convenience sample was used, consisting mostly of students at the University of Ljubljana and members of different COVID-19 related Facebook groups. Responses of 490 participants (397 women, 92 men and one non-binary), aged from 18 to 70 years (M = 35.7, SD = 13.2), were analyzed. The majority (56.5%) of the participants had a college degree, 41.8% reported on having a high school diploma and 1.6% completed only elementary school. Furthermore, 31.6% of them were students, 54.7% were employed, 9.0% were unemployed and 4.7% were retired.

2.2 Measures

Demographic data was obtained through a series of questions on age, gender, years of education and employment status.

Religiosity was measured by the participants' level of agreement with the statement "*I would define myself as a religious person."* on a 7-point Likert scale with anchors, 1 (*Strongly disagree*) and 7 (*Strongly agree*).

Use of social media as an information source about COVID-19 was measured by moving an interactive slider between values 0 and 100 to estimate the percentage of information about the new coronavirus they obtained through social media.

Trust in Science was measured by the Trust in Science and Scientists Inventory [5], which contains 21 items (e.g., *We can trust science to find answers that explain the natural world.*). Participants were asked to rate their agreement with the provided statements on a 5-point Likert scale with anchors, 1 (*Strongly disagree*) and 5 (*Strongly agree*). Confirmatory factor analysis (CFA) showed poor one-factor model fit, so we excluded item 11, which was semantically very similar to items 9 and 10. Additionally, we allowed for some residual covariances according to modification indexes. The fit of the modified 20-item scale was acceptable: $\chi 2(166) = 484.642$, $p < .001$, CFI = .939, TLI = .930, RMSEA = .070, 90% CI: [.063, .078], SRMR = .042. The shorter version of the scale also showed excellent internal consistency ($\alpha = .95$).

3 RESULTS

Firstly, the factor structure of the translated Trust in Science and Scientist Inventory was assessed by confirmatory factor analysis (CFA), using R package lavaan [17]. Since the data were non-normally distributed, we used the robust maximum likelihood method (MLM) of model estimation. After minor modifications were implemented to achieve an acceptable one-factor model fit, the total trust in science score was calculated as a mean value of all items. All further analyses were done in IBM SPSS version 25.0 [18].

Secondly, descriptive statistics and intercorrelations were calculated for all measured variables. The results showed that trust in science was negatively correlated with age (r = -.14, p = .002), religiosity (r = -.16, $p < .001$) and use of social media as an information source about COVID-19 (r = -.35, $p < .001$), while it was positively correlated with male gender (r_{pb} = .21, $p < .001$) and total years of formal education (r = .29, $p < .001$).

Thirdly, when we determined that all assumptions for multiple linear regression were met, hierarchical linear regression analysis was conducted. Trust in science was entered into the analysis as a criterion variable, while all other measured variables were consecutively added as predictors (see Table 1). In the first step age and gender together explained 6.5% of variance in trust in science with younger individuals and men exhibiting more trust. Both predictors were significant, although the relative importance of gender was greater. In the second step religiosity explained only 1.8% of additional variance in trust in science, however the change in R^2 was statistically significant. Those who were less religious showed significantly higher levels of trust even when age and gender were accounted for. Furthermore, both age and gender remained significant predictors of trust despite slight decrease of gender's β value. In the third step the years of formal education turned up to be the most important positive predictor of trust in science, additionally explaining 6.7% of its variance. Inclusion of education slightly lowered the β values of age and religiosity, however all included predictors remained statistically significant. In the fourth step the share of COVID-19 information obtained from social media was added into the equation, explaining an additional 5.8% of variance in trust in science. The results showed that those who relied more on social networks to obtain information were less likely to trust in science. Altogether, a combination of five

Table 1: The results of the hierarchical linear regression analysis

	Step 1			Step 2			Step 3			Step 4			Step 5		
Variable	***B***	***SE***	**β**	***B***	***SE***	**β**	***B***	***SE***	**β**	***B***	***SE***	**β**	***B***	***SE***	**β**
Age	-.01	.00	-.14**	-.01	.00	-.14**	-.01	.00	-.11**	-.01	.00	-.11**	-.01	.00	-.11**
Male gender	.46	.10	.21***	.42	.10	.19***	.41	.09	.19***	.28	.09	.13**	.28	.09	.13**
Religiosity				-.07	.02	-.14**	-.05	.02	-.11*	-.03	.02	-.07	-.03	.02	-.07
Education							.10	.02	.26***	.08	.02	.21***	.09	.03	.22**
SM information										-.01	.00	-.26***	-.01	.01	-.21
Edu x SM info													.00	.00	-.05
R^2			.064			.083			.149			.207			.207
$\triangle R^2$			.064***			.018**			.067***			.058***			.000

Note. *$p < .05$. **$p < .01$. ***$p < .001$.

predictors explained 20.7% of variance in trust in science. However, after the variable of social media use was included, β values of gender, education and religiosity decreased, thus designating religiosity as a non-significant predictor. Finally, analysis in the fifth step showed that there was no significant interaction between education and social media use when predicting trust in science.

4 DISCUSSION AND CONCLUSIONS

The aim of our research was to examine the predictors of trust in science in the context of COVID-19 pandemic since such knowledge could be used to implement communication changes that might motivate higher compliance with preventive measures and protect public health.

Regarding age, the results were in line with our assumption that younger individuals are more likely to trust in science (H1). Although our finding is supported by some of the previous research [7], it is still somewhat surprising, since general trust is known to increase with age [19]. Negative relationship between trust in science and age could be explained by lower average educational levels among the elderly, as both knowledge about science and certain cognitive skills, which are thought to be related to higher trust in science [6][20] are developed through education [16][21]. Indeed, in our study age and education were negatively correlated (r = -.12, p = .010), however age remained a significant predictor even when education was controlled for. Another possibility may be that the relationship between age and trust in science is underlaid by religiosity, as previous research showed that older individuals are more likely to be religious [22] and that religiosity also predicts lower trust in science [10]. However, our results showed that religiosity and age were not significantly correlated (r = -.03, p = .504), therefore undermining the described reasoning.

The results of our study were also in line with the assumption that male gender would be positively related to trust in science (H2). Even though some of the previous studies [8] indicated that this relationship could be entirely accounted for by other sociodemographic variables, we found that gender remained a significant predictor of trust in science even when age, religiosity and years of education were controlled. One possible explanation for this result may be that on average women have less specific science-related knowledge than men. Although in our research male gender was not significantly related to years of total education (r_{pb} = .04, p = .440), education of men and women might differ in terms of its type and field of interest. For example, Global Gender Gap Report 2022 showed that only 33% of STEM graduates in Slovenia are female [23]. In line with the above, Fox & Firebaugh [24] also found that years of education did not explain the gender gap in science confidence. Moreover, their research pointed out that gender differences can in large part be attributed to lower perceived utility of science by women.

Based on previous studies, which showed that religiosity predicts negative attitudes towards science [10], we also hypothesized that religiosity would be negatively associated with trust in science (H3). The results were in line with our assumption, however when in addition to all other sociodemographic variables, social media use was inserted into the model, religiosity was no longer a significant predictor of trust in science. Indeed, an unusual positive correlation could be observed between religiosity and social media use as an information source about COVID-19 (r = .21, $p < .001$). A possible explanation for this phenomenon may be that social media use is highly prevalent among religious individuals since social networks are often seen as channels that can be used to effectively minister to others [25]. Obtaining (mis)information from social media may thus be a side effect of extensive use of social networks for other purposes. An alternative explanation may also be that religious individuals are more likely to adopt conspiracy beliefs [15]. Since conspiracy ideation is likely to influence the perception of traditional media as deceiving [26], those who are more religious may thus be inclined to use informal sources of information, such as social media.

Regarding education and social media use, the results supported both of our hypotheses that trust in science would be positively related to years of education (H4) and negatively related to perceived share of information about COVID-19 that was obtained on social media (H5). Although more educated

individuals were also less religious (r = -.10, p = .023) and obtained smaller share of information on social media (r = -21, p < .001), education remained an important predictor of trust in science even when other variables were controlled. As previously suggested, this could be explained by the fact that critical thinking, which is thought to interrelate with trust in science [20], develops through education [16]. Furthermore, in contrast to previous research that reported on the positive relationship between social media use and trust in science [13], our results showed that in the times of the COVID-19 pandemic obtaining information from social media might in fact be detrimental for trust in science. Since social media's regulations on shared content are less strict compared to the traditional media, we believe the quick dispersion of COVID-19 conspiracy beliefs through social media could lower trust in science. Additionally, we hypothesized that social media use would not reflect in high levels of scientific distrust as long as the individuals would be sufficiently educated (H6). We assumed that well educated individuals would be able to critically evaluate the quality of obtained information due to their advanced critical thinking skills [16]. In contrast to our expectations, the results showed that there was no significant interaction between education and social media use when predicting trust in science. In our opinion, this finding could be based on the fact that: a) years of education are not a valid indicator of critical thinking skills, or b) that critical thinking abilities are somewhat irrelevant in the case when one's information space is so limited that they do not have any relevant data upon which information from social media could be judged.

To conclude, our findings suggest that in order to restore trust in science and reinforce health-related behavior in the context of the pandemic, it would be expedient to develop communication strategies that would specifically target older women, who are less educated, more religious and are extensive social media users. However, these findings are subjected to some limitations of our research design. Firstly, the data may not be entirely representative due to the convenience sampling method. Secondly, correlational design of our study does not allow for causal inferences. And thirdly, the used trust in science measure was one-dimensional, although some researchers argue that it is necessary to differentiate between trust in scientific methods and trust in scientific institutions [27]. Therefore, our suggestion for future research would be to examine how these two distinct forms of trust in science relate to health behavior and to identify which are the most important risk factors for either of them.

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REFERENCES

[1] Office for National Statistics, 2021. *Leaving no one behind – a review of who has been most affected by the coronavirus pandemic in the UK: December 2021*. Office for National Statistics, Newport. Available at: https://www.ons.gov.uk/economy/environmentalaccounts/articles/leavingnoonebehindareviewofwhohasbeenmostaffectedbythecoronaviruspandemicintheuk/december2021#economic-impact

[2] Yann Algan Eva Davoine, Martial Foucault and Stefanie Stantcheva, 2021. Trust in scientists in times of pandemic: Panel evidence from 12 countries. *Proceedings of the National Academy of Sciences of the United States of America* 118, 40 (Sep, 2021), Article e2108576118. DOI: 10.1073/pnas.2108576118

[3] Bernard Barber, 1987. Trust in science. *Minerva* 25 (Mar, 1987), 123–134 DOI: 10.1007/BF01096860

[4] Florian Wintterlin, Friederike Hendriks, Niels Mede, Rainer Bromme, Julia Metag and Mike Schäfer, 2022. Predicting public trust in science: The role of basic orientations toward science, perceived trustworthiness of scientists, and experiences with science. *Frontiers in Communication* 6 (Jan, 2022). DOI: 10.3389/fcomm.2021.822757

[5] Louis Nadelson, Cheryl Jorcyk, Dazhi Yang, Mary Jarratt Smith, Sam Matson, Ken Cornell and Virginia Husting, 2014. Trust in science and scientists. *School Science and Mathematics* 114 (Jan, 2014), 76–86. DOI: 10.1111/ssm.12051

[6] Fabienne Crettaz von Roten, 2004. Gender differences in attitudes toward science in Switzerland. *Public Understanding of Science,* 13 (Apr, 2004) 191–199. DOI: 10.1177/0963662504043870

[7] Paul Brewer and Barbara Ley, 2013. Whose science do you believe? Explaining trust in sources of scientific information about the environment. *Science Communication* 35, 1 (Feb, 2013), 115–137. DOI: 10.1177/1075547012441691

[8] Bernadette C. Hayes and Vicki N. Tariq, 2000. Gender differences in scientific knowledge and attitudes toward science: a comparative study of four Anglo-American nations. *Public Understanding of Science* 9 (Oct, 2000), 433–447. DOI: 10.1088/0963-6625/9/4/306

[9] John Evans and Michael Evans, 2008. Religion and science: Beyond the epistemological conflict narrative. *Annual Review of Sociology* 34 (Aug, 2008), 87–105. DOI: 10.1146/annurev.soc.34.040507.134702

[10] Jonathon McPhetres and Miron Zuckerman, 2018. Religiosity predicts negative attitudes towards science and lower levels of science literacy. *PLoS ONE* 13, 11 (Nov, 2018), Article e0207125. DOI: 10.1371/journal.pone.0207125

[11] Amitai Etzioni and Clyde Nunn, 1974. The public appreciation of science in contemporary America. *Daedalus* 103, 3 (Jan, 1974), 191–205. DOI: 10.1007/978-94-010-1887-6_15

[12] Hee-Je Bak, 2001. Education and public attitudes toward science: Implications for the "Deficit Model" of education and support for science and technology. *Social Science Quarterly* 82, 4 (Dec, 2001), 779–795. DOI: 10.1111/0038-4941.00059

[13] Brigitte Huber, Matthew Barnidge, Homero Gil de Zúñiga and James Liu, 2019. Fostering public trust in science: The role of social media. *Public understanding of science* 28, 7 (Sep, 2019), 759–777. DOI: 10.1177/0963662519869097

[14] Ramez Kouzy, Joseph Abi Jaoude, Atif Kraitem, Molly B. El Alam, Basil Karam, Elio Adib, Jabra Zarka et al., 2020. Coronavirus goes viral: Quantifying the COVID-19 misinformation epidemic on Twitter. *Cureus* 12, 3 (Mar, 2020), Article e7255. DOI: 10.7759/cureus.7255

[15] Žan Zelič, Martin Berič and Darja Kobal Grum, 2022. Examining the role of Covid-19 conspiracy beliefs in predicting vaccination intentions, preventive behavior and willingness to share opinions about the coronavirus. *Studia Psychologica* 64, 1 (Mar 2022), 136–153. DOI: 10.31577/sp.2022.01.844

[16] Christopher R. Huber and Nathan R. Kuncel, 2016. Does college teach critical thinking? A meta-analysis. *Review of Educational Research* 86, 2 (Jun, 2016), 431–468. DOI: 10.3102/0034654315605917

[17] Yves Rosseel, 2012. lavaan: An R package for structural equation modeling. *Journal of Statistical Software* 48, 2 (May, 2012), 1–36. DOI: 10.18637/jss.v048.i02

[18] IBM Corp. 2017. IBM SPSS Statistics for Windows, Version 25.0. IBM Corp., Armonk, NY.

[19] Michael Poulin and Claudia Haase, 2015. Growing to trust: Evidence that trust increases and sustains well-being across the life span. *Social Psychological and Personality Science* 6, 6 (Mar, 2015), 614–621. DOI: 10.1177/1948550615574301

[20] John Kleinig, 2016. Trust and critical thinking. *Educational Philosophy and Theory* 50, 2 (Jun, 2016), 1–11. DOI: 10.1080/00131857.2016.1144167

[21] Bryan Kennedy and Meg Hefferon, 2019. *What Americans know about science?* Pew Research Center, Washington, DC. Available at: https://www.pewresearch.org/science/2019/03/28/what-americans-know-about-science/

[22] Vern L. Bengtson, Merril Silverstein, Norella M. Putney and Susan C. Harris, 2015. Does religiousness increase with age? Age changes and generational differences over 35 years. *Journal for the Scientific Study of Religion* 54, 2 (Sep, 2015), 363–379. DOI: 10.1111/jssr.12183

[23] *Global Gender Gap Report 2022*. World Economic Forum, Geneva. Available at: https://www.weforum.org/reports/global-gender-gap-report-2022/

[24] Mary F. Fox and Glenn Firebaugh, 1992. Confidence in science: The gender gap. *Social Science Quarterly* 73, 1 (Mar, 1992), 101–113.

[25] Pamela J. Brubaker and Michel M. Haigh, 2017. The religious Facebook experience: Uses and gratifications of faith-based content. *Social Media + Society* 3, 2 (Apr, 2017), 1–11. DOI: 10.1177/2056305117703723

[26] Stephen Marmura, 2014. Likely and Unlikely Stories: Conspiracy Theories in an Age of Propaganda. *International Journal of Communication 8*, 1 (May, 2014), 2377–2395.

[27] Peter Achterberg, Willem de Koster and Jeroen van der Waal, 2017. A science confidence gap: Education, trust in scientific methods, and trust in scientific institutions in the United States, 2014. *Public understanding of science* 26, 6 (Dec, 2015), 704–720. DOI: 10.1177/0963662515617367

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Odkrivanje znanja in podatkovna skladišča - SiKDD
Data Mining and Data Warehouses - SiKDD

Urednika / Editors

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PREDGOVOR

Tehnologije, ki se ukvarjajo s podatki so v devetdesetih letih močno napredovale. Iz prve faze, kjer je šlo predvsem za shranjevanje podatkov in kako do njih učinkovito dostopati, se je razvila industrija za izdelavo orodij za delo s podatkovnimi bazami, prišlo je do standardizacije procesov, povpraševalnih jezikov itd. Ko shranjevanje podatkov ni bil več poseben problem, se je pojavila potreba po bolj urejenih podatkovnih bazah, ki bi služile ne le transakcijskem procesiranju ampak tudi analitskim vpogledom v podatke – pojavilo se je t.i. skladiščenje podatkov (data warehousing), ki je postalo standarden del informacijskih sistemov v podjetjih. Paradigma OLAP (On-Line-Analytical-Processing) zahteva od uporabnika, da še vedno sam postavlja sistemu vprašanja in dobiva nanje odgovore in na vizualen način preverja in išče izstopajoče situacije. Ker seveda to ni vedno mogoče, se je pojavila potreba po avtomatski analizi podatkov oz. z drugimi besedami to, da sistem sam pove, kaj bi utegnilo biti zanimivo za uporabnika – to prinašajo tehnike odkrivanja znanja v podatkih (data mining), ki iz obstoječih podatkov skušajo pridobiti novo znanje in tako uporabniku nudijo novo razumevanje dogajanj zajetih v podatkih. Slovenska KDD konferenca pokriva vsebine, ki se ukvarjajo z analizo podatkov in odkrivanjem znanja v podatkih: pristope, orodja, probleme in rešitve.

FOREWORD

Data driven technologies have significantly progressed after mid 90’s. The first phases were mainly focused on storing and efficiently accessing the data, resulted in the development of industry tools for managing large databases, related standards, supporting querying languages, etc. After the initial period, when the data storage was not a primary problem anymore, the development progressed towards analytical functionalities on how to extract added value from the data; i.e., databases started supporting not only transactions but also analytical processing of the data. At this point, data warehousing with On-Line-Analytical-Processing entered as a usual part of a company’s information system portfolio, requiring from the user to set well defined questions about the aggregated views to the data. Data Mining is a technology developed after year 2000, offering automatic data analysis trying to obtain new discoveries from the existing data and enabling a user new insights in the data. In this respect, the Slovenian KDD conference (SiKDD) covers a broad area including Statistical Data Analysis, Data, Text and Multimedia Mining, Semantic Technologies, Link Detection and Link Analysis, Social Network Analysis, Data Warehouses.

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Emotion Recognition in Text using Graph Similarity Criteria

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ABSTRACT

In this paper, a method of classifying text into several emotion categories employing different measures of similarity of two graphs is proposed. The emotions utilized are happiness, sadness, fear, surprise, anger and disgust, with the latter two joined into one category. The method is based on representing a text as a graph of n-grams; the results presented in the paper are obtained using the value of 5 for n: the n-grams were the sequences of 5 characters. The graph representation of the text was constructed based on observing which n-grams occur close together in the text; additionally, frequencies of their connections were utilized to assign edge weights. To classify the text, the graph was compared with several emotion category graphs based on different graph similarity criteria. The former relate to common vertices, edges, and the maximum common subgraphs. The evaluation of the model on the test data set shows that utilizing the construction of the maximum common subgraph to obtain the graph similarity measure results in more accurate predictions. Additionally, employing the number of common edges as a graph similarity criterion yielded more accurate results compared to employing the number of common vertices to measure the similarity between the two graphs.

KEYWORDS

emotion recognition, text classification, machine learning, graphs, graph similarity

1 INTRODUCTION

Emotion recognition is a problem that can be connected to different fields such as natural language processing, computer vision, deep learning, etc. [4] In this paper, the focus is on the task of recognizing emotions in texts.

In the literature, several approaches have been introduced that target this problem. Some of them employ vertex embedding vectors for emotion detection and recognition from text. The embedding vectors grasp the information related to semantics and syntax; however, a limitation of such approaches is that they do not capture the emotional relationship that exists between words. Some methods attempting to alleviate this issue include building a neural network architecture adopting pre-trained word representations. [3] Some text classification approaches employ n-grams to construct the text representation, e.g., to deal with the task of language identification. [9]

In this paper, the approach to emotion recognition employs n-grams to obtain graph representation of text. The text is viewed as a sequence of characters that is divided into n-grams, i.e., shorter overlapping sequences of characters as presented in Figure 1.

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In Section 2, it is further explained how the graph of n-grams is constructed for a given text and how an emotion label is assigned to the text based on the similarity with the emotion category graphs. Afterwards, in Section 3, the method is compared with related approaches.

In Section 4, an overview of results is focused on differences between the performance of the model when different graph similarity criteria are used. It is followed by the discussion of the model's limitations in Section 5.

2 PROPOSED METHOD

2.1 Constructing the Graph of n-grams

The method used in the paper to obtain text representation in the form of the graph of n-grams is the following.

- The given text was separated into n-grams of characters. Also, different values of n have been tested. The results in Section 4, use $n = 5$. The n-grams into which the given text was split were overlapping.
- The n-grams obtained in this way were utilized to represent the labels of vertices of the graph.
- The edges of the graph were created in the following manner. The ends of edges were the vertices that corresponded to n-grams that occurred close to each other in the text, e.g., the edge is connecting the first n-gram at the beginning of the text with the second n-gram (these two n-grams would overlap with each other), as seen in Figure 1. Different values have been tested for the maximal distance between the two vertices allowed for these two vertices to still be connected with the edge. The results in Section 4, use the value of 7.
- Performance of the model with both, the directed and the undirected graphs, has been tested.

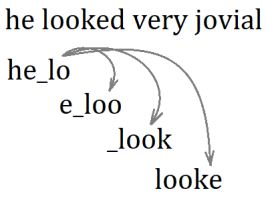

Figure 1: Constructing the edges between the 5-grams that occur close to each other

In Figure 2, it is depicted how the edges are constructed between the vertices labelled with n-grams. For the clarity of representation, each n-gram is shown connected to 3 other n-grams instead of 7. It is important to note that if the same n-grams occurred in the text more than once, there was still only one vertex with this n-gram as a label: the connections of the n-gram have been aggregated at a single vertex.

Additionally, the graph constructed is weighted. The weights of the edges are obtained utilizing the frequencies of connections

of n-grams in the given text. In other words, the edge weights are initialized to 0. Then, when constructing the graph of n-grams for a text, every time a certain edge would be added, instead of adding it, the weight of the edge is increased by 1.

Afterwards, the edge weights are normalized to be in the range (0, 1); hence, the edge weights are more comparable among the graphs of n-grams for different texts.

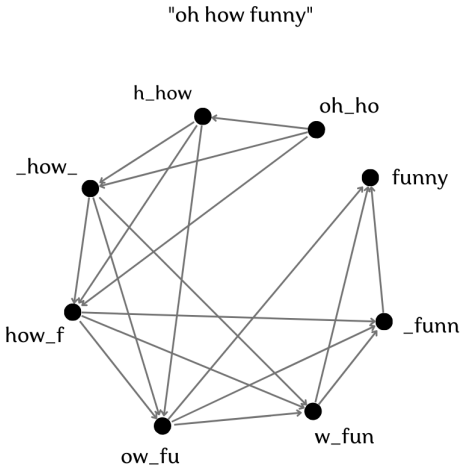

Figure 2: Constructing the edges between the 5-grams in the text fragment *"oh how funny"*

2.2 Constructing the Emotion Category Graphs

The core of the method is the construction of the graph of n-grams as described in Section 2.1. In the data set used to tune the model, there were shorter texts labelled with one of the following 5 emotions: happy, sad, surprised, fearful, or angry-disgusted. Overall, there were 1207 sentences included in the data set; out of this, the model was trained using 1086 sentences (to construct the emotion category graphs) and evaluated on 121 sentences (the split proportion is 90 : 10).

The process of obtaining the emotion category graphs is presented below.

(1) The data set was split into 5 parts containing only the text labelled with the same emotion.
(2) Then, the texts in each part of the data set were used to obtain 5 graphs corresponding to each emotion.
   (a) This process can be viewed as for each text labelled with a certain emotion, constructing the graph of n-grams as explained in Section 2.1.
   (b) Afterwards, merge these graphs separately for different emotions to obtain 5 larger graphs of n-grams; during the merging process, the edges are aggregated in such a way that there are not any two vertices in the emotion category graph sharing the same label (the character n-gram to which they correspond).

2.3 Assigning an Emotion to a Given Text

Utilizing the 5 emotion category graphs corresponding to different emotions, for a given text, it is determined, to which emotion the text most likely corresponds. For that, the pairwise similarity measures of the graph of the given text and of the 5 emotion category graphs are employed.

In other words, it is tested, to which of the 5 graphs the graph of the given text is most similar and the corresponding emotion is assigned to the given text.

Several similarity criteria of the two graphs have been explored.

(1) The number of *vertices* common to both graphs: the vertices are considered common if they share the same label (the n-gram they represent) in both graphs.
(2) The number of *edges* common to both graphs: the edge is considered common if the same vertices (vertices with the same labels) are the endpoints of the edge in both graphs and the edge weights are the same.
(3) The number of vertices in the *maximum common subgraph* (MCS) of the two graphs. Finding the maximum common subgraph is equivalent to finding a graph with the maximum number of vertices so that it is a subgraph of each of the two graphs. [8]
(4) The number of edges in the maximum common subgraph (MCS) of the two graphs.
(5) $z = \frac{m(m-1)}{2} - e$, where m denotes the number of vertices in the maximum common subgraph of the two graphs, and e denotes the number of edges in the maximum common subgraph.

3 RELATED WORK

In the literature describing related approaches to text classification and emotion recognition, deep learning models are often utilized to obtain high-quality predictions. [7]

Apart from the approaches that employ word embedding vectors [6], there are also methods that connect neural networks and graphs. Such approaches may be similar to the method described in this paper since the graph representation of text may be obtained in a similar way based on the semantic connections between words. One example of this kind of model is the graph neural network that is enhanced by utilizing BERT to obtain semantic features. [11]

The crucial part of the method in this paper is the graph similarity criterion that is used when comparing the graph of the given text with different emotion category graphs. The similar way as the construction of the maximum common subgraph is used in this method, it can be employed in combination with the probabilistic classifiers. [10]

The approach in this paper, on the other hand, does not employ probabilistic classifiers such as Bayes Classification or Support Vector Machine. [2] Instead, the emotion for which the similarity measure between the corresponding emotion category graph and the graph of the given text is maximised is assigned to the text.

Additionally, it is important to note that it is possible to incorporate alternative graph similarity criteria, e.g., related to subgraph matching, edit distance, belief propagation, etc. [5]

4 RESULTS

4.1 Experimental Setup

The data set used to train and evaluate the model was the one distributed by Cecilia Ovesdotter Alm. [1] It included the sentences each labelled with one of the following emotions: happiness, sadness, fear, surprise, anger, and disgust. The latter two emotions were joined into one category.

During the evaluation stage, for each sentence, a corresponding emotion was predicted, e.g., the text *"then the servant was*

Table 1: Results of text classification using directed graphs

Similarity criterion	Accuracy	Precision	Recall	F1
Common vertices	0.488	0.506	0.332	0.323
Common edges	0.537	**0.683**	0.408	0.432
z	0.372	0.074	0.200	0.108
Vertices in the MCS	0.570	0.622	0.426	0.446
Edges in the MCS	**0.579**	0.625	**0.454**	**0.478**

Table 2: Results of text classification using undirected graphs

Similarity criterion	Accuracy	Precision	Recall	F1
Common vertices	0.488	0.506	0.332	0.323
Common edges	0.554	**0.669**	0.429	**0.460**
z	0.372	0.074	0.200	0.108
Vertices in the MCS	0.545	0.527	0.399	0.406
Edges in the MCS	**0.570**	0.581	**0.439**	0.453

greatly frightened and said it may perhaps be only a cat or a dog" was labelled fearful, while the text *"he looked very jovial did little work and had the more holidays*" was recognized to be related to the emotion of happiness.

The value of n that appeared to yield the best results and was also used to obtain the results in Tables 1 and 2 was 5. Furthermore, each 5-gram (except those at the end of the text) is connected to 7 5-grams further in the text.

In Tables 1 and 2, the "common edges" criterion means that the two edges from both graphs are considered common if they have the same weight and the same endpoints.

Additionally, in Table 1, z denotes the difference between the the actual number of edges in the maximum common subgraph and the number of edges in the complete graph with m vertices, where m is the number of vertices in the maximum common subraph.

In the trials that yielded the results in Table 1, the edges were directed and in the trials that yielded the results in Table 2, the edges were undirected.

4.2 Analysis

From the results in Table 1 and 2, it may be noticed that the highest accuracy on the test data set was achieved when the number of edges in the maximum common subgraph was used as the similarity measure. In Table 1, the second highest accuracy was achieved when the number of vertices in the maximum common subgraph was utilized.

From this, it may be observed that the construction of the maximum common subgraph reflects the similarity better in certain cases; possible reasons may be that deeper semantic relationships can be captured this way since connections between multiple n-grams are considered at the same time.

In Tables 3 and 4, the confusion matrices are presented for the trials when the number of edges in the maximum common subgraph was used as the criterion of graph similarity.

From the Tables 1 and 2, it is evident that this similarity criterion corresponded to the highest accuracy of predictions for both undirected and directed graphs. However, the accuracy corresponding to this similarity criterion is higher when the graphs are directed (0.579 compared to 0.570).

Table 3: Confusion matrix: directed graph, number of edges in the MCS as the similarity criterion

Actual/pred.	Happy	Fearful	Surpr.	Sad	Angry-Disg.
Happy	**43**	1	0	0	1
Fearful	7	**6**	1	3	0
Surprised	6	1	**2**	1	1
Sad	12	1	0	**12**	1
Angry-Disg.	11	2	0	2	**7**

Table 4: Confusion matrix: undirected graph, number of edges in the MCS as the similarity criterion

Actual/pred.	Happy	Fearful	Surpr.	Sad	Angry-Disg.
Happy	**42**	1	0	1	1
Fearful	8	**6**	1	2	0
Surprised	6	1	**1**	1	2
Sad	11	1	0	**13**	1
Angry-Disg.	11	2	0	2	**7**

Table 5: Confusion matrix: directed graph, number of common edges as the similarity criterion

Actual/pred.	Happy	Fearful	Surpr.	Sad	Angry-Disg.
Happy	**42**	1	0	2	0
Fearful	10	**4**	0	3	0
Surprised	6	0	**2**	3	0
Sad	13	0	1	**12**	0
Angry-Disg.	16	1	0	0	**5**

Table 6: Confusion matrix: undirected graph, number of common edges as the similarity criterion

Actual/pred.	Happy	Fearful	Surpr.	Sad	Angry-Disg.
Happy	**41**	1	0	2	1
Fearful	11	**4**	0	2	0
Surprised	6	0	**2**	3	0
Sad	12	0	1	**13**	0
Angry-Disg.	14	1	0	0	**7**

Furthermore, the accuracy corresponding to the similarity criterion being the number of the common edges (considering both the endpoints and the weight of the edge) is higher by 0.017 when the graphs are undirected than when the graphs are directed (0.554 compared to 0.537). When the graphs utilized are undirected, the model might be more flexible regarding the exact order of the words that occur together.

In Tables 5 and 6, confusion matrices are presented for the trials when the number of edges common to both graphs, considering the endpoints and the weights of the edges, was used as the the criterion of graph similarity.

5 DISCUSSION

A strength of the approach presented in this paper is the ability to capture the context of the given words on different levels; this is related to the process of constructing the edges of the graph by connecting n-grams that occur together in the text. Additionally,

the breadth of the contextual frame considered may be varied by altering the number of *n*-grams with which a certain *n*-gram is connected when constructing the edges.

However, overall, the accuracy values noted in Tables 1 and 2, were not very high possibly indicating that the training data set was not large enough. Moreover, the data set did not include texts corresponding to different emotions in even proportions resulting in an imbalance which could have also had a detrimental influence on the quality of predictions. The confusion matrices (Tables 3, 4, 5, and 6) indicate, e.g., that the texts were often falsely assigned the emotion of happiness since it was the most abundant class in the data set.

One of the limitations of the design of the model described it that although it may be reasonable to expect that to obtain more accurate predictions on the test data set, training the model (obtaining the emotion category graphs) on a larger corpus of texts is needed, this may bring a significant rise in computational complexity since the category graphs would possess significantly larger amounts of vertices and edges.

This is especially important if the maximum common subgraphs are constructed when obtaining a similarity measure, since for each text in the test data set, a maximum common subgraph would have to be constructed several times: between the graph of *n*-grams for a given text and each emotion category graph (5 such graphs in this case).

A possible solution to the problem of having too large category graphs might be reducing the length of *n*-grams, i.e., using smaller values of *n*, and hence reducing the number of vertices in the graph.

Also, reducing the number of *n*-grams with which a certain *n*-gram is connected when constructing the edges of the graph may be investigated as a possible solution. However, if this value is too low, too much contextual information may be lost; therefore, it appears necessary that for each value of n, the optimal number of *n*-grams with which a certain *n*-gram is connected is determined experimentally.

6 CONCLUSION

In this paper, the model that utilizes graph similarity criteria to classify a given text into one of the emotion categories is described. The core of the method is to construct a graph of *n*-grams for a given text and to compare this graph to each of the emotion category graphs. The text is classified into the emotion category, the graph of which yielded the highest similarity value when compared to the graph of the given text.

From the results of the trials noted in Tables 1 and 2, it may be concluded that among the graph similarity criteria described, that number of edges in the maximum common subgraph resulted in the highest quality of predictions.

Furthermore, it may also be noted that employing the number of edges common to both graphs resulted in higher prediction accuracy than using the number of common vertices (0.537 and 0.488 accuracy for the directed graphs).

This may appear to be intuitively reasonable as using edges may seem to incorporate more contextual information. Additionally, it may be important to investigate the effect of the difference between the size of the graph of *n*-gram for the given text and the size of the emotion category graph on the probability that the same connections between the two *n*-grams are found in both graphs. Moreover, it may be more probable that the same vertices (vertices labelled with the same *n*-gram) are contained in both graphs resulting in more noisy data.

To conclude, the future work on the task of emotion recognition related to the proposed method may, on the one hand, be focused on employing alternative graph similarity measures in addition to those described in this paper, e.g., those connected to deriving the edit distance or to the belief propagation. [5] Furthermore, clustering algorithms may be used to obtain the patterns characteristic to the emotion categories and further employ them for the emotion recognition task. To this end, both, the vertex clustering algorithms as well as the clustering of graphs as objects, might be utilized. Additionally, graph neural network architecture may be built along with incorporating the graphs of *n*-grams as the input for the network.

7 ACKNOWLEDGEMENTS

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REFERENCES

[1] Alm, E. C. O. Affect in text and speech, 2008.
[2] Bahritidinov, B., and Sanchez, E. Probabilistic classifiers and statistical dependency: The case for grade prediction. pp. 394–403.
[3] Batbaatar, E., Li, M., and Ryu, K. H. Semantic-emotion neural network for emotion recognition from text. *IEEE Access 7* (2019), 111866–111878.
[4] Guo, J. Deep learning approach to text analysis for human emotion detection from big data. *Journal of Intelligent Systems 31*, 1 (2022), 113–126.
[5] Koutra, D., Ramdas, A., Parikh, A., and Xiang, J. Algorithms for graph similarity and subgraph matching, 2011.
[6] Li, S., and Gong, B. Word embedding and text classification based on deep learning methods. *MATEC Web of Conferences 336* (01 2021), 06022.
[7] Prasanna, P., and Rao, D. Text classification using artificial neural networks. *International Journal of Engineering and Technology(UAE) 7* (01 2018), 603–606.
[8] Quer, S., Marcelli, A., and Squillero, G. The maximum common subgraph problem: A parallel and multi-engine approach. *Computation 8*, 2 (may 2020), 48.
[9] Tromp, E., and Pechenizkiy, M. Graph-based n-gram language identification on short texts. *Proceedings of Benelearn 2011* (01 2011), 27–34.
[10] Violos, J., Tserpes, K., Varlamis, I., and Varvarigou, T. Text classification using the n-gram graph representation model over high frequency data streams. *Frontiers in Applied Mathematics and Statistics 4* (2018).
[11] Yang, Y., and Cui, X. Bert-enhanced text graph neural network for classification. *Entropy (Basel) 23* (11 2021).

SLOmet – Slovenian Commonsense Description

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ABSTRACT

This paper presents Slovenian commonsense description models based on the COMET framework for English. Inspired by MultiCOMETs approach to multilingual commonsense description, we finetune two Slovenian GPT-2 language models. Experimental evaluation based on several performance metrics shows comparable performance to the original COMET GPT-2 model for English.

KEYWORDS

deep learning, commonsense reasoning, multilingual natural language processing, slovenian language model, gpt-2

1 Introduction

Recent research [1] into commonsense representation and reasoning in the field of natural language understanding has demonstrated promising results for automatic commonsense generation. Given a simple sentence or common entity, such technology can generate plausible commonsense descriptions relating to it. However, further testing on complex sentences, uncommon entities, or by increasing the quantity of requested commonsense descriptions usually gives nonsensical results.

Following the recent success on the automatic generation of commonsense descriptions proposed in COMET-ATOMIC 2020 [1], we focus on extending the COMET framework to the Slovenian language. We investigate the impact of different Slovenian language models on the overall performance of commonsense description generation. In our previous research [2], we expanded on an existing approach for automatic knowledge base construction in English [3] to work on different languages. We utilized the original ATOMIC dataset [4]. This was performed by finetuning the original English GPT model from COMET 2019 on automatically translated Slovenian data and evaluated based on exact overlap for the generated commonsense descriptions. Evaluations were performed on a small subset of 100 sentences. In this work we use the updated ATOMIC-2020 dataset [1] and finetune two Slovenian GPT-2 language models. We evaluate the models' performance using several performance metrics including BLEU, CIDEr, METEOR and ROUGE-L. The evaluation is performed on several thousand sentences and entities; we investigate how the predicted commonsense descriptions' performance relates to the language model used. Furthermore, given the complexity of the Slovenian language compared to English, we anticipate a noticeable drop in performance across all metrics for the Slovenian language models.

The main contributions of this paper are (1) the comparison of the performance of commonsense description models using different Slovenian language models and the English model, (2) a comprehensive evaluation using a variety of performance metrics. An additional contribution (3) is the Slovene ATOMIC-2020 dataset acquired by machine translation from the original English dataset [6].

The rest of this paper is organized as follows: Section 2 provides the data description. Section 3 describes the problem and the experimental setting. Section 4 exhibits our evaluation results. The paper concludes with discussion and directions for future work in Section 5.

2 Data Description

To train the Slovenian commonsense description models, we use data from the ATOMIC-2020 dataset, as proposed in the COMET framework for English. The ATOMIC-2020 dataset consists of English sentences and entities, labelled by up to 23 commonsense relation types describing their semantics.

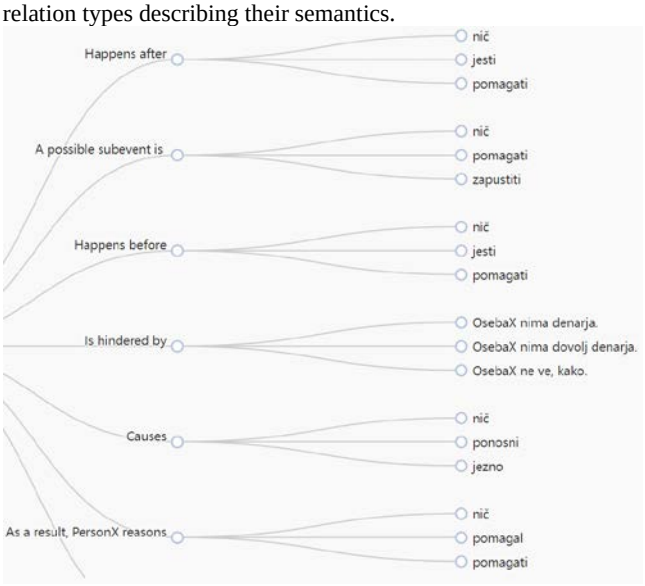

Figure 1 Close-up of "Event-Centered" descriptor values predicted for an example Slovene sentence "PersonX is sad" ("OsebaX je žalostna" in Slovenian)

We refer to them as descriptors, 9 of which are identical to those used in our previous research [2]. The 23 descriptors are organized into 3 categories: "Physical-Entity", "Event-Centered", and "Social-Interaction". The "Physical-Entity" descriptors capture knowledge about the usage, location, content, and other properties of objects. The "Event-Centered" descriptors include IsAfter, Causes and other descriptors describing events. The "Social-Interaction" descriptors include xIntent, xNeed, oReact to distinguish between causes and effects in social settings. An example of a part of a labeled sentence is shown in Figure 1.

Sentences and entities were manually labelled by human workers on Amazon Turk; they were assigned open-text values for 23 commonsense descriptors, reflecting the workers' subjective commonsense knowledge. For instance, when workers were given the sentence "PersonX chases the rabbit" and asked to label it for the "xWant" descriptor, one wrote "catch the rabbit" and another wrote "cook the rabbit for dinner". A more detailed explanation can be found in the ATOMIC-2020 paper. There are 1.33 million (possibly repeating) descriptor values. The distribution of data across the descriptors is depicted in [1].

To finetune our Slovenian language models, we have automatically translated the sentences, entities, and descriptor values from the ATOMIC-2020 dataset from English to Slovenian. The translation was done using DeepL's Translate API [7]. We have found that while the majority of inspected translations were of good quality, there were also incorrect translations due to word disambiguation problems. Nevertheless, we conclude that the dataset is of good enough quality to be used for our experiments. The translated dataset is publicly available [6].

3 Problem Description and Experimental Setting

The addressed problem is predicting the most likely values for each descriptor in the Slovene-translated ATOMIC-2020 dataset, given a Slovenian input sentence or entity. We take inspiration from the approach proposed in MultiCOMET [2].

To compare the performance of the models, we utilize a variety of performance metrics described below. Each performance metric is a value between 0 and 1 indicating the quality of a generated commonsense descriptor value. Values closer to 1 represent higher quality descriptions.

BLEU — Bilingual Evaluation Understudy was first used to evaluate the quality of machine translated text by examining the overlap of candidate text n-grams in the reference text. BLEU-1 only uses 1-grams in the evaluation, while BLEU-4 only considers 4-grams. [8]

CIDEr — Consensus-based Image Description Evaluation was originally used to measure image description quality. It first transforms all n-grams to their root form, then calculates the average cosine similarity between the candidate and reference TF-IDF vectors. [9]

METEOR — Metric for Evaluation of Translation with Explicit Ordering is a metric initially used for evaluating machine translation input. The metric is based on the harmonic mean of unigram precision and recall with other features such as stemming and synonymy matching. [10]

ROUGE-L — Recall-Oriented Understudy for Gisting Evaluation is a metric used for evaluating machine produced summaries or translations against a set of human-produced references. The score is calculated using Longest Common Subsequence based statistics, which involves finding the longest subsequence common to all sequences in a set. [11]

Comparison of the Slovene commonsense models was performed by finetuning two state-of-the-art Slovene GPT-2 language models: macedonizer/sl-gpt2 [12], gpt-janez [13]. As a reference model, we used the original COMET-2020 GPT2-XL English language model [1]. Moving forward, we will refer to our Slovenian finetuned models as "COMET sl-gpt2" and "COMET gpt-janez".

4 Experimental Results

We performed a train, test, and development split on the ATOMIC-2020 dataset identical to the split used in COMET-2020. Our evaluation split consisted of over 150,000 descriptor values with their corresponding sentences and entities.

We finetuned our Slovene commonsense models on our training set consisting of over 1 million descriptor values. Both models were trained for 3 epochs under the same parameters; the maximum input length was set to 50, the maximum output length was set to 80; the training was performed using a train batch size of 64. The model updates were performed using the weighted adam optimizer [14] with the starting learning rate set to 10^{-5}. The experiment's implementation can be found on our GitHub repository [5].

Model	Language	BLEU-1	BLEU-2	BLEU-3	BLEU-4	CIDEr	METEOR	ROUGE-L
COMET sl-gpt2	Slovene	0.297	0.150	0.086	0.058	0.487	0.207	0.383
COMET gpt-janez	Slovene	**0.324**	**0.174**	**0.108**	**0.076**	**0.508**	**0.225**	**0.397**
COMET (GPT2-XL)	English	0.407	0.248	0.171	0.124	0.653	0.292	0.485

Table 1: Comparison of the two Slovene commonsense models with the English model at the bottom.

Experimental results show performance comparable to the original COMET-2020 English model. Both Slovene models were

comparable to the English model across all metrics, "COMET gpt-janez" consistently outperformed "COMET sl-gpt2" achieving a METEOR score of 0.225 compared to 0.207. The performance gap was smallest for BLEU-4, as all models struggled to produce generations whose 4-grams overlapped with those in the reference set. The gap in performance between the Slovene and English models could be attributed to multiple factors. The English model from COMET-2020 was trained for longer on more capable hardware and is larger. Moreover, the machine translation done to acquire our dataset can be erroneous at times.

To illustrate the performance of the models, we investigate their generated descriptor values on the same inputs. Table 2 shows a side-by-side example comparison of the descriptor values generated by our three models, given the same input sentence in their respective language. Table 3 compares the models on an example entity. For the example sentence "Marko went to the shop", the descriptor "oWant" indicates what the others want as a result of the event. "COMET gpt-janez" generates a valid output "None" but fails to provide alternatives. The other two models agree on the most likely descriptor value being "None" ("nič" in Slovenian) and provide plausible alternatives. The "IsBefore" descriptor relates to possible events following the input event. In our case, "COMET gpt-janez" gives the most plausible output of "Buys something". The other two models provide still plausible outputs including "Is in the pet store" and "PersonX buys a new car".

Marko je šel v trgovino (Marko went to the shop)

Descriptor	COMET sl-gpt2	COMET gpt-janez	COMET (GPT2-XL)
oWant	Nič	Nič	None
	Se zahvaliti osebiX	Nič	To give him a receipt
	se zahvaliti	Nič	To give him a discount
IsBefore	Zaslužiti denar	Kupiti nekaj	PersonX buys a new car
	V trgovino za hišne ljubljenčke	Kupiti nekaj	PersonX takes the car back home
	V trgovino z živili	Kupiti nekaj	PersonX buys a new one

Table 2: Illustrative example comparing the output of the three models on the same input sentence across two descriptors.

For our example entity "car", the descriptor "ObjectUse" describes possible usages for that entity. Table 3 shows all models are capable of generating plausible descriptor values for such common entities. Nevertheless, the descriptor "HasProperty" proves challenging for the Slovenian models, suggesting a car is "crazy" and is "found in the car". The English model gives reasonable outputs such as "Found in parking lot".

Avto (car)

Descriptor	COMET sl-gpt2	COMET gpt-janez	COMET (GPT2-XL)
ObjectUse	Vožnja do trgovine	Priti do hiše	Drive to the store
	Vožnja do hiše	Priti do hiše	Get to the store
	Vožnja do cilja	Priti do hiše	Drive to the restaurant
HasProperty	Noro	Najden v avtomobilu	Found in parking lot
	Vrata	Najden v avtomobilu	Found on road
	Pohištvo	Najden v avtomobilu	Found in car dealership

Table 3: Illustrative example comparing the output of the three models on the same input entity across two descriptors.

In our example sentence and entity, COMET gpt-janez returns the same output when different commonsense descriptors are requested. We have observed this for all input sentences and entities thus far. We presume such results are due to the trained parameters in the original gpt-janez model, as macedonizer/sl-gpt2 was finetuned using the same workflow and returns different descriptor values. While unsure of the exact cause, we reason it could be due to an insufficient vocabulary or unoptimized choice of parameters during training.

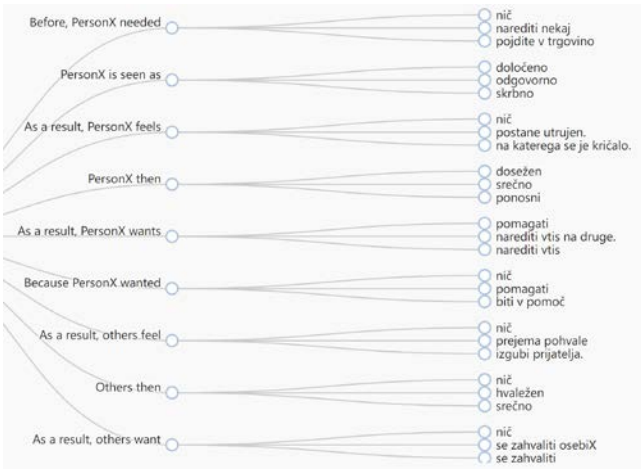

Figure 2 Close-up of "Social-Interaction" descriptor values predicted for an example Slovene sentence "John is very important" ("Janez je zelo pomemben" in Slovenian)

Figures 1, 2 and 3 show the outputs generated by "COMET sl-gpt2" for three different inputs. Figure 2 visualizes the output for the sentence "John is very important". Outputs include "PersonX is then accomplished, happy, proud" and "As a result, others want none, to thank PersonX". We can see that for many descriptors the highest ranked output is "None" ("nič" in Slovenian), indicating no commonsense inference can be made.

Figure 3 Close-up of "Physical-Entity" descriptor values predicted for an example Slovene entity "banana"

Figure 3 exhibits the output for the entity "banana", the model claims the banana can be used to prepare food, is located in a building or shop, desires to be eaten for dinner and does not desire to be frozen. On the other hand, the model claims the banana is made up of clothes and is capable of going to a restaurant. This is likely due to the overall significantly lower number of physical-entity descriptor values provided in the ATOMIC-2020 dataset.

In Figure 1 we can see the "Event-Centered" descriptors for the sentence "PersonX is sad". Top descriptor values are again "None", but the model also claims it is more difficult for PersonX to be sad, if PersonX has no money.

5 Discussion

This paper applied an existing approach to multilingual commonsense description to the Slovene language. To implement our approach, we machine translated the ATOMIC-2020 dataset to Slovene and finetuned two Slovene commonsense models. We compared our models to the original English commonsense model from COMET-2020 and achieved comparable experimental results across multiple performance metrics. Among others, our models achieved a 0.487 CIDEr score, a 0.383 ROUGE-L score, and a BLEU-1 score of 0.297.

Through examination of individual examples, we observed that while "COMET gpt-janez" has the highest performance scores on the Slovene language, it fails to provide alternative descriptor values. "COMET sl-gpt" provides multiple values for the same descriptor, but in average has lower performance. It is important to emphasize the models were trained on subjective commonsense knowledge provided by individual humans. For example, workers labelled the sentence "PersonX digs holes" with the descriptor values "PersonX plants a garden" and "PersonX places fence posts in the holes" for the "IsBefore" descriptor. While both labels are plausible for some context, they are not necessarily true.

Possible directions for future work include evaluating the models' performance for individual descriptors, as there are drastic differences in quantity of training data and lengths of values across them. After achieving results comparable to the original English commonsense model COMET-2020 GPT2-XL, we intend to finetune and evaluate models for other languages.

ACKNOWLEDGMENTS

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REFERENCES

[1] Hwang, J.D., Bhagavatula, C., Le Bras, R., Da, J., Sakaguchi, K., Bosselut, A., & Choi, Y. (2021). COMET-ATOMIC 2020: On Symbolic and Neural Commonsense Knowledge Graphs. AAAI.
[2] Mladenic Grobelnik, A., Mladenić, D., & Grobelnik, M. (2020). MultiCOMET - Multilingual Commonsense Description. In Proc. SiKDD 2020, Ljubljana, Slovenia (pp. 37–40).
[3] Antoine Bosselut, Hannah Rashkin, Maarten Sap, Chaitanya Malaviya, Asli Celikyilmaz, Yejin Choi. (2019). COMET: Commonsense Transformers for Automatic Knowledge Graph Construction.
[4] Maarten Sap, Ronan Le Bras, Emily Allaway, Chandra Bhagavatula, Nicholas Lourie, Hannah Rashkin, Brendan Roof, Noah A. Smith, Yejin Choi. (2019). ATOMIC: An Atlas of Machine Commonsense for If-Then Reasoning. Paul G. Allen School of Computer Science & Engineering, University of Washington, Seattle, USA. Allen Institute for Artificial Intelligence, Seattle, USA.
[5] SLOmet-ATOMIC 2020 Github https://github.com/eriknovak/RSDO-SLOmet-atomic-2020#slomet-atomic-2020-on-symbolic-and-neural-commonsense-knowledge-graphs-in-slovenian-language Accessed 30.08.2022
[6] ATOMIC-2020 Slovene Machine Translated Data https://www.dropbox.com/sh/gs8iqcwpwkaqkuf/AAAmnCqG89JOz_umtq42MMxxa?dl=0 Accessed 30.08.2022
[7] DeepL Translate API https://www.deepl.com/pro-api Accessed 30.08.2022
[8] Papineni, Kishore & Roukos, Salim & Ward, Todd & Zhu, Wei Jing. (2002). BLEU: a Method for Automatic Evaluation of Machine Translation.
[9] Vedantam, R., Lawrence Zitnick, C., & Parikh, D. (2015). Cider: Consensus-based image description evaluation. In Proceedings of the IEEE conference on computer vision and pattern recognition (pp. 4566-4575).
[10] Lavie, Alon & Denkowski, Michael. (2009). The METEOR metric for automatic evaluation of Machine Translation. Machine Translation. 23. 105-115.
[11] Lin, C.-Y. 2004. ROUGE: A Package for Automatic Evaluation of Summaries. In Text Summarization Branches Out.
[12] Documentation page for "macedonizer/sl-gpt2" on HuggingFace https://huggingface.co/macedonizer/sl-gpt2 Accessed 1.09.2022
[13] gpt-janez supporting project: RSDO https://www.cjvt.si/rsdo/en/project/ Accessed 30.08.2022
[14] I. Loshchilov, F. Hutter, Decoupled weight decay regularization, in: International Conference on Learning Representations, 201

Measuring the Similarity of Song Artists using Topic Modelling

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ABSTRACT

In music streaming platforms, it is necessary a recommendation system to provide users with similar songs of what they already listen and also recommend new artists they might be interested in. In this paper, we present a method to find similarities between artists that uses topic modelling. We have evaluated the method using a data set with music artists and their lyrics. The results show the method finds similar artists, but also is dependant on the quality of the generated topic clusters.

KEYWORDS

song lyrics, topic modelling, clustering, sentence embeddings, language models

1 INTRODUCTION

Nowadays, there are a plenty of music platforms to choose from and listen to music. There, new artists appear every day and many different songs are published. If we take into account all that have been created, we get a large selection of songs which can increase the difficulty of finding suitable songs or artists to listen to.

To find a suitable artist or songs, different aspects can be considered. One such aspect can be the topic of the song; a song topic can be interpreted as the main subject of the song, for example it can be an emotion, an event, a message, or something else. When searching for suitable artists one could decide to search for artists who have songs on similar topics.

In this paper, we propose an topic modeling-based approach for measuring the similarity of the music artists based only on their song lyrics. The approach uses language models for generating song embeddings used to create the topic clusters. These topic clusters are then analyzed to find the similar artists. The experiment was performed on a data set of songs corresponding to fourteen (14) music artists. While the experiment shows that similar artists can be detected using the approach, there is still room for improving its performance.

The main contribution of this paper is a novel approach for detecting similar music artists using topic modelling.

The reminder of the paper is structured as follows: Section 2 contains the overview of the related work on using topic modelling on song data sets. Next, we present the methodology in Section 3, and describe the experiment setting in Section 4. The experiment results are found in Section 5, followed by a discussion in Section 6. Finally, we conclude the paper and provide ideas for future work in Section 7.

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2 RELATED WORK

Related works to our topic modeling approach use Latent Dirichlet Allocation (LDA) [1]. One work uses a topic modeling technique for sentiment classification, classifying between happy and sad songs, by using generated topics created with LDA and Heuristic Dirichlet Process [12]. From a data set consisting of 150 lyric they've been able to retrieve the sub-division of two defined sentiment classes [3]. Another work used LDA and Pachinko allocation [7] on a large data set for assessing the quality of the generated topics with applying supervised topic modeling approach. [8]. In our paper we use topic modeling to generate a set of topic clusters used to calculate the similarity between artists.

3 METHODOLOGY

In this section, we present the methodology used in this paper. We present the topic modeling approach used to generate the topic clusters, followed by a description of how the topic clusters are used to measure the similarity between the artists.

3.1 Topic Modeling

To create the topic clusters we use BERTopic [5], a method which uses document embeddings with clustering algorithms to create topic clusters. While BERTopic is described in a separate work, we present a brief description of its workflow. The workflow is also presented in Figure 1.

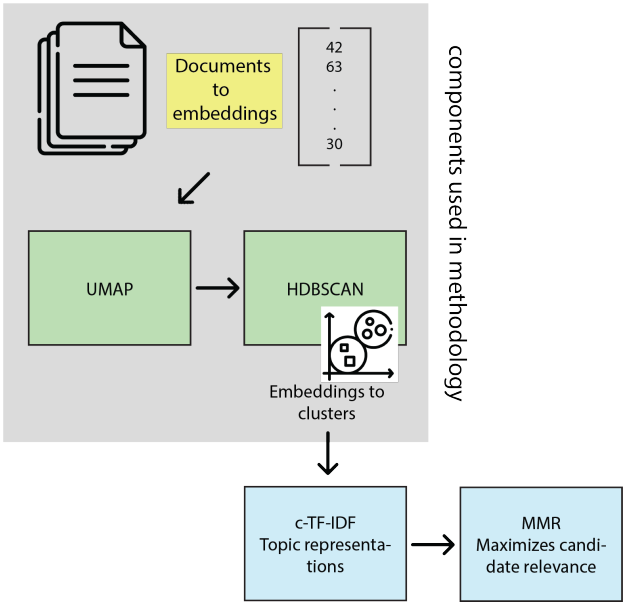

Figure 1: The BERTopic methodology workflow. The highlighted part is used in our approach. The image has been designed using resources from Flaticon.com.

Document Embeddings. Document vector representations are generated using a sentence-transformer [11] model. The model creates a semantic representation of the documents, which allows measuring the semantic similarity. The available models support creation of both monolingual and multilingual vectors. Since the embeddings will be used as an input of a clustering algorithm, dimensionality reduction is performed to improve the clustering results. The dimensionality reduction algorithm used is UMAP [10].

Document Clustering. Once the document embeddings are prepared, they are input into a clustering algorithm to create the topic clusters. The algorithm used is HDBSCAN [9], an optimized extension of the DBSCAN [4] algorithm. The chosen algorithm creates clusters based on the density of the document embedding space, which allows the documents to not be assigned to a cluster if it's not similar to any of the neighbouring documents.

Topic Word Description. Once the topic clusters are created, a topic word description is generated using the document's text. For each cluster the TF-IDF score is calculated for each word found in any of the cluster's documents; the scores are called cluster TF-IDF (c-TF-IDF). The words with the highest c-TF-IDF score are then chosen as the topic word description. Furthermore, maximal marginal relevance (MMR) is performed to diversify the selected words by measuring both the words relevance to the documents, and its similarity to the other selected words. Note that the topic word description were used only for the preliminary analysis of our work, but not for measuring artists similarity.

3.2 Artists' Similarity using Topic Clusters

Once the topic clusters are created, the similarity between artists can be measured. First, for each topic we count the songs that corresponds to a particular artist. This gives us the number of songs an artist has in a particular topic. To ensure that the presence is strong enough, we decide to remove the artists from a topic if the number of their associated songs is below some threshold. The threshold is set to five (5) in order to ensure that the songs were not assigned to a cluster by coincidence. Afterwards, for each pair of artists we calculate their similarity using the following equation:

$$\text{sim}(a, b) = \frac{|A \cap B|}{|A|}, \tag{1}$$

where A is the set of topics of artist a, and B is the set of topics of artist b.

4 EXPERIMENT

We now present the experiment setting. First, we introduce the data set used and its pre-processing steps. Next, we describe the implementation details.

4.1 Dataset

To test our approach, we use a dataset with raw lyrics data [2]. The dataset consists of 218,210 rows containing the following attributes:

- *Song name.* The name of the song.
- *Release year.* The year when the song was released.
- *Song artist.* The name of the artist.
- *Artist genre.* The genre of the song.
- *Song lyrics.* The lyrics text of the song.

The attributes used in our analysis are song name, artist and lyrics.

Data Processing. For our experiment we took fourteen (14) artists of various degrees of similarity. This reduces the data set to 4,470 rows which is 2.05% of the whole data set.

After reviewing the lyrics, we realized that the data set has many song variations by the same artist, which can be seen as duplicates. To find and remove the duplicates, we created the TF-IDF representations for the songs, and calculated the cosine similarity with all other songs of the same artist; if the similarity is greater than 50% it was labeled as a duplicate and removed from the data set. This resulted in a smaller data set containing 3,455 song lyrics.

The final data set statistics used for our experiments is shown in Table 1.

Table 1: The experiment data set statistics. For each artist we denote the music genre of the artist (genre), the number of their songs in the data set (songs), and the average number of words in the song's lyrics (avg. length).

Artist	genre	songs	avg. length
black-sabbath	Rock	160	184
bon-jovi	Rock	320	266
dio	Rock	127	203
aerosmith	Rock	208	226
ac-dc	Rock	171	193
coldplay	Rock	138	174
50-cent	Hip-Hop	318	502
2pac	Hip-Hop	259	648
eminem	Hip-Hop	369	640
black-eyed-peas	Hip-Hop	119	463
celine-dion	Pop	182	230
britney-spears	Pop	225	313
frank-sinatra	Jazz	356	133
ella-fitzgerald	Jazz	503	156
Together	-	3,455	319

4.2 Implementation details

In this section, we present the details of how the approach is developed.

Language model. The method uses the pre-trained Sentence Transformer model, more precisely the `all-mpnet-base-v2` model[1], available via the HuggingFace's transformer library [13]. It can take up to 384 tokens as one input, which is more than the average number of words in our data set, and returns a 768 dimensional dense vectors. The vectors have been shown to be appropriate for task such as clustering and semantic search.

Dimensionality reduction. To perform dimensionality reduction, we set the UMAP parameters as follows: Fist, the number of neighboring sample points used when making the manifold approximation is set to five (5), to make the algorithm use the local proximity of the documents. Second, we set the dimensionality of the embeddings to one (1). This values were selected using hyper-parameter tuning.

[1] https://huggingface.co/sentence-transformers/all-mpnet-base-v2

Clustering algorithm. In the HDBSCAN algorithm, the minimum number of documents in a cluster is set to five (5).

5 RESULTS

In this section, we present the experiment results. We analyze the topic clusters, followed by the description of the finding on artist's similarity.

Topic Cluster Analysis. The experiment has generates 215 topic clusters, out of which only 107 have at least one artist with more than five (5) songs in it. The cluster containing songs that are deemed as outliers is not included in the analysis.

The statistics of the topic clustering is shown in Table 2. Evidently, artists with a larger number of songs are spread over several topic clusters than those with less songs.

Table 2: Topic clustering results. For each artist we show the number of different topics the artist is asociated with (topics), and the average number of their songs in the associated topics (avg. songs).

Artist	topics	#avg. songs
black-sabbath	6	5
bon-jovi	10	6
dio	4	7
aerosmith	9	6
ac-dc	7	5
coldplay	2	5
50-cent	17	9
2pac	13	9
eminem	18	9
black-eyed-peas	3	12
celine-dion	8	6
britney-spears	12	6
frank-sinatra	16	8
ella-fitzgerald	28	8

Artists' Similarity Analysis. The artists' similarity is shown in Figures 2 and 3, which show the heatmaps of the absolute and relative co-occurrence of artists in topic clusters, respectively.

By looking at rows of Figure 2, we see the number of common topics with other artists. For example, by taking 50-cent with his 17 topics, we see that he shares five (5) of them with 2pac, one (1) with black-eyed-peas, one (1) with ac-dc, and six (6) with eminem. From this we conclude that 50-cent, 2pac and eminem have more topics in common than the rest of the artists. In other words, 50-cent is more similar to the 2pac and eminem than to the rest of the artists.

Figure 3 shows the similarities calculated using Equation 1. The similarities become more visible, but at the same time can be also misleading. Artists with smaller number of topics can result in higher similarity with other artists with higher number of topics. For example, Coldplay have two (2) topics, one of which is shared with Bon Jovi. Despite the fact that only one topic is in common, it is unlikely they have a similarity of 50%.

6 DISCUSSION

In this section we discuss the advantages and disadvantages of the proposed methodology, and its possible improvements.

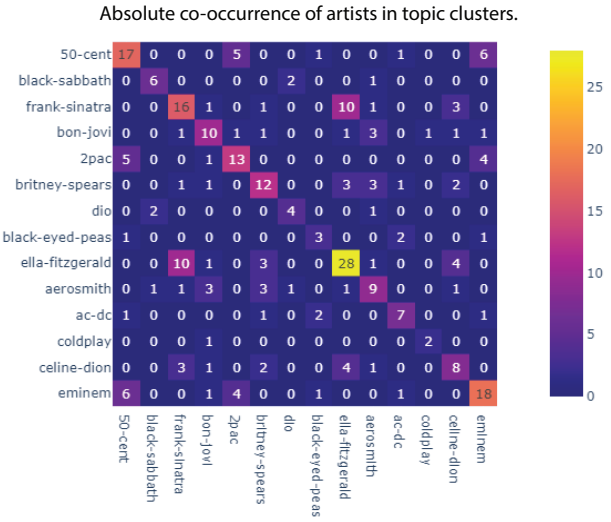

Figure 2: The absolute co-occurrence of artists in topic clusters.

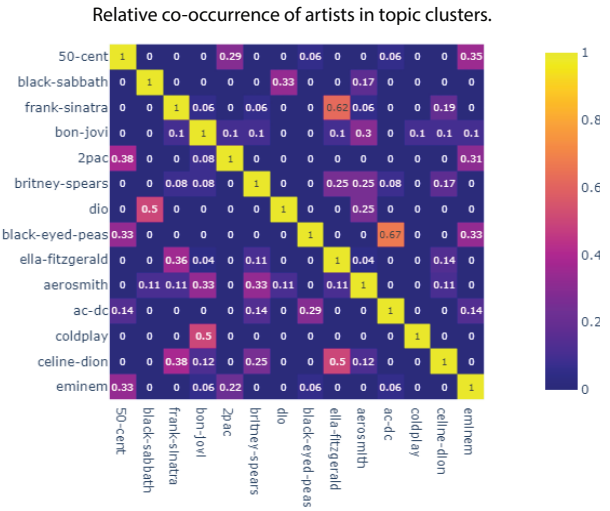

Figure 3: The relative co-occurrence of artists in topic clusters. Artists with smaller number of topics can result in higher similarity with other artists.

Language Models Limitations. The chosen language model `all-mpnet-base-v2` supports a maximum sequence length of 384 tokens which is the downside of this model for our experiment. Although the average number of words in the song lyrics is below the input limit, some artist have songs that are longer than that. However, songs have repeating sections, e.g. chorus, which is most likely inside the first 384 words. Therefore, the language models may not create a representation out of the whole song's lyrics, but it might capture the majority because of the song's repeated text.

Clustering Algorithm Selection. The clustering algorithm HDBSCAN can create a cluster consisting of examples, which do not fall into any of the topic clusters. It is convenient when instead of forcing songs into clusters, it labels them as outliers. The downside is when the majority of songs are labeled as outliers. To

avoid this, other clustering algorithms that assign a cluster to every document can be used, for example K-means clustering [6].

6.1 Topic Cluster Discussion

Some artists with a small number of songs have a lower number of topics assigned, which is a problem for finding similarities. On the other side artists with higher number of songs tend to have more topics. Additionally, to avoid taking into account small number of artist co-occurrances, which can be a product of data noise, a filter threshold can be considered to remove them from the final analysis.

7 CONCLUSION

In this paper we present a way to measure similarity between music artists using topic modeling. We cluster lyrics and compare artists based on the generated topic clusters. The results have shown that the approach finds similar artists. However, it is heavily dependent on the number and quality of the topic clusters.

In the future, we intend to apply the methodology on a larger data set of song lyrics and artists. In addition, we intend to use all of the topic cluster information (including topic word descriptions) in order to improve the methodology's performance.

ACKNOWLEDGMENTS

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REFERENCES

[1] David M. Blei, Andrew Y. Ng, and Michael I. Jordan. "Latent dirichlet allocation". In: *J. Mach. Learn. Res.* 3 (2003), pp. 993–1022. ISSN: 1532-4435. DOI: http://dx.doi.org/10.1162/jmlr.2003.3.4-5.993. URL: http://portal.acm.org/citation.cfm?id=944937.

[2] Connor Brennan, Sayan Paul, Hitesh Yalamanchili, Justin Yum. *Classifying Song Genres Using Raw Lyric Data with Deep Learning*. Accessed August 30, 2022. https://github.com/hiteshyalamanchili/SongGenreClassification. 2018.

[3] Maibam Debina Devi and Navanath Saharia. "Exploiting Topic Modelling to Classify Sentiment from Lyrics". In: *Machine Learning, Image Processing, Network Security and Data Sciences*. Ed. by Arup Bhattacharjee et al. Singapore: Springer Singapore, 2020, pp. 411–423. ISBN: 978-981-15-6318-8.

[4] Martin Ester et al. "A density-based algorithm for discovering clusters in large spatial databases with noise". In: AAAI Press, 1996, pp. 226–231.

[5] Maarten Grootendorst. "BERTopic: Neural topic modeling with a class-based TF-IDF procedure". In: *arXiv preprint arXiv:2203.05794* (2022).

[6] Xin Jin and Jiawei Han. "K-Means Clustering". In: *Encyclopedia of Machine Learning*. Ed. by Claude Sammut and Geoffrey I. Webb. Boston, MA: Springer US, 2010, pp. 563–564. ISBN: 978-0-387-30164-8. DOI: 10.1007/978-0-387-30164-8_425. URL: https://doi.org/10.1007/978-0-387-30164-8_425.

[7] Wei Li and Andrew McCallum. "Pachinko allocation: DAG-structured mixture models of topic correlations". In: *ICML '06: Proceedings of the 23rd international conference on Machine learning*. New York, NY, USA: ACM, 2006, pp. 577–584. ISBN: 1595933832. DOI: 10.1145/1143844.1143917. URL: http://portal.acm.org/citation.cfm?id=1143917.

[8] Alen Lukic. *A comparison of topic modeling approaches for a comprehensive corpus of song lyrics*. Tech. rep. Tech report, Language Technologies Institute, School of Computer Science …, 2015.

[9] Leland McInnes and John Healy. "Accelerated Hierarchical Density Based Clustering". In: *2017 IEEE International Conference on Data Mining Workshops (ICDMW)*. 2017, pp. 33–42. DOI: 10.1109/ICDMW.2017.12.

[10] Leland McInnes, John Healy, and James Melville. *UMAP: Uniform Manifold Approximation and Projection for Dimension Reduction*. 2018. DOI: 10.48550/ARXIV.1802.03426. URL: https://arxiv.org/abs/1802.03426.

[11] Nils Reimers and Iryna Gurevych. "Sentence-BERT: Sentence Embeddings using Siamese BERT-Networks". In: *Proceedings of the 2019 Conference on Empirical Methods in Natural Language Processing*. Association for Computational Linguistics, Nov. 2019. URL: https://arxiv.org/abs/1908.10084.

[12] Chong Wang, John Paisley, and David Blei. "Online variational inference for the hierarchical Dirichlet process". In: *Proceedings of the fourteenth international conference on artificial intelligence and statistics*. JMLR Workshop and Conference Proceedings. 2011, pp. 752–760.

[13] Thomas Wolf et al. "Transformers: State-of-the-Art Natural Language Processing". In: *Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing: System Demonstrations*. Online: Association for Computational Linguistics, Oct. 2020, pp. 38–45. DOI: 10.18653/v1/2020.emnlp-demos.6. URL: https://aclanthology.org/2020.emnlp-demos.6.

Exploring the Impact of Lexical and Grammatical Features on Automatic Genre Identification

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ABSTRACT

This study analyses the impact of several types of linguistic features on the task of automatic web genre identification applied to Slovene data. To this end, text classification experiments with the fastText models were performed on 6 feature sets: original lexical representation, preprocessed text, lemmas, part-of-speech tags, morphosyntactic descriptors, and syntactic dependencies, produced with the CLASSLA pipeline for language processing. Contrary to previous work, our results reveal that the grammatical feature set can be more beneficial than lexical representations for this task, as syntactic dependencies were found to be the most informative for genre identification. Furthermore, it is shown that this approach can provide insight into variation between genres.

KEYWORDS

language processing, linguistic features, automatic genre identification, web genres, Slovene

1 INTRODUCTION

Automatic genre identification (AGI) is a text classification task where the focus is on genres as text categories that are defined based on the conventional function and/or the form of the texts. In text classification tasks, texts are generally given to the machine learning models in form of words or characters that are then further transformed into numeric vectors by using bag-of-words representations, or word embeddings created by training deep neural networks on the surface text. However, recent development of tools for linguistic processing for numerous languages, including Slovene, allows transformation of the original running text into various other sets of features to which further transformation into numeric representations can be applied. By learning on these linguistic sets, we get insight into the importance of features that cannot be analysed separately when given the running text, i.e., word meaning, function of a word, and its relation to other words.

When previous work compared importance of various textual feature sets on the performance of the models in automatic genre identification, lexical features, i.e., word or character n-grams, mainly provided the best results ([6], [7]). However, it was noted that by learning on lexical features, the models could learn to classify texts based on the topic instead of genre characteristics, and would not be able to generalize beyond the dataset.

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As learning on lexical features can introduce bias towards topic, Laippala et al. (2021) recently experimented with combining lexical with grammatical features, which are represented as part-of-speech tags, conveying information on the word type (e.g., noun, verb). This showed to yield better results than using solely lexical features, and provided more stable models, i.e., models that are able to generalize beyond the training data. Furthermore, their analysis revealed that the importance of feature sets varies between genre categories, and that while some are most efficiently identified when learning on lexical features, others benefit more from grammatical representations.

However, these experiments were in past mostly performed on English datasets. This article is the first to analyse the impact of various feature sets on automatic genre identification applied to Slovene data. This research was made possible by the recent development of the first Slovene dataset, manually annotated with genre, as well as the creation of state-of-the-art language processing tools for Slovene. To compare textual representations, additional feature sets were created from a selection of texts annotated with genre, presented in Section 2, by using common preprocessing methods and language processing (see Section 3). Thus, in this paper, 6 textual representations are compared: 1) original, running text that we consider as our baseline, 2) preprocessed text, i.e. lowercase text without punctuation, digits and stopwords, 3) lemmas, i.e. base dictionary forms of words, 4) part-of-speech (PoS) tags, i.e. main syntactic word types (e.g., noun, verb), 5) morphosyntactic descriptors (MSD), i.e. extended PoS tags which include information on morphosyntactic features (e.g., number, case), 6) syntactic dependencies, i.e. types of dependency relations between words (e.g. subject, object). The feature sets are compared based on their impact on the performance of the fastText models on the automatic text classification task. The results of the experiments, presented in Section 4, give insights into the role of linguistic feature sets on this task and the differences in performance between genre categories.

2 DATASET

For performing experiments in automatic genre identification, the Slovene Web genre identification corpus GINCO 1.0 [2] was used. The dataset consists of the "suitable" subset, annotated with genre, and the "not suitable" subset that comprises texts which can be deemed as noise in the web corpora, e.g., texts without full sentences, very short texts, machine translation etc. In this research, only the "suitable" subset, containing 1002 texts, was used.

The GINCO schema consists of 24 genre labels. However, previous experiments, performed with the fastText model on the entire dataset, showed that the model is not potent enough to differentiate between a large number of labels that are mostly represented by less than 100 texts, reaching micro and macro

Table 1: The original GINCO categories (left) included in the reduced set, and the reduced set of labels (right), used in the experiments, with the total number of texts (later divided between the train, dev and test split) in the parentheses.

GINCO	Reduced Set
News/Reporting Opinionated News	News (198)
Information/Explanation Research Article	Information/Explanation (127)
Opinion/Argumentation Review	Opinion/Argumentation (124)
Promotion Promotion of a Product Promotion of Services Invitation	Promotion (191)
Forum	Forum (48)

F1 scores of 0.352 and 0.217 respectively (see [3]). Therefore, to be able to infer any meaningful conclusions, this article focuses only on the most frequent genre labels, created by merging some labels. Instances of less frequent labels that could not be merged, namely *Instruction*, *Legal/Regulation*, *Recipe*, *Announcement*, *Correspondence*, *Call*, *Interview*, *Prose*, *Lyrical*, *Drama/Script*, *FAQ*, and the labels *Other* and *List of Summaries/Excerpts*, which can be considered as noise, were not used. To focus only on the instances that are representative of their genre labels, texts that were manually annotated as hard to identify (parameter `hard`) were not used in the experiments. Furthermore, paragraphs that were deemed to be noise in the text, e.g., cookie consent text, and were marked by the annotators with the `keep` parameter set to `False`, were left out of the final texts.

Thus, the final set of labels, used in the experiments, shown in Table 1, consists of 5 genre categories, *Information/Explanation*, *News*, *Opinion/Argumentation*, *Promotion* and *Forum*. As shown in the Table, the dataset is imbalanced, with *News* and *Promotion* being the most frequent classes, consisting of almost 200 instances, while *Forum* is the least represented class, consisting of about 50 texts. The subset, consisting of 688 texts in total, followed the original stratified split of 60:20:20, encoded in the GINCO 1.0 dataset, and the models were trained on the training set, tested on the test set, while the dev split was used for evaluating the hyperparameter optimisation.

3 FEATURE ENGINEERING

Feature engineering is a process of identifying features that are most useful for a specific task with the goal of improving performance of a machine learning model. In text classification experiments, basic preprocessing methods are often used to reduce the number of unique lexical features (words or characters) without losing much information which could provide better results. To test whether preprocessing the text improves the results for this task, the first additional feature set was created by preprocessing the running text as extracted from the GINCO dataset. Preprocessing consisted of the following steps: converting text to lowercase, and removing digits, punctuation and function words known as stopwords, e.g., conjunctions, prepositions etc.

In addition to this, various linguistic representations were created by applying linguistic processing to the texts, and replacing words with corresponding lemmas or grammatical tags. The language processing was performed with the CLASSLA pipeline [5]. The following text representations were produced: lexical feature set, consisting of lemmas, and three grammatical feature sets: part-of-speech (PoS) tags, morphosyntactic descriptors (MSD), and syntactic dependencies. The realisation of the created feature sets is illustrated on an example sentence in Table 2.

4 MACHINE LEARNING EXPERIMENTS

4.1 Experimental Setup

The experiments were performed with the linear fastText [1] model which enables text classification and word embeddings generation. The model is a shallow neural network with one hidden layer where the word embeddings are created and averaged into a text representation which is fed into a linear classifier. The model takes as an input a text file where each line contains a separate text instance, consisting of a label and the corresponding document. Thus, for each feature set, appropriate train, test and dev files were created, and the model was trained on each representation separately [1]. To observe the dispersion of results, five runs of training were performed for each feature set. To measure the model's performance on the instance and the label level, the micro and macro F1 scores were used as evaluation metrics.

The hyperparameter search was performed by training the model on the training split of the baseline text and evaluating it on the dev split. The automatic hyperparameter optimisation provided by the fastText model did not yield satisfying results, as three runs of automatic hyperparameter optimisation produced very different results in terms of proposed optimal hyperparameter values and yielded micro F1 0.479 ± 0.02 and macro F1 0.382 ± 0.06. Therefore, we continued searching for optimal hyperparameters by manually changing one hyperparameter at a time

[1]The code for data preparation and machine learning experiments is published here: https://github.com/TajaKuzman/Text-Representations-in-FastText.

Table 2: An example of the feature sets used in the experiments.

Feature Set	Example
Baseline - Running Text	V Laškem se bo v nedeljo, 21.4.2013 odvijal prvi dobrodelni tek Veselih nogic.
Preprocessed Baseline	laškem nedeljo odvijal dobrodelni tek veselih nogic
Lemmas	v Laško se biti v nedelja , 21.4.2013 odvijati prvi dobrodelen tek vesel nogica .
PoS	ADP PROPN PRON AUX ADP NOUN PUNCT NUM VERB ADJ ADJ NOUN ADJ NOUN PUNCT
MSD	Sl Npnsl Px——y Va-f3s-n Sa Ncfsa Z Mdc Vmpp-sm Mlomsn Agpmsny Ncmsn Agpfpg Ncfpg Z
Dependencies	case nmod expl aux case obl punct nummod root amod amod nsubj amod nmod punct

and conducting classification experiments. The optimum number of epochs revealed to be 350, the learning rate was set to 0.7, and the number of words in n-grams to 1. For the other hyperparameters, the default values were used. Manual hyperparameter search revealed to be considerably more effective than automatic optimisation, as it yielded the average micro and macro F1 scores of 0.625 ± 0.004 and 0.618 ± 0.003 respectively, which is in average 0.15 points better micro F1 and 0.24 points better macro F1 compared to the results of automatic optimisation.

To analyse whether our choice of technology is the most appropriate one, we compared the performance of the fastText model, which uses the hyperparameters mentioned above, with the performance of various non-neural classifiers, commonly used in text classification tasks: dummy majority classifier which predicts the most frequent class to every instance, support vector machine (SVM), decision tree classifier, logistic regression classifier, random forest classifier, and Naive Bayes classifier. We used the default parameters for the classifiers. The models are compared based on their performance on the baseline text which was transformed into the TF-IDF representation where necessary. As shown in Table 3, fastText outperforms all other classifiers with a noticeable difference especially in the macro F1 scores, reaching 17 points higher scores than the next best classifier, the Naive Bayes classifier.

Table 3: Micro and macro F1 scores obtained by various classifiers, trained and tested on the baseline text.

Classifier	Micro F1	Macro F1
Dummy Classifier	0.24	0.08
Support Vector Machine	0.49	0.33
Decision Tree	0.34	0.35
Logistic Regression	0.52	0.38
Random Forest classifier	0.51	0.41
Naive Bayes classifier	0.54	0.42
FastText	**0.56**	**0.59**

4.2 Results of Learning on Various Linguistic Features

To explore the role of various textual representations on the automatic genre identification of Slovene web texts, we conducted text classification experiments with the fastText models on 6 feature sets:

- three lexical sets: a) baseline text, i.e., the original running text, b) preprocessed baseline text, i.e., baseline text converted to lowercase and without punctuation, digits and function words, c) lemmas, i.e., words reduced to their base dictionary forms;
- three grammatical sets: a) part-of-speech (PoS), i.e., main word types, b) morphosyntactic descriptors (MSD), i.e., extended PoS tags, c) syntactic dependencies, i.e., types of words defined by their relation to other words.

First, by comparing the baseline representation and the preprocessed representation, we aimed to determine whether common preprocessing methods can improve the results in the AGI task. As shown in Table 4, the results reveal that applying preprocessing methods improves the performance, especially on the micro F1 level. Analysis of the F1 scores obtained for each label in Figure 1 reveals that preprocessing especially improves the identification of *Promotion* and *News*. The two labels are the most frequent genre classes in the dataset which explains larger improvement of the micro F1 scores. If we compare the baseline text and the preprocessed text to the third lexical set, i.e., lemmas, the results show that by using lowercase words, reduced to their dictionary base form, the performance is further improved, although only slightly, as can be seen in Table 4.

Table 4: Average micro and macro F1 scores obtained from five runs of training and testing on each representation separately.

Representation	Micro F1	Macro F1
Baseline Text	0.560 ± 0.00	0.589 ± 0.00
Preprocessed Baseline	0.596 ± 0.00	0.597 ± 0.00
Lemmas	0.597 ± 0.01	0.601 ± 0.00
PoS	0.540 ± 0.01	0.547 ± 0.01
MSD	0.563 ± 0.01	0.536 ± 0.02
Dependencies	**0.610** ± 0.00	**0.639** ± 0.00

Secondly, we compared various lexical and grammatical feature sets, obtained with language processing tools. In previous work, which analysed English genre datasets, lexical features yielded better results than grammatical feature sets ([4], [6], [7]). Our results revealed that this conclusion holds also for Slovene when training on part-of-speech tags. Similar conclusion can be made for the extended part-of-speech tags (MSD) which only slightly improve the micro F1 scores compared to the baseline while there is a decrease in the macro F1 scores (see Table 4). However, the third grammatical feature set, consisting of tags for syntactic dependencies, which was not used in previous work, significantly outperformed the baseline text and all other feature sets. As shown in Figure 1, the improvement is especially noticeable for the categories *Forum*, *Opinion/Argumentation* and *News*. By learning on the dependencies instead on lexical features, the model learns from the structure of the sentences in the text, i.e., the syntax, instead of word meanings that can be more related to topic than genre, which could be the reason why this representation was revealed to be the most beneficial for the task.

As in previous work (see [4]), the experiments have revealed a dependence between the text representation and performance on specific genre labels, which is illustrated in Figure 1. The results show that *Promotion* and *Information/Explanation* can be most successfully identified when learning purely on the meaning of the words, i.e., on lemmas. In contrast to that, for identifying *News*, grammatical representations are more useful than lexical ones. Similarly, *Opinion/Argumentation* benefits more from grammatical feature sets than lexical representations, except in case of the MSD tags which significantly decreased the results for this class, yielding F1 scores below 0.3. Interestingly, although *Forum* is the least frequent label, its features seem to be the easiest to identify in the majority of representations. This genre benefits the most from learning on syntactic dependencies tags, which yielded F1 scores of almost 0.9.

5 CONCLUSIONS

In this paper, we have investigated the dependence of automatic genre classification on the lexical and grammatical representation of text. Our experiments, performed on three lexical and three

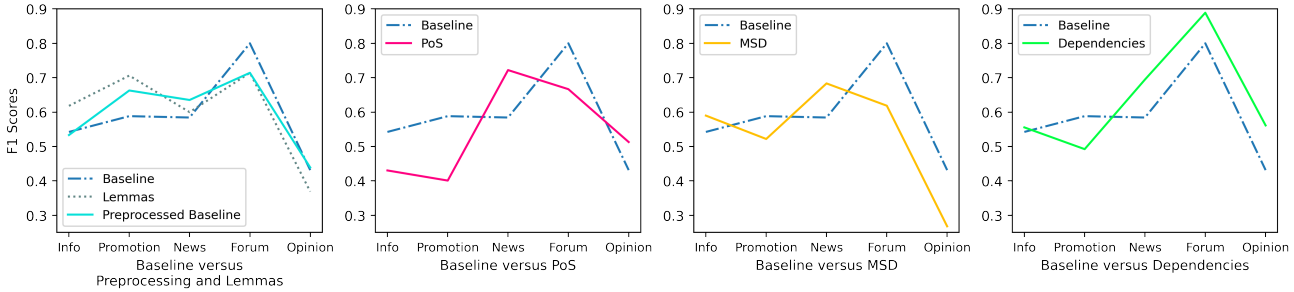

Figure 1: The impact of various linguistic features on the F1 scores of genre labels (*Information/Explanation, Promotion, News, Forum* and *Opinion/Argumentation*).

grammatical feature sets, revealed that the choice of textual representation impacts the results of automatic genre identification. Similarly to previous work, it was revealed that part-of-speech features give worse results than lexical features. However, a grammatical feature set, consisting of syntactic dependencies, that has not been studied in previous work, revealed to be the most beneficial for the automatic genre identification task. Furthermore, the experiments revealed variation between genres regarding the impact of feature sets on the F1 scores of each label. While some genres, such as *Promotion*, benefit more from learning on lexical features, others, such as *Opinion/Argumentation*, benefit more from grammatical representations.

However, it should be noted that this study has been limited to the 5 most frequent genre labels, as the previous experiments showed that the fastText model is not potent enough to identify other categories represented by a small number of instances ([3]). Thus, the results of these experiments give insight into which linguistic features are the most important for differentiating between the five most frequent genres, not for identifying the 24 original labels that encompass all the genre variation found on the web, and include noise. This is why we plan to continue genre annotation campaigns to enlarge the Slovene genre dataset, which would allow extending the analysis to all genre labels. In addition to this, as we are interested in cross-lingual genre identification, in the future, we plan to analyse the importance of linguistic feature sets on the Croatian and English genre datasets to analyse whether the characteristics of genre labels are language independent.

The fastText model was revealed to be useful for the analysis of the impact of linguistic features on the AGI task, however, previous work on automatic genre identification using the GINCO dataset revealed that if the aim of the research is to create the best-performing classifier and not to analyse the impact on the performance, the Transformer-based pre-trained language models are much more suitable for the task ([3]). This was also confirmed by our experiments on the running text, where the base-sized XLM-RoBERTa model reached micro and macro F1 scores 0.816 and 0.813, which is 22–26 points more than the fastText model. Based on the findings from this paper, one of the reasons why the Transformer models perform better could also be that the Transformer text representations incorporate information on syntax as well. In the future, we plan to investigate this further, adapting the classifier heads so that the syntactic information has a larger impact on the classification than the lexical parts of the representation.

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REFERENCES

[1] Armand Joulin, Edouard Grave, Piotr Bojanowski, and Tomas Mikolov. 2016. Bag of tricks for efficient text classification. *arXiv preprint arXiv:1607.01759*.

[2] Taja Kuzman, Mojca Brglez, Peter Rupnik, and Nikola Ljubešić. 2021. Slovene web genre identification corpus GINCO 1.0. Slovenian language resource repository CLARIN.SI. (2021). http://hdl.handle.net/11356/1467.

[3] Taja Kuzman, Peter Rupnik, and Nikola Ljubešić. 2022. The GINCO Training Dataset for Web Genre Identification of Documents Out in the Wild. In *Proceedings of the Language Resources and Evaluation Conference*. European Language Resources Association, Marseille, France, 1584–1594. https://aclanthology.org/2022.lrec-1.170.

[4] Veronika Laippala, Jesse Egbert, Douglas Biber, and Aki-Juhani Kyröläinen. 2021. Exploring the role of lexis and grammar for the stable identification of register in an unrestricted corpus of web documents. *Language resources and evaluation*, 1–32.

[5] Nikola Ljubešić and Kaja Dobrovoljc. 2019. What does Neural Bring? Analysing Improvements in Morphosyntactic Annotation and Lemmatisation of Slovenian, Croatian and Serbian. In *Proceedings of the 7th Workshop on Balto-Slavic Natural Language Processing*. Association for Computational Linguistics, Florence, Italy, (August 2019), 29–34. DOI: 10.18653/v1/W19-3704. https://www.aclweb.org/anthology/W19-3704.

[6] Dimitrios Pritsos and Efstathios Stamatatos. 2018. Open set evaluation of web genre identification. *Language Resources and Evaluation*, 52, 4, 949–968.

[7] Serge Sharoff, Zhili Wu, and Katja Markert. 2010. The Web Library of Babel: evaluating genre collections. In *LREC*. Citeseer.

Stylistic features in clustering news reporting: News articles on BREXIT

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ABSTRACT

We present a comparison of typical bag-of-words features with stylistic features. We group the news articles published from three different regions of the UK namely London, Wales, and Scotland. Hierarchical clustering is performed using typical bag-of-words and stylistic features. We present the performance of 25 stylistic features and compare them with the bag-of-words. Our results show that bag-of-words are better to be used while clustering news reporting at the regional level whereas stylistic features are better to be used while clustering news reporting at the level of news publishers/newspapers.

KEYWORDS

news reporting, topic modeling, stylistic features, clustering

1 INTRODUCTION

The role of content is an essential research topic in news spreading. Media economics scholars especially showed their interest in a variety of content forms since content analysis plays a vital role in individual consumer decisions and political and economic interactions [6]. The content basically refers to the type of language that is used in the news. It is used to convey meaning and it can impact social and psychological constructs such as social relationships, emotions, and social hierarchy [8]. The everyday act of reading the news is such a big area in which small differences in reporting may shape how events are perceived, and ultimately judged and remembered [5].

News reporting across different regions requires methods to find reporting differences. [7] characterize the relationship between the volume of online opioid news reporting and measures differences across different geographic and socio-economic levels. Scholars across disciplines have explored the institutional, organizational, and individual influences that study the quality and quantity of coverage [3].

Features that could classify news reporting across different regions can be adapted to classify the news. A detailed analysis of textual features is performed by [1] where they derived multiple features for creating clusters of news articles along with their comments. These features include terms in the title, terms in the first sentence, terms in the entire article, etc. Multi-view clustering on multi-model data can provide common semantics to improve learning effectiveness. It exploits different levels of features from the raw features, including low-level features, high-level features, and semantic features [16].

The news coverage registers the occurrence of specific events promptly and reflects the different opinions of stakeholders [4]. We take Brexit as an event to be researched on the topic of news reporting differences across the different regions of the UK. On 23 June 2016, the British electorate voted to leave the EU. This event has already been studied following different aspects such as fundamental characteristics of the voting population, driver of the vote, political and social patterns, and possible failures in communication [2, 9]. In this paper, we explore how different stylistic features help in clustering news articles related to Brexit than bag-of-words (BOW).

Following are the main scientific contributions of this paper:

(1) We present a comparison of clustering (using two different textual features: bag-of-words and stylistic features) for news reporting about Brexit in three different regions (London, Scotland, and Wales) of the UK.
(2) We show in our experiments that the bag-of-words are better to be used while clustering news reporting at the regional level whereas stylistic features are better to be used while clustering news reporting at the level of news publishers/newspapers.

Table 1: List of all the stylistic features that are used for clustering.

No.	Feature	No.	Feature
1.	Percentage of Question Sentences	2.	Average Sentence Length
3.	Percentage of Short Sentences	4.	Average Word Length
5.	Percentage of Long Sentences	6.	Percentage of Semicolons
7.	Percentage of Words with Six and More Letters	8.	Percentage of Punctuation marks
9.	Percentage of Words with Two and Three Letters	10.	Percentage of Pronouns
11.	Percentage of Coordinating Conjunctions	12.	Percentage of Prepositions
13.	Percentage of Comma	14.	Percentage of Adverbs
15.	Percentage of Articles	16.	Percentage of Capitals
17.	Percentage of Words with One Syllable	18.	Percentage of Colons
19.	Percentage of Nouns	20.	Percentage of Determiners
21.	Percentage of Verbs	22.	Percentage of Digits
23.	Percentage of Adjectives	24.	Percentage of Full stop
25.	Percentage of Interjections		

2 RELATED WORK

In this section, we review the related literature about topic modelling, and different types of textual features.

2.1 Topic Modelling

Topic modelling is used to infer topics from the collection of text-document. Some techniques used only frequent words whereas

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Table 2: Total number of news articles about Brexit published in three different regions (London, Scotland, and Wales).

Regions	Newspapers	News articles	Total
London	bankofengland.co.uk	8	4248
	bbc.com	2209	
	dailymail.co.uk	768	
	Independent.co.uk	191	
	inews.co.uk	52	
	metro.co.uk	1	
	neweconomics.org	1	
	rspb.org.uk	8	
	theguardian.com	1167	
	theneweuropean.co.uk	1	
	thesun.co.uk	235	
	cityam.com	3	
	conservativewomen.uk	1	
	dailypost.co.uk	1	
	ft.com	2	
	mirror.co.uk	9	
	raeng.org.uk	1	
	standard.co.uk	20	
Scotland	news.stv.tv	533	533
Wales	gov.wales	3	280
	nation.wales	122	
	Walesonline.co.uk	156	

some use pooling to generate relevant topics and maintain coherence between topics [14]. Topics are typically represented by a set of keywords. Examples of such algorithms are the Latent Dirichlet Allocation (LDA), Latent Semantic Analysis (LSA) and Probabilistic Latent Semantic Analysis (LSA). Clustering-based topic modelling is another solution.

2.2 Stylistic Features

News reporting differences can be reflected through one's speech, writing, and images etc [10, 12]. A language independent features have been used for different tasks of NLP such as plagiarism detection, author diarization. These features considers the text of documents as a sequence of tokens (i.e. sentences, paragraphs, documents). On the basis of these tokens, various types of statistics could be drawn from any language [13]. Stylistic features represent the writing style of a document and have been used for understanding the author writing styles in the past [10]. We use it to explore the clustering of the news articles based on their reporting differences across different regions. Table 1 shows the list of 25 stylistic features used for the development of our proposed clustering of news articles.

2.3 Bag-of-words

A bag-of-words model is a way of extracting features from text. It is basically a representation of text that describes the occurrence of words within a document. It firstly identifies a vocabulary of known words and then measures the presence of known words. Topic modelling is typically based on the bag-of-words (BOW). The essential idea of the topic model is that a document can be represented by a mixture of latent topics and each topic is a distribution over words [11].

3 DATA COLLECTION

We collected news articles reporting on Brexit in the English language from the UK Web Archive (UKWA). The dataset consists of 5061 news articles after pre-processing. Due to the unavailability of news articles from other regions of the UK, we selected only the regions (London, Scotland, and Wales) which have a sufficient amount of news articles. Table 2 presents the number of news articles published from different regions and by different news publishers.

4 METHODOLOGY

The presented research focuses on clustering news articles. To this end, we experiment clustering with the combination of different features observing their performance. Our methodology consists on four steps and compares the performance of stylistic features and bag-of-words in clustering news articles, as shown in Figure 1.

In the first step, we select Brexit under topic and themes on UK web archive[1]. After crawling the list of news articles, we extracted the meta data of news publishers from Wikipedia-infobox. The meta-data extraction process is explained in our previous work [15]. In this process, we extracted the headquarters of news publishers. Due to the unavailability of news articles from other regions of the UK, we selected only the regions (London, Scotland, and Wales) which have a sufficient amount of news articles. In the second step, we perform parsing of the html web pages and extract the body text.

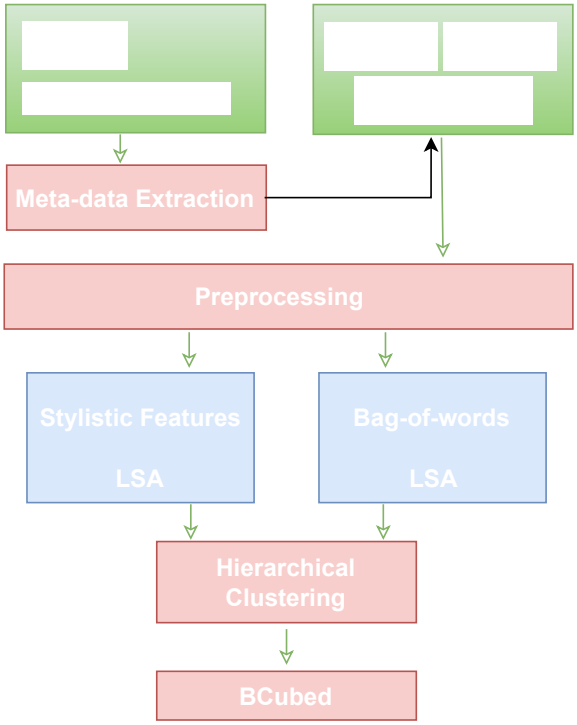

Figure 1: Methodology to clustering regional news using bag-of-words and stylistic features.

[1]https://www.webarchive.org.uk/en/ukwa/collection/910

Since the third step required pre-processing for bag-of-words, we convert the text to lowercase and remove the stop words and punctuation marks. In the third step for the stylistic features, we extract the stylistic features(see Table 1) for all three regions and perform LSA (Latent Semantic Analysis). Similarly, for the bag-of-words, we use the pre-processed text and perform LSA. We also perform LSA on the combination of both types of features. 100 latent dimensions have been used for LSA because it is recommended. We perform LSA and hierarchical clustering using the python library SciPy, and scikit-learn and use the weighted distance between clusters. After performing the LSA, we apply hierarchical clustering and utilize two different types of evaluation measures namely BCubed F1 and Silhouette Scores. For LSA and hierarchical clustering, we use the python library SciPy, and scikit-learn.

5 EXPERIMENTAL EVALUATION

We have performed experimental evaluations using intrinsic (Silhouette) and extrinsic (BCubed-F) evaluation measures. The intrinsic evaluation metrics are used to calculate the goodness of a clustering technique whereas extrinsic evaluation metrics are used to evaluate clustering performance. For extrinsic evaluation, we consider clusters generated by k-means clustering using typical bag-of-words as ground truth clusters. The value of k in k-means clustering ranges from 2 to 20. K-means identifies k centroids, and then allocates every data point to the nearest cluster while keeping the centroids as small as possible. We cannot set the value of k to 1 which means there are no other clusters to allocate the nearest data point.

Silhouette is used to find cohesion. It ranges from -1 to 1. 1 means clusters are well apart from each other and clearly distinguished. 0 means clusters are indifferent, or we can say that the distance between clusters is not significant. -1 means clusters are assigned in the wrong way.

BCubed F-measure defines precision as point precision, namely how many points in the same cluster belong to its class. Similarly, point recall represents how many points from its class appear in its cluster.

- **Silhouette Score:** $S(i) = \frac{b(i)-a(i)}{max(a(i),b(i))}$

where S(i) is the silhouette coefficient of the data point i, a(i) is the average distance between i and all the other data points in the cluster to which i belongs, and b(i) is the average distance from i to all clusters to which i does not belong.

- **BCubed Precision and Recall:**

$$Correctness(i,j) = \begin{cases} 1, if\ L(i) = L(j)\ and\ C(j) = C(j) \\ 0, if otherwise \end{cases}$$

$$BCubed\ Precision = \frac{1}{N}\sum_{i=1}^{N}\sum_{j \epsilon C(i)} \frac{Correctness(i,j)}{|C(i)|}$$

$$BCubed\ Recall = \frac{1}{N}\sum_{i=1}^{N}\sum_{j \epsilon L(i)} \frac{Correctness(i,j)}{|L(i)|}$$

where |C(i)| and |L(i)| denote the sizes of the sets C(i) and L(i), respectively. L(i) and C(i) denote the class and clusters of a point i.

- **BCubed-F Score:** $F = \frac{2 \times BcubedPrecision \times BcubedRecall}{BcubedPrecision + BcubedRecall}$

6 RESULTS AND ANALYSIS

Figure 2 shows the three line graphs. Each graph shows Silhouette scores across a different number of clusters (from 2 to 20) representing different regions of the UK such as Scotland, Wales, and London respectively. Blue and red lines represent bag-of-words (BOW) and stylistic features.

We can see that for all three graphs, the silhouette score of stylistic features is significantly high for all three regions except at one point for Scotland. It means that cohesion is higher and the distance between the clusters is more significant using stylistic features than BOW which is mostly too close to 0. It suggests that these features are better at partitioning news articles into clusters than BOW.

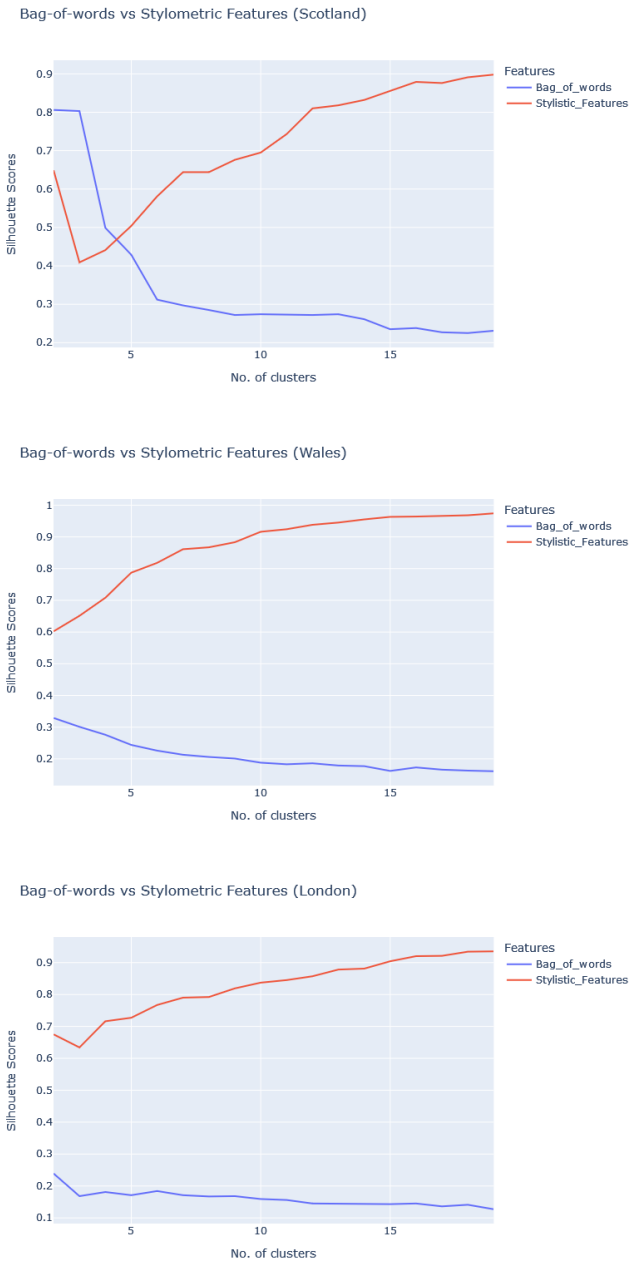

Figure 2: The line graphs represent average silhouette scores across a different number of clusters. The blue line represents the score generated using bag-of-words and the red line represents the score generated using stylistic features. The three-line graphs are generated for three different regions Scotland, Wales, and London respectively.

Table 3: The group of news articles published from three different regions of the UK is considered as ground truth clusters and the Bcubed-F score is calculated using three types of features including bag-of-words, stylistic features, and a combination of both types of features.

No.	Features	Bcubed-F Score
1.	Bag-of-words	0.75
2.	Bag-of-words and stylistic features	0.51
3.	Stylistic features	0.54

Table 4: The group of news articles published from 22 different news publishers of the UK is considered as ground truth clusters and the Bcubed-F score is calculated using three types of features including bag-of-words, stylistic features, and a combination of both types of features.

No.	Features	Bcubed-F Score
1.	Bag-of-words	0.53
2.	Bag-of-words and stylistic features	0.57
3.	Stylistic features	0.66

However, it is insufficient to say that stylistic features are better for news reporting differences at this stage because it is not necessary that the resulting clusters by internal partitioning can be equal to the ones that are based on news reporting differences.

We consider each region (London, Scotland, and Wales) as a ground truth cluster of the news articles published in that region. Table 3 shows Bcubed-F scores when the ground truth clusters were matched with the one that was created using bag-of-words, stylistic features, and a combination of both types of features. Similarly, we consider each newspaper/news publisher shown in Table 2 as a ground truth cluster of the news articles published by that newspaper/news publisher. Table 4 shows Bcubed-F scores when the ground truth clusters were matched with the one that was created using bag-of-words, stylistic features, and a combination of both types of features. The scores using bag-of-words considering regions as ground truth clusters are significantly high (0.75) than stylistic features (0.54) and a combination of all features (0.51). The scores using stylistic features considering newspaper/news publishers as ground truth clusters are significantly high (0.66) than bag-of-words (0.53) and a combination of all features (0.57). The higher scores in regional news reporting suggest that bag-of-words is better to be used for clustering or classification because the newspapers/news publishers report in different styles in a certain region. Similarly, when it comes to classifying or clustering news reporting across different newspapers/news publishers then stylistic features are more useful because the newspapers/news publishers follow a different reporting style.

7 CONCLUSIONS

In this paper, we have presented the comparison of different features observing their performance over clustering news articles. The goal of this work was to investigate the performance of stylistic features and typical bag-of-words. The data consists of news articles about a popular event Brexit that are collected from UKWA. These news articles belong to three different regions of the UK including Scotland, London, and Wales. Our experimental results suggest that bag-of-words are better to be used while clustering news reporting at the regional level whereas stylistic features are better to be used while clustering news reporting at the level of news publishers/newspapers.

ACKNOWLEDGMENTS

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REFERENCES

[1] Ahmet Aker, Monica Paramita, Emina Kurtic, Adam Funk, Emma Barker, Mark Hepple, and Rob Gaizauskas. 2016. Automatic label generation for news comment clusters. In *Proceedings of the 9th International Natural Language Generation Conference*. Association for Computational Linguistics, 61–69.

[2] Sascha O Becker, Thiemo Fetzer, and Dennis Novy. 2017. Who voted for brexit? a comprehensive district-level analysis. *Economic Policy*, 32, 92, 601–650.

[3] Danielle K Brown and Summer Harlow. 2019. Protests, media coverage, and a hierarchy of social struggle. *The International Journal of Press/Politics*, 24, 4, 508–530.

[4] Honglin Chen, Xia Huang, and Zhiyong Li. 2022. A content analysis of chinese news coverage on covid-19 and tourism. *Current Issues in Tourism*, 25, 2, 198–205.

[5] Elizabeth W Dunn, Moriah Moore, and Brian A Nosek. 2005. The war of the words: how linguistic differences in reporting shape perceptions of terrorism. *Analyses of social issues and public policy*, 5, 1, 67–86.

[6] Frederick G Fico, Stephen Lacy, and Daniel Riffe. 2008. A content analysis guide for media economics scholars. *Journal of Media Economics*, 21, 2, 114–130.

[7] Yulin Hswen, Amanda Zhang, Clark Freifeld, John S Brownstein, et al. 2020. Evaluation of volume of news reporting and opioid-related deaths in the united states: comparative analysis study of geographic and socioeconomic differences. *Journal of Medical Internet Research*, 22, 7, e17693.

[8] Qihao Ji, Arthur A Raney, Sophie H Janicke-Bowles, Katherine R Dale, Mary Beth Oliver, Abigail Reed, Jonmichael Seibert, and Arthur A Raney. 2019. Spreading the good news: analyzing socially shared inspirational news content. *Journalism & Mass Communication Quarterly*, 96, 3, 872–893.

[9] Moya Jones. 2017. Wales and the brexit vote. *Revue Française de Civilisation Britannique. French Journal of British Studies*, 22, XXII-2.

[10] Ifrah Pervaz, Iqra Ameer, Abdul Sittar, and Rao Muhammad Adeel Nawab. 2015. Identification of author personality traits using stylistic features: notebook for pan at clef 2015. In *CLEF (Working Notes)*. Citeseer, 1–7.

[11] Zengchang Qin, Yonghui Cong, and Tao Wan. 2016. Topic modeling of chinese language beyond a bag-of-words. *Computer Speech & Language*, 40, 60–78.

[12] Abdul Sittar and Iqra Ameer. 2018. Multi-lingual author profiling using stylistic features. In *FIRE (Working Notes)*, 240–246.

[13] Abdul Sittar, Hafiz Rizwan Iqbal, and Rao Muhammad Adeel Nawab. 2016. Author diarization using cluster-distance approach. In *CLEF (Working Notes)*. Citeseer, 1000–1007.

[14] Abdul Sittar and Dunja Mladenic. 2021. How are the economic conditions and political alignment of a newspaper reflected in the events they report on? In *Central European Conference on Information and Intelligent Systems*. Faculty of Organization and Informatics Varazdin, 201–208.

[15] Abdul Sittar, Dunja Mladenić, and Marko Grobelnik. 2022. Analysis of information cascading and propagation barriers across distinctive news events. *Journal of Intelligent Information Systems*, 58, 1, 119–152.

[16] Jie Xu, Huayi Tang, Yazhou Ren, Liang Peng, Xiaofeng Zhu, and Lifang He. 2022. Multi-level feature learning for contrastive multi-view clustering. In *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*, 16051–16060.

Automatically Generating Text from Film Material – A Comparison of Three Models

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ABSTRACT

The paper focuses on audio analysis and text generation using film material as an example. The proposed approach is done by using three different models (Wav2Vec2, HuBERT, S2T) to process the sound from different audio-visual units. A comparative analysis shows the strengths of different models and factors of different materials that determine the quality of text generation for functional film annotation applications.

KEYWORDS

Text generation, automated transcription, cinema, film, video

1 INTRODUCTION

Applications like automatic text captions for video materials have become more and popular and extensively used by users on different media, spanning from the computer, television, smartphones and other technologies that enable audio-visual consumption. However, even though these applications have to an extent already become a staple in our everyday lives, their performance often varies and still has not reached optimal functionality. There are many challenges when we work with text generation out of audio-visual materials. These span from the structure and quality, the type or category of sound, the age of the recordings and the models on which such translation is based on. The main goal of this paper is to provide a practical demonstration of a few basic models for automatic annotation. The goal is to take into account the currently most common procedures of such an endeavour and figure out how to minimize the loss function of the models to allow an optimal generation of text out of film or video more sufficiently.

The rest of this paper is organized in the following way. Section 2 provides a description of the problem in the context of contemporary consumption of audio-visual materials via most popular information and communication technologies. Section 3 delineates the methodology used and describes the approach used to tackle the problem in a concrete demonstration. Section 4 presents the models being used and describes our implementation of them, specifying the dynamics of the obtained results. A conclusion is reached in section 5, where the paper offers a discussion on the outcome and possible directions for future work.

2 PROBLEM DESCRIPTION

In recent years, audio-visual data has become as influent if not more influent as traditional text-based information. With this, the task of extracting information from the former and transforming it into the latter is becoming useful for different purposes [1, 2]. One example is that text annotations enable better comprehension in cases of bad sound quality or even allow the material to be understood in situations where sound consumption is impossible. Another one is a possible speed up of the video that the annotations provide due to their ability to keep the content integral in a clear graphic form. The consumption process can be made more time efficient with textual information compensating for the distortions of audio-visual quality that can be brought about with the manipulations of playing options. Furthermore, in a general sense, combining audio-visual material with text can solve many problems on different levels of film or video production. This can span from the preparing phases of pre-production such as writing the script, to the post-production phases where one needs good orientation over a vast quantity of material. Proper text generation can facilitate easier orientation in such work and allows for more efficient organization of the media materials.

In this paper, we will focus on those components that contribute to the quality of proper automated text generation as a prerequisite of such developmental strategies. The main contributions of this paper are: (1) an analysis of the factors that influence automatic transcription of film or video material (2) implementation and comparison of a few different models for sound annotation (3) reflection on how this process can be used for more complex tasks

3 METHODOLOGY

The problem we are solving is to take a piece of audio-visual material, convert it into a code that a model for automatic text generation can take as input and then generate output of text that matches the sound recording of the input in an optimal way. An optimal result should provide a close correspondence of the utterances in the film material and eventually identify different types and categories of sound such as dialogue, noise, music etc. We will do an analysis of the factors that influence the quality of automatically generated transcriptions in the following steps: 1) a comparison of different models for generating text from audio files, 2) an analysis of how the quality of transcriptions differs in relation to noise in the background (silence, music,

dialogues), 3) an evaluation of how the clarity of speech influences the quality of transcriptions, and 4) an assessment to what extent it is more difficult to generate quality transcriptions from older audio-inscriptions (films).

Reflecting on the results of our procedure, we will think about how to improve the quality in cases when quality of transcriptions is bad. Aside from quality we will measure the time demands of models, that is how much time do the models need to generate transcriptions from the audio writing.

The following model were used:

1) Wav2Vec2 [4] is a framework for self-supervised representation learning from raw audio that was made open-source by Facebook. It is the first Automatic Speech recognition model included in Transformers as one of the central parts of Natural Language Processing. Figure 1 shows the model's architecture.

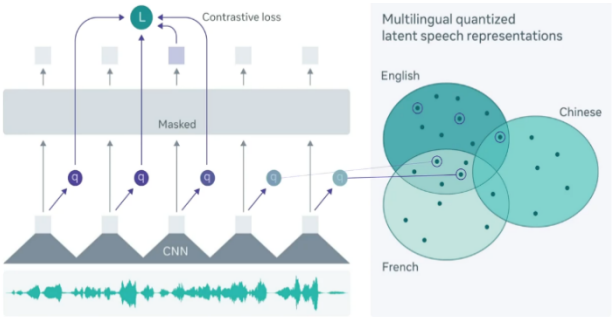

Figure 1. Wav2Vec2 learns speech units from multiple languages using cross-lingual training [4].

The model starts by processing the raw waveform with a multilayer convolutional neural network. This yields latent audio representations of 25ms that are fed into a quantizer and a transformer. From an inventory of learned units, the quantizer chooses appropriate ones, while half of the representations are masked before being used. The transformer then adds information from the whole of the audio sequence and with the output leads to solving the contrasting task with the model identifying the correct quantized speech units for the masked positions.

2) HuBERT [3] (Hidden-Unit BERT) is an approach for self-supervised speech representation that uses masking in a similar way and in addition adds an offline clustering step that provides aligned target labels for a prediction loss. This prediction loss is applied over the masked regions, which leads the model to learn a combined language and acoustic model over the continuous inputs. By focusing on the consistency of the unsupervised clustering step rather than the intrinsic quality of the assigned cluster labels, HuBERT can either match or improve the Wav2Vec2 model. Figure 2 shows the model's architecture.

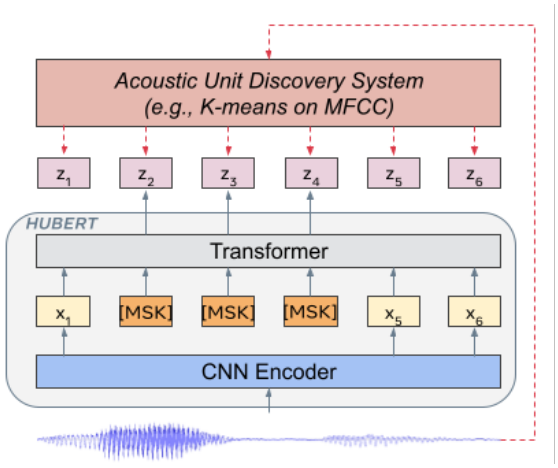

Figure 2. HuBERT predicts hidden clusters assignments using masked frames (y2, y3, y4 in the figure) generated by one or more iterations of k-means clustering [7].

3) S2T [5] (Speech2Text) is a transformer-based encoder-decoder (seq2seq) model that uses a convolutional downsampler to dramatically reduce the length of audio inputs over one half before they are fed into the encoder. It generates the transcripts autoregressively and is trained with standard autoregressive cross-entropy loss.

4 EXPERIMENT SETTING

4.1 Evaluation metric

We have used WER (Word error rate) as the metric of the performance of the models which computes the error rate on the comparison of substitutions, deletions, insertions and correct words. Original text was used for each of the model and each film example, removing the punctuation.

$$WER = \frac{S + D + I}{N}$$

where...
S = number of substitutions
D = number of deletions
I = number of insertions
N = number of words in the reference

4.2 Data set

The dataset was formed with clips of different films. The films used were classics of world cinema (*The Godfather, 2001: A Space Odyssey, Star Wars, Frankenstein, Fight Club, Paris, Texas, Scent of A Woman, Tomorrow and Tomorrow and Tomorrow*). 14 clips of sizes spanning from 5 to 30 seconds were used with the lengthier ones incorporating different sound contents (like speech, shouting, whispering etc.). The first step was to prepare the audio in such a format that the models will be able to read it, so the clips were changed from mp4 to wav. An online converter, **cloudconvert** [https://cloudconvert.com], was used as the clips were fairly short and the results could be directly added to the Kaggle dataset from the browser itself.

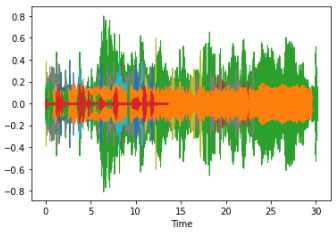

Figure 3: A superposition of waveform graphs of all the examples.

4.3 Implementation details

Programming was done on Kaggle, where code was written in Python and after the experiments were set up, and the GPU was activated for faster computation. The general process using each of the models is the following. First, an encoder takes raw data and puts it in the model. In our demonstration, tokenizers were used at the start, but as S2T tokenizers was not equipped to get the audio, it had to be changed to a processor. To retain consistency, the same step was applied to the other two models as well. Once data gets in the model, the model predicts particular syllables for each sound with certain probabilities and then in an additional step selects those with the highest probability based in the context of the semantic whole of the sentence. In the final step, the decoder (again the tokenizers / the processors) takes the output of the model and transforms it into text.

5 EXPERIMENT RESULTS

The ground rules for our project were that each model had a particular function that took sound as input and produced text as output with each audio having the text extracted separately. Subsequently different models were compared according to the accuracy of the results according to different criteria and a variety of scenarios (noise, music, number of characters, tempo of speech etc.). We will illustrate the obtained results via a concrete example. We will take a clip with relatively clear sound from the film *A Few Good Men* (1992), a digitized version of a well preserved celluloid film. The sound is clear and the dialogue takes places in a court practically in complete silence of the surroundings with the speech changing from normal tone to screaming. The clip is 22 seconds long and its waveform is shown in Figure 4. The original text is as following:

A: Did you order the Code Red?!
B: You don't have to answer that question!
C: I'll answer the question. You want answers?
A: I think I'm entitled!
C: You want answers!?
A: I want the truth!
C: You can't handle the truth! Son, we live in a world that has walls, and those walls have to be guarded by men with guns. Who's gonna do it? You? You, Lieutenant Weinberg?

The produced transcriptions are as follows:

Wav2Vec2:
YOU WAR THE CORA YOU DON'T HAVE TO ANSWER THE QU ESTION I'LL ANSWER THE QUESTION YOU WANT ANSWERS I THINK I'M ENTITLE YOU WANT ANT A AT THE TRUE YOU CA N'T HANDLE THE TRUTH SON WE LIVE IN A WORLD THAT H AS WALLS AND THOSE WALLS HAVE TO BE GUARDED BY ME N WITH GUNS WHO'S GON TO DO IT YOU YOU LIEUTENANT WINEBERG

HuBERT:
OMARTER TE CORET YOU DON'T HAVE TO ANSWER THAT Q UESTION I'LL ANSWER THE QUESTION YOU WANT ANSWERS I THINK I'M ENTITLED YOU WANT ANSWERRTHE TRUTH YO U CAN'T HANDLE THE TRUTH SON WE LIVE IN A WORLD TH AT HAS WALLS AND THOSE WALLS HAVE TO BE GUARDED B Y MEN WITH GUNS WHO'S GOING TO DO IT YOU YOU LIEUT ENANT WINBURG

S2T:
DEAR LORD THE CORRET YOU DON'T HAVE THE ANSWER T HAT QUESTION I'LL ANSWER THE QUESTION YOU WANT AN SWERS BUT THEY CAN'T ENTITLE YOU ONE AND THE TRUTH YOU CAN'T HANDLE THE TRUTH SOME WE LIVE IN A WORL D THAT HAS WALLS AND THOSE WALLS HAVE TO BE GUARD ED BY MEN WITH GUNS WHOSE TENANT DO IT YOU LIEUTE NANT WINEBURG THOSE HAVE TO BE GUARDED BY MEN WI TH GUNS WHOSE CANNON DO IT YOU YOU LIEUTENANT WI NEBURG YOU LIEUTENANT WINEBURG

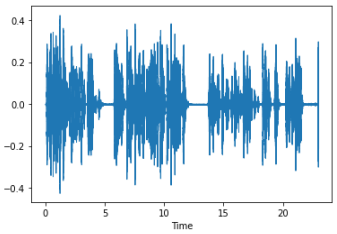

Figure 4. A scene from A Few Good Men (1992), a still and waveform graph from the used sequence.

The lower the WER number, the better the results. The models did not have a noticeable variation of speed, while the quality of their performance varied due to different factors. Hubert gave overall the best results from the point of view of readability. According to the rate of correspondence between input audio and output text, HuBERT comparably gave the better rate of the transcription in case of videos with poor audio quality from Wav2Vec2, i.e. that from older or damaged films, while Wav2Vec2 gave better performance in case of background music, but had the tendency of adding too much insertions. S2T had the tendency to produce mistakes, seen in peaking numbers over 1.0. The overall results are given in Table 1.

It is important to note that the average given does not reflect the better overall accuracy, but is the sum of different factors. So the models can be good at transcribing particular words, but can add or drop extra words in the process and therefore make the overall text less comprehensible. An important factor is the way the original text that is used for comparison is written – omitting punctuations and properly writing the words even if they are mispronounced will improve the results. Finally, it is crucial that all the texts are in caps lock, or the comparison won't work and will produce misleading results.

As the used example shows, it is mostly clarity of speech that will determine how the models perform. As the models were pre-trained and were not trained according to the specific data used, they were in general surprisingly efficient. The

discrepancies in different treatments of the same audio are visible, but in general as long as the dialogue was clear, the results were comparable. Music seemed to cause bigger problems for the model than background noise, while additional speech in the background proved most problematic. Emotional influences on speech did not prove that problematic and even affective utterances were transcribed comparably with neutral speech if the sound data was of high quality.

Table 1. The WER scores for each model. The bold values represent the best performances on the given clip. The best performing model is HuBERT.

Clip number	Wav2Vec2	HuBERT	S2T
1	69%	**53%**	91%
2	100%	**0%**	100%
3	100%	**95%**	**95%**
4	**27%**	30%	36%
5	**17%**	**17%**	**17%**
6	39%	**18%**	43%
7	**28%**	**28%**	64%
8	70%	**46%**	55%
9	50%	**25%**	100%
10	57%	**37%**	73%
11	62%	**38%**	51%
12	100%	**95%**	100%
13	60%	**33%**	73%
14	9%	**4%**	9%
Average	56%	**37%**	65%

The WER usually shows the results in a metric between 0 and 1, however in case the annotation results were extremely unsuccessful, the higher extreme may surpass the limit. In our case, up to 1.6 was reached, however in the chart, it was limited down to 1.0 for purposes of clarity.

5 DISCUSSION AND FURTHER WORK

So as a general principle, when taking clips from films, the main factor that can potentially influence the quality of the generated text in a negative way is the background noise. As one can expect, the model will work best when nothing is in the background and worst when people are talking in the background. Ideally, to improve the quality one would train the models for the specific material, using a similar type of material and accordingly doing a pre-classification according to the main categories of sound analysis (ie. monologue, dialogue, background noise, music, echo, normal speech, loud speech, shouting, whispering etc.) - especially when using older or less preserved material, which drastically differs in sound data from newer or more preserved works.

In our research we expanded on and adapted existing work on automated text generation models, providing an analysis of the factors that determine the quality of such results from film material. As an example, we applied our approach on different film material, ranging in the quality and age of the clips and the structure of the sound data.

A useful strategy for the future from the perspective of film practice would be to find ways to link transcriptions with a script. A precondition of such an endeavour would be to implement an algorithm for recognizing the person speaking and identifying the source with descriptions (“person A is speaking, then person B, then person A has a long monologue, person C answers” etc.). Another important task would be identifying the sounds of different categories and providing fitting audio-signs (sound of squeaking steps, playing of music etc.). From these steps one could eventually at least to some extent automatically generate scripts for films or find ways to develop tools for easier text-based classification of audio-visual material.

CONCLUSIONS

In this paper we explored ways to generate text out of audio information presented in film and video material. We used three different models to evaluate various film units, Wav2Vec2, HuBERT, and S2T. We found that the model HuBERT achieved best results, while the remaining two methods performed similarly.

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REFERENCES

1 A. Ramani, A. Rao, V. Vidya and V. B. Prasad, "Automatic Subtitle Generation for Videos," *2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS)*, 2020, pp. 132-135, doi: 10.1109/ICACCS48705.2020.9074180.

2 Rustam Shadiev, Yueh-Min Huang, Facilitating cross-cultural understanding with learning activities supported by speech-to-text recognition and computer-aided translation, Computers & Education, Volume 98, 2016, Pages 130-141

3 Wei-Ning Hsu, Benjamin Bolte, Yao-Hung Hubert Tsai, Kushal Lakhotia, Ruslan Salakhutdinov, Abdelrahman Mohamed. HuBERT: Self-Supervised Speech Representation Learning by Masked Prediction of Hidden Units. [arXiv:2106.07447v1 [cs.CL], Submitted on 14 Jun 2021].

4 Alexei Baevski, Henry Zhou, Abdelrahman Mohamed, Michael Auli. wav2vec 2.0: A Framework for Self-Supervised Learning of Speech Representations.. [arXiv:2006.11477v3, Submitted on 20 Jun 2020 (v1), last revised 22 Oct 2020 (this version, v3)].

5 Changhan Wang, Yun Tang, Xutai Ma, Anne Wu, Dmytro Okhonko, Juan Pino. fairseq S2T: Fast Speech-to-Text Modeling with fairseq. [arXiv:2010.05171v1, Submitted on 11 Oct 2020] .

6 Wav2vec2.0: Learning the structure of speech from raw audio. [https://ai.facebook.com/blog/wav2vec-20-learning-the-structure-of-speech-from-raw-audio Submitted on 24 Sep 2020, Access. 9.1.2022

7 Hsu, Wei-Ning, et al. "Hubert: Self-supervised speech representation learning by masked prediction of hidden units." IEEE/ACM Transactions on Audio, Speech, and Language Processing 29 (2021): 3451-3460.

The Russian invasion of Ukraine through the lens of ex-Yugoslavian Twitter

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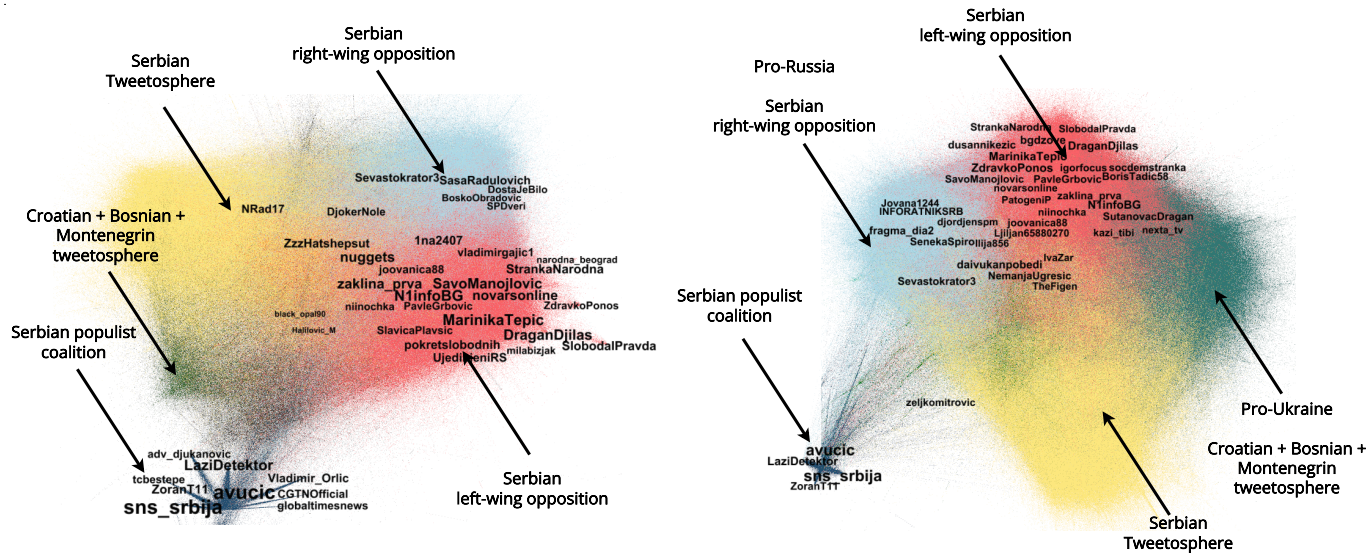

Figure 1: Pre-invasion (left) and invasion (right) ex-Yugoslavian retweet networks. Node colors represent communities. Labeled arrows point to the main communities, with labels inferred from the community users. The in-network labels represent the names of the most retweeted accounts.

ABSTRACT

The Russian invasion of Ukraine marks a dramatic change in international relations globally, as well as at specific, already unstable, regions. The geographical area of interest in this paper is a part of ex-Yugoslavia where the BCMS (Bosnian, Croatian, Montenegrin, Serbian) languages are spoken, official varieties of a pluricentric Serbo-Croatian macro-language [4]. We analyze 12 weeks of Twitter activities in this region, six weeks before the invasion, and six weeks after the start of the invasion. We form retweet networks and detect retweet communities which closely correspond to groups of like-minded Twitter users. The communities are distinctly divided across countries and political orientations. Some communities detected after the start of the Russian invasion also show clear pro-Ukrainian or pro-Russian stance. Such analyses of social media help in understanding the role and effect of this conflict at the regional level.

KEYWORDS

social network analysis, community detection, Twitter

1 INTRODUCTION

The Russian invasion of Ukraine brings about dramatic changes to the world. Analysing the structure and content of the communication on social media, such as Twitter, can give more insight into the causes, developments and consequences of this conflict. The geographical area of interest in our research is a part of ex-Yugoslavia where the BCMS (Bosnian, Croatian, Montenegrin, Serbian) languages are spoken, official varieties of the pluricentric Serbo-Croatian macro-language. This area is strongly politically divided by diverging influences of NATO (Croatia, Montenegro, North Macedonia, Bosniak and Croatian entity in Bosnia and

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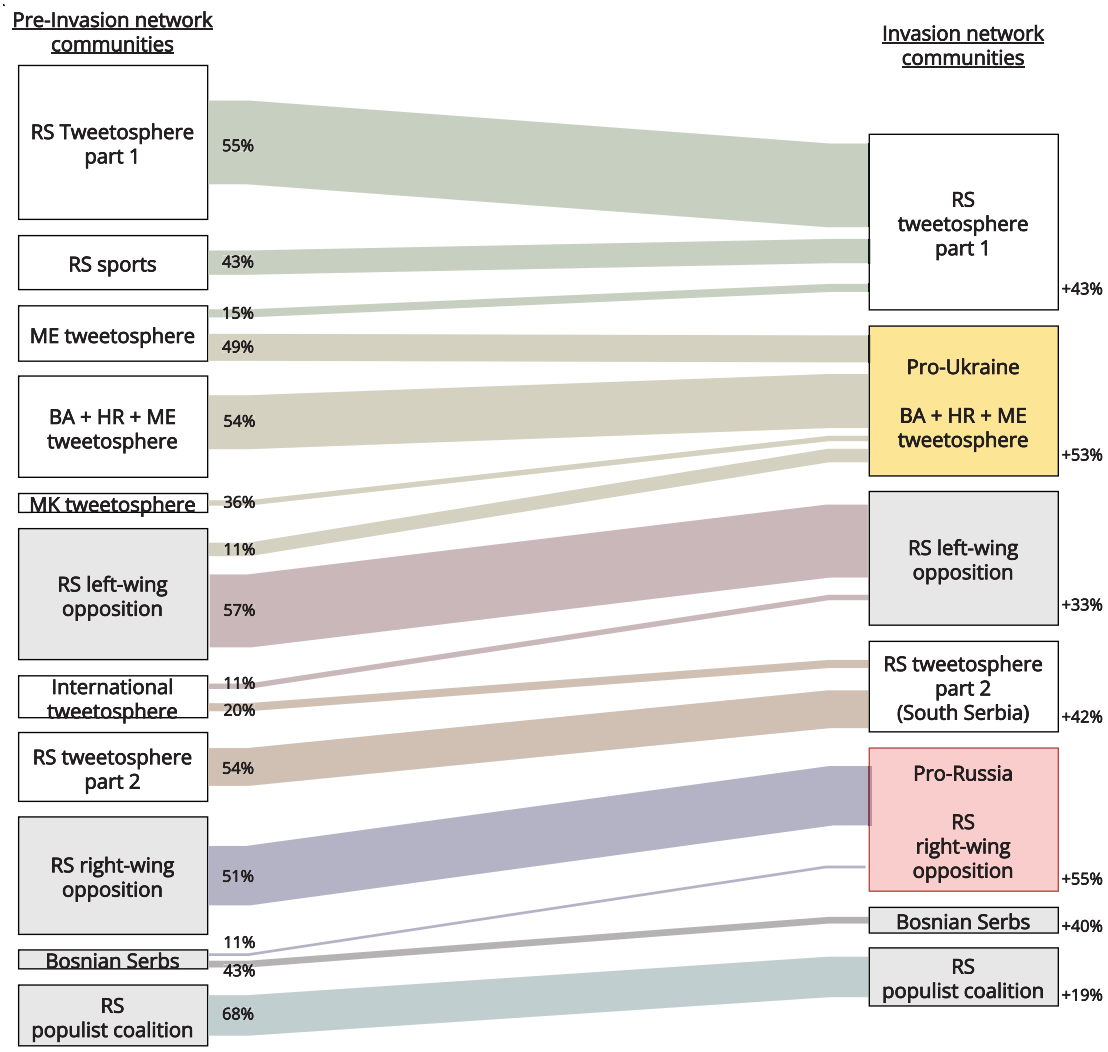

Figure 2: A Sankey diagram showing the transitions of users from the pre-invasion network communities (left) to the invasion network communities (right). Rectangle height is proportional to the community sizes. Percentages near the pre-invasion communities show the portion of users found in the corresponding invasion communities. Percentages on the right-hand side of the invasion communities show the portion of users not previously present in the large communities of the pre-invasion network. Gray rectangles depict the communities tightly related to politics, with the yellow and red denoting the detected pro-Ukraine and pro-Russia leaning communities, respectively.

Herzegovina) and Russia (Serbia, Serbian entity in Bosnia and Herzegovina). While Croatia is full EU member since 2013, Montenegro, North Macedonia and Serbia are EU candidate members, while Bosnia and Herzegovina is a potential candidate. Regarding military alliances, NATO members are Croatia (since 2007), Montenegro (since 2017) and North Macedonia (since 2020), while Serbia does not aspire to join NATO, primarily due to a complex Serbia-NATO relationship caused by the NATO intervention in Yugoslavia in 1999.

To shed light on the impact of the Russian invasion on this brittle and complex geographical and political area, we use social network analysis over available Twitter data, 6-weeks before and 6-weeks during the invasion. We discover a complex landscape of ideology-specific and country-specific communities (see Figure 1), and analyse the transition into evident pro-Ukraine and pro-Russia leanings. We also present a method to measure the similarity of the communities before and during the invasion by analyzing URL and hashtag usage. As the communities show very divergent properties, we echo concerns of the heavy polarization and possible destabilization of this area of the Balkans.

2 RESULTS

The data analysed in this study were collected with the TweetCat tool [3], focused on harvesting tweets of less frequent languages. TweetCat is continuously searching for new users tweeting in the language of interest by querying the Twitter Search API for the most frequent and unique words in that language. Every user identified to tweet in the language of interest is continuously collected from that point onward. This data collection procedure is run for the BCMS set of languages since 2017. During the 12 weeks of our focus, we collected 1.2M tweets and 3.8M retweets from 45,336 users. A rough estimate of the per-country production of tweets via URL usage from country-specific top-level domains (upper part of Table 1) shows for Twitter to be much more popular in Serbia and Montenegro than in Croatia or Bosnia and Herzegovina. This has to be taken into account while analysing the communities of the underlying tweetosphere.

We created **pre-invasion** and **invasion retweet networks** (users as nodes, retweets as edges) from the collected data. We applied community detection (Ensemble Louvain [1]) on the two

Country	Population	URLs		
Serbia (RS)	**7.2M (47.3%)**	**106K (44.2%)**		
Croatia (HR)	3.9M (25.6%)	19.6K (8.1%)		
Bosnia and Herzegovina (BA)	3.5M (23.0%)	14.9K (6.2%)		
Montenegro (ME)	620K (4.1%)	24.7K (10.2%)		
Total	15.2M	242K		
Pre-invasion communities	**Users**	**Tweets**	**Retweets**	**Intra-com. RTs**
RS tweetosphere part 1	**13K (29.0%)**	**125K (24.9%)**	300K (18.9%)	80.3%
RS tweetosphere part 2	2.5K (5.6%)	35.8K (7.1%)	63.2K (4.0%)	62.3%
RS sports	1.6K (3.6%)	12.6K (2.5%)	25.6K (1.6%)	53.8%
ME tweetosphere	1.7K (3.8%)	22.7K (4.5%)	44.6K (2.8%)	74.5%
BA + HR + ME tweetosphere	5.6K (12.4%)	37.8K (7.5%)	59K (3.7%)	75.3%
Macedonian tweetosphere	200 (0.4%)	721 (0.1%)	771 (0.1%)	77.7%
International tweetosphere	934 (2.0%)	8.5K (1.7%)	11.5K (0.7%)	62.3%
RS populist coalition	2.0K (4.8%)	52.4K (10.4%)	396K (24.9%)	**98.7%**
RS left-wing opposition	9.3K (20.6%)	105K (20.9%)	**408K (25.5%)**	80.5%
RS right-wing opposition	7.6K(16.8%)	87.8K (17.4%)	247K (15.5%)	72.1%
Bosnian Serbs	139 (0.3%)	2.2K (0.4%)	3.8K (0.2%)	83.1%
Total	45.3K	502.9K	1590K	
Invasion communities	**Users**	**Tweets**	**Retweets**	**Intra-com. RTs**
RS tweetosphere part 1	**16.9K (29.5%)**	160K (22.4%)	387K (16.8%)	71.1%
RS tweetosphere part 2	4.5K (7.7%)	57.3K (8.1%)	118K (5.1%)	58.1%
Pro-Ukraine BA + HR + ME tweetosphere	12.4K (21.7%)	76.1K (10.6%)	235K (10.2%)	64.7%
Pro-Russia RS right-wing opposition	11.1K (19.4%)	129K (17.9%)	508K (22.1%)	65.1%
RS populist coalition	1.8K (3.1%)	**208K (29.1%)**	450K (19.5%)	**95.6%**
RS left-wing opposition	9.8K (17.2%)	191K (26.7%)	**590K (25.6%)**	72.6%
Bosnian Serbs	356 (0.6%)	5.4K (0.7%)	7.1K (0.3%)	62.3%
Total	57.4K (+26.7%)	717K (+42.8%)	2302K (44.8%)	

Table 1: The first part shows general population of each BCMS country and their respective tweet URL shares (.rs, .hr, .ba and .me). The second part shows the pre-invasion network communities with the number of users, tweets, retweets and intra-community retweets. The third part shows the same statistics for the invasion network communities. Grey rows depict political communities, while yellow and red show the pro-Ukraine and pro-Russia communities, respectively.

networks and analysed the community properties and user transitions [2]. We identified and named the large communities (more than 100 users) by a careful analysis of their most influential users and hashtag/URL usage. Figure 2 depicts the user transitions between the two networks, while Table 1 shows general statistics of each community. We discovered the following peculiarities:

- The BCMS tweetosphere is dominated by Serbian (RS) users and content.
- The political communities are more active compared to the non-political ones.
- RS populist coalition community (led by the Serbian president Aleksandar Vučić) forms a very strong echo chamber, with less than 2% of all users, yet more than 25% of tweets and retweets and more than 95% of intra-community retweets.
- RS populist coalition and left-wing opposition remain neutral on the invasion topic.
- RS right-wing opposition and the Bosnian Serbs show a clear pro-Russia stance.
- Croatian, Bosnian and Montenegrin communities show a clear pro-Ukraine stance.

In order to compare the pre-invasion and invasion communities in terms of content and political leanings, our following goal was to compare the pool of hashtags used and URLs shared by the community users. Therefore, we developed a simple community similarity method. First, we preprocessed the URLs by manually filtering out the ones coming from social media sources like Twitter, Facebook, Youtube etc., as well as URL shorteners. With this, we created a subset in which more than 99% of the URLs were news media, making it ideal for media polarization analysis. Once we extracted the domain of the URLs, we then created sorted lists of the top 50 URL domains and top 50 hashtags for each community, sorted by the usage counts. Finally, in order to calculate the similarities between communities, we used the Rank-biased overlap (RBO) measure for indefinite rankings [5].

We found out that the matchings between the pre-invasion and invasion communities based on highest-user-overlap transitions are also visible through the URL and hashtag similarities (see Figure 3). In fact, for each pre-invasion community, its respective highest-user-overlap invasion community is also the highest RBO pair for both URLs and hashtags. In other words, there is a strong positive correlation between the user transition percentages (Figure 2) and the RBO scores. E.g., 68% of the users from the pre-invasion "RS populist coalition" community transition in the "RS populist coalition" community in the invasion network. Meanwhile, The URL RBO of this pair is 0.64, while the hashtag RBO is 0.43, both as the highest combination for the pre-invasion "RS populist coalition" community, clearly matching it with its invasion transition-based counterpart. This shows that our simple similarity method based on URLs and hashtags can even help in better matching communities in the task of community evolution [6].

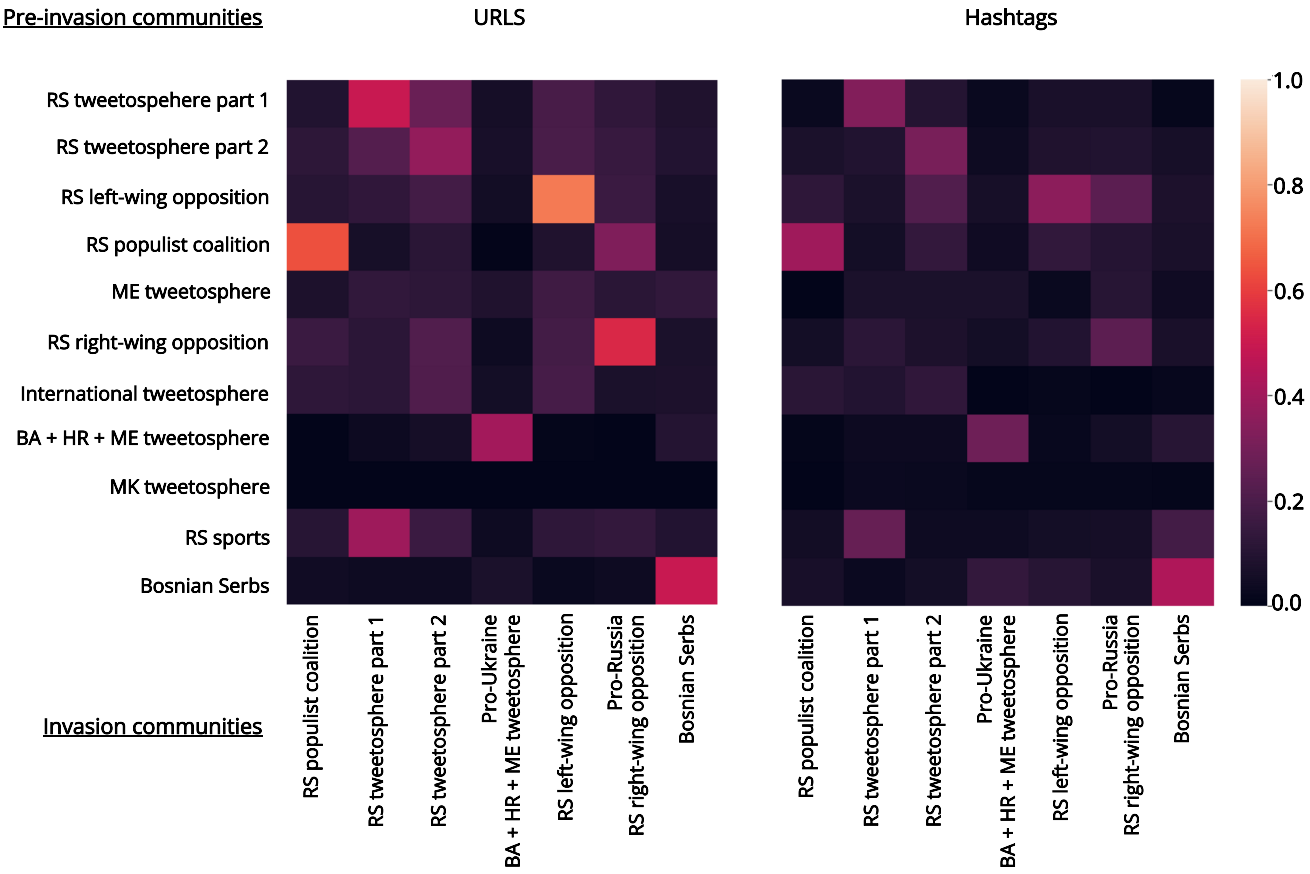

Figure 3: Domain and hashtag community similarities. A heatmap showing the similarities between the pre-invasion and invasion network communities based on the top 50 URLs (left) and hashtags (right). Similarities are calculated using the Rank-biased overlap (RBO) measure for indefinite rankings [5].

3 CONCLUSION

In this work, we investigated the Russian invasion of Ukraine through the lens of Twitter in the ex-Yugoslavian region where Bosnian, Croatian, Montenegrin and Serbian are spoken. We analyzed 12 weeks of Twitter activities in this region, six weeks before the invasion, and six weeks after the start of the invasion. For each period, we created retweet networks and detected retweet communities. We followed the transition of users from the pre-invasion to the invasion period and analyzed these groups of like-minded Twitter users, discovering that they are distinctly divided across countries and political orientations. For the invasion network, we were also able to detect communities which show clear pro-Ukrainian and pro-Russian stance.

Another contribution was a simple method for comparing retweet network communities based on the content of the tweets. The method showed a strong correlation with the most prominent user transitions we formerly discovered.

A continuation of this work is to expand it to a multidisciplinary research, with the aim to meticulously analyze the polarized content between the communities in collaboration with domain experts who are knowledgeable in ex-Yugoslavian politics. Beyond obtaining interesting insights, we also aim to explore two frequent issues in using social media for societal analyses: (1) uptake bias of specific social networks across countries and communities, and (2) entanglement of the main event with other large-scale events.

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REFERENCES

[1] B. Evkoski, I. Mozetič, P. Kralj Novak. Community evolution with Ensemble Louvain. In *10th Intl. Conf. on Complex Networks and their Applications*, Book of abstracts, pp. 58–60, Madrid, Spain, 2021.

[2] B. Evkoski, I. Mozetič, N. Ljubešić, and P. Kralj Novak. Community evolution in retweet networks. *PLoS ONE*, 16(9):e0256175, 2021. Non-anonymized version available at https://arxiv.org/abs/2105.06214.

[3] N. Ljubešić, D. Fišer, and T. Erjavec. TweetCaT: a tool for building Twitter corpora of smaller languages. In *Proc. 9th Intl. Conf. on Language Resources and Evaluation*, pp. 2279–2283, ELRA, Reykjavik, Iceland, 2014.

[4] N. Ljubešić, M. Miličević Petrović, and T. Samardžić. Borders and boundaries in Bosnian, Croatian, Montenegrin and Serbian: Twitter data to the rescue. Journal of Linguistic Geography 6:2, DOI 10.1017/jlg.2018.9, pp 100-124, Cambridge University Press, 2018

[5] W. Webber, A. Moffat, Alistair, and J. Zobel. A similarity measure for indefinite rankings. ACM Trans. Information Systems 28(4):20, 2010.

[6] G. Rossetti and R. Caxabet. Community discovery in dynamic networks: a survey. ACM computing surveys (CSUR) 51.2 (2018): 1-37.

Visualization of consensus mechanisms in PoS based blockchain protocols

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ABSTRACT

In the past decade, decentralized systems have been increasingly gaining more attention. Much of the attention arguably comes from both financial, and sociological acceptance, and adoption of blockchain technology. One of the frontiers has been the design of new consensus protocols, topology optimisation in these peer to peer(P2P) networks, and gossip protocol design. Analogue to agent based systems, transitioning from the design to implementation is a difficult task. This is due to the inherent nature of such systems, where nodes or actors within the system only have a local view of the system with very little guarantees on availability of data. Additionally, such systems often offer no guarantees of a system wide time synchronisation. This research offers insight into the importance of visualisation techniques in the implementation phase of vote based consensus algorithms, and P2P overlay network topology. We present our custom visualisations, and note their usefulness in debugging, and identifying potential issues in decentralized networks. Our use case is an implementation of a blockchain protocol.

KEYWORDS

Grafana, visualisation, consensus mechanism, blockchain protocols, P2P, overlay network

1 INTRODUCTION

Distributed systems are notoriously difficult to inspect and their problems difficult to identify. The difficulty stems from the fact that predominant issues can be stochastic and difficult to reproduce, and from the inability to easily observe, compare, and test multiple programs running on separate machines at the same time. Another important aspect in distributed systems is that they inherently make heavy use of the network. The use of various network protocols imposes additional complexity, which increases the search space in identifying bugs. In recent years, distributed systems have been gaining more attention both in academia and private sector. This increasing interest can be largely attributed to the rapid development of distributed ledger technology, and blockchain. In recent years, many new consensus mechanisms, blockchain protocols, network protocols, improvement in gossip protocols have been proposed. Many of them are transitioning from a theoretical framework to a practical implementation. However, public distributed ledgers (or distributed ledger technology or DLT) and blockchains secure their consensus mechanisms and provide spam resistance through the use of tokens representing value. The use of digital value within the protocol enables the protocol to enforce a level of security through economic incentives, and game theoretical aspects that make most attack vectors economically infeasible or impractical for the attacker. A good example of this is the Proof of Stake (PoS) consensus mechanism, where nodes in the decentralized protocol secure the consensus mechanism by requiring nodes to stake and lock up a considerable amount of value, which can be deducted (usually refereed to as slashing) by the protocol in case the node misbehaves. The economic aspect of public blockchains poses a very high security risk. With such strong economic incentives to identify and exploit potential bugs, and system faults, it is of upmost importance for the developers to thoroughly test and examine potential problems. However, the aforementioned difficulties in debugging distributed and decentralized protocols require developers to be equipped with tools that supports their efforts.

In this study, we review the state of the art approaches in testing and debugging voting based consensus mechanisms and decentralized networks. We develop a visualisation specifically designed for researchers and developers to test such networks and compare real-time observed data with the expected. We conclude that visualisation techniques can be complementary to traditional log based debugging, and testing techniques. Moreover, we provide our tools as open source software as plugins for popular visualisation platform Grafana. Both tools make no assumptions on the data storage implementation. The plugins can be configured via Grafana plugin configuration interface to fit the specifics of the protocol implementation. We validate our tools by applying them to a custom developed blockchain, and then explain how successful they turned out to be in identifying anomalies and bugs in the protocols.

2 THE ROLE OF VISUALIZATIONS IN DEBUGGING COMPLEX DISTRIBUTED SYSTEMS

Distributed and decentralized systems are difficult to debug as developers are working on the third layer. Which includes L1 (code level bugs), issues with concurrency on L2 (individual runtime), and finally the third dimension for potential bugs arising from the message exchange between nodes. In general, it is often hard to capture the state in a distributed system as debuggers cannot be attached to all nodes' run-times. Additionally, it is often difficult to reproduce errors when they are inherently stochastic. We consider several methods, such as *Logging, Remote debugging, Simulations* and *Visualisations*.

- Logging is the most common debugging method for all three layers. However, in distributed systems it is important to aggregate logs, and analyze them as a time series.

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Additionally, aggregating distributed logs assumes the system has some method of clock synchronization protocol. Log collection has been proven to be effective in detecting performance issues for systems such as *Hadoop* [12] and *Darkstar* [13]. The aggregation can be done with specific tools for log collection such as *InfluxDB* [8], *Logstash* [10], etc. Aggregated logs then can be viewed in a form of a dashboard using tools like Grafana (see Figure 1).

Figure 1: Part of the Grafana dashboard used by developers to gain insight into a running PoS based blockchain network.

- Remote debugging is a technique where a locally running debugger is connected to a remote node in the distributed system. This allows developers to use the same features as if they were debugging locally. However, it is difficult to determine which remote node should be debugged. Additionally, in case of Byzantine behaviour due to network faults connecting the debugger could fail.
- Distributed deterministic simulation and replay is a technique that attempts to address the issues of reproducibility in distributed systems. Tools like *Friday* [5] and *liblog* [6] can be used to record the specific state of the network to use and analyze it later. The technique suggests implementing an additional layer that abstracts the underlying hardware and the network interfaces to allow for an exact replay of all the state changes and messages exchanged between nodes. Tools such as FoundationDB or even custom systems are built on containerisation software.
- Visualisation and time series analysis attempts at capturing the state of the system, and all the nodes by visualising the collected logs. Tools like Prometheus [11] and Grafana [2] are used extensively. Tools like *Theia* [4] and *Artemis* [3] are designed for monitoring and analyzing performance problems in distributed systems and support built-in visualization tools for data exploration. However, such tools provide logs aggregated based summaries of the distributed systems and are not capable of observing underlying low-level network properties, e.g. monitoring network communication, especially in real-time while the system is running. *ShiViz* [1] on the other hand displays distributed system executions as an interactive timespace diagram. With this tool all the necessary events and interactions can be viewed in an orderly manner and inspected in detail. ShiViz visualization is based on logical ordering, meaning that unlike our tools, it is not capable of running in real-time, together with the considered distributed network. ShiViz also works with aggregated logs about various types of events of the distributed system and unlike our tools does not support direct database connections. ShiViz is generalized and works with all kind of distributed systems, while our tools are created specifically for monitoring PoS voting based consensus mechanisms and underlying network topology of the distributed system.

3 RESEARCH OBJECTIVES

The main goal of this research is to build visualisation tools that offer more insight into a running distributed system using the time series log collection data. The targeted system is a custom proof of stake based blockchain. Such tools should visualize if nodes contributing to the consensus learned about their correct roles, and if they perform their roles accordingly. In the consensus algorithms this is done by sending messages, so the tools should visualise messages exchanged between nodes.

In the structured P2P networks information spreads using gossip protocols and network topology changes every time slot. Our tools should visualize such changes in the network topology by drawing nodes and their cluster representatives, while at the same time indicating the consensus roles for each node.

In our implementation time series data comes from InfluxDB, but we want our tools to have no assumption on the data storage implementation and there are other popular databases, such as kdb+ and Prometheus, that work well with time series data. Because of that we choose Grafana as a platform for visualizations, which supports all of the aforementioned databases and many more at the time of writing.

In this work we implement two Grafana plugins built to visualize PoS based blockchains, and decentralized network topology. Our tools are designed with generality in mind, and are hence applicable to other PoS voting based blockchains and other distributed ledger implementations. We evaluate our tools by applying it to the custom developed blockchain and note their usefulness in debugging and identifying potential issues in decentralized networks.

4 GRAFANA PLUGINS FOR VISUALISING VOTE BASED CONSENSUS MECHANISMS AND P2P OVERLAY NETWORKS

We have developed two plugins that extend the functionality of Grafana. Figure 2 outlines the architecture used in production. A server running a database instance (preferably time series i.e. InfluxDB), and the Grafana platform. Depending on the underlying blockchain implementation, nodes can insert their telemetry directly to the database, or if possible have an archive node gather telemetry from nodes, and report them. In this example, a cluster was used to run multiple nodes. A coordinating node is responsible for maintaining an overlay network and serving the nodes within the overlay with a DHCP, DNS, and routing. Nodes are packed within docker containers and submitted to the coordinator, which uses built in load balancing and distributes them to other cluster nodes.

The telemetry inserted is timestamped to create a time series stream of data that is consumed by Grafana. Figure 1 shows a small part of the dashboard created within Grafana using the built-in plugins for typical visualisations. These visualisations are time series data of a running blockchain showing telemetry reported by the nodes. However, rendering telemetry from hundreds of nodes as factors is hardly informative.

Both plugins were developed as React components, using a well-known D3.js JavaScript library for animations and life-cycle of the plugins is managed by Grafana

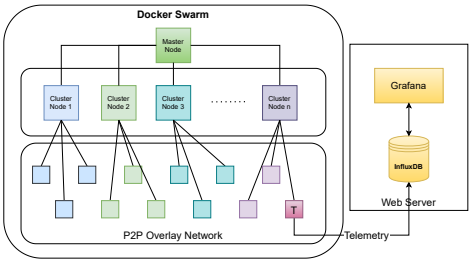

Figure 2: System architecture.

4.1 Network Plugin

P2P networks propagate information using gossip protocols. There are many variations of the general and implementation specifics but in general the family of protocols aims at gossiping the fact that new information is available in the network. Should a node hear about the gossip, and require the information it will contact neighbouring nodes asking for the data. In general, gossip protocols make no assumptions about the topology of the overlay network. However, with structured networks, the information exchange can be made much more efficient. The observed blockchain implementation utilized a semi structured network topology for propagating consensus based information. This is made possible by using a seed string shared between nodes that is used for pseudo-random role election every block. Using the seed, nodes self-elect into roles without the need to communicate. However, when performing roles, committee members must attest to the candidate block produced by the block producer. The seeded random is therefore also used to cluster the network using a k-means algorithm. The clustering is again performed by each node locally. The shared seed guarantees that nodes will produce the same topology, which is then used to efficiently propagate attestations to the block producer.

The network topology hence changes every slot. The plugin aims to visualize the changes in the network topology by drawing nodes, and their cluster representatives. Additionally, the consensus roles for each node are indicated with the vertex color. Figure 3 shows the network plugin rendering a test network of 30 nodes in real-time. The node in the center coloured green is the elected block producer for the current slot, nodes surrounded by the red stroke are cluster representatives, the rest of the nodes are coloured based on their role in the current slot.

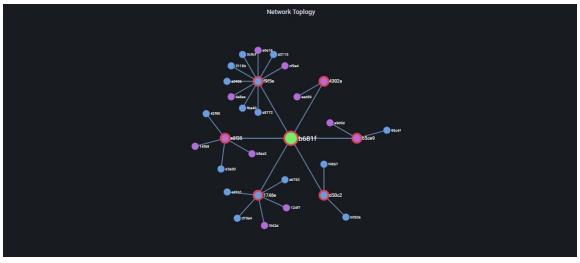

Figure 3: Network topology plugin visualising a test network of 30 nodes in real time.

4.2 Consensus Plugin

The aim of visualising the consensus mechanism is to quickly evaluate if nodes contributing to the consensus learned about their correct roles, and if they perform their roles accordingly. In order to have a scalable visualisation, nodes are placed around a circle, and scaled according to the size of the network. Roles are visualized with a color map. Each slot, nodes change their roles, and execute the protocol accordingly. To visualise the execution, the plugin visualises messages exchanged between nodes in a form of animated lines flying from an origin node to the destination node. The animations are time synchronous, and transfer times, and latencies are taken into account. Additionally, every message is logged with a type, indicating the sub protocol within which it was created. As an example, messages being sent from committee members to the block producer are attestations for the current block. The animated lines are coloured indicating the message type.

The thickness of the animated lines indicates the size of the payload transferred between nodes. Figure 4 shows the consensus plugin running live visualising a test network of 30 nodes. The green coloured node indicates the block producer role for the current slot, nodes coloured violet are part of the committee, and blue nodes are validators.

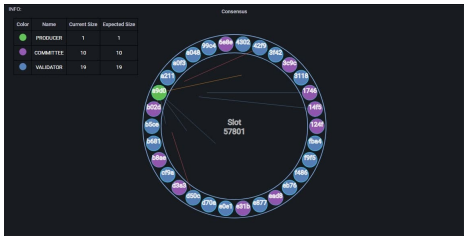

Figure 4: Consensus plugin (with legend) visualising a test network of 30 nodes in real time.

4.3 Generality

In order to use the above plugins, users have to provide certain data to the Grafana dashboard and this can be done through Grafana GUI. For the plugins to work all of the data should follow a specific naming policy. For example, for the Consensus plugin there is one necessary query to visualize data about the nodes of the network. It can be provided using SQL or Grafana GUI:

```
SELECT "slot", "node", "duty" FROM "<table-name>"
WHERE $timeFilter
```

Both plugins can be customized from the Grafana options menu. For example, users can add new roles, name and color them. Figure 5 shows the consensus plugin options menu, where users can additionally turn on or off display of messages, nodes or containers labels and so on. For both plugins, users have to manually provide the *slot time* of the network in the plugins options menus.

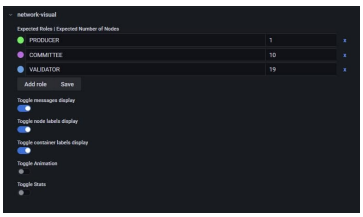

Figure 5: Consensus plugin options menu.

By using our tools we can visualize other protocols. For example with the consensus plugin we can visualize the famous Paxos algorithm, first introduced in [7] by Leslie Lamport. For that, we should provide the plugin with the *Nodes* and *Messages* queries. For the *Nodes* query, parameters *slot*, *node* and *duty* should be provided, which represent the slot number, node id and the role of the node respectively. From the point of nodes and slots, for this visualization Paxos works in the same way as the example of the PoS based consensus we mentioned before. For the *duty* parameter, nodes can have one of the three roles: *proposer*, *acceptor* or *learner*. That is why in the options menu of the plugin we should create 3 roles and name them according to the names from the data table.

We should specify *slot time* (in seconds) in the plugin options menu and at this point we can set the Grafana dashboard refresh time and see the results, since all the necessary conditions are fulfilled. But in order to gain more information from the plugin, we should add the *Messages* query. For the data we should have the following parameters: *id*, *source*, *target* and *endpoint*, which represent the message id, node id that sends the messages, node id that receives the message and the type of the message. For the additional information we can specify parameters *delay* (in seconds) and *size* of the message.

If we know the expected amount of nodes for some role, we can put it in the in plugin options menu to see this information in the plugin legend. In a similar way we should be able to visualize other consensus protocols, for example 2PC or Raft [9].

Source code for both plugins is open source, licensed under the MIT license and available on GitLab, where users can find the installation procedure of the plugins:

- Network plugin - https://gitlab.com/rentalker/topology-visualization-plugin,
- Consensus plugin - https://gitlab.com/rentalker/consensus-visualization-plugin.

5 CONCLUSION

We developed two Grafana plugins for visualising PoS based blockchains, and the underlying overlay network topology. The plugins were used to identify critical bugs, and faults in the protocol. With the help of visualisations, we were able to detect two problems when running test-nets.

- **Network congestion:** for every slot, validators must report their statistics to the block producer. Prompt delivery is desired but not critical. However, as the network grew in size, reporting statistics to a single node (block producer) became increasingly latent as all nodes attempted to propagate messages in tandem, and even more importantly, the network topology required a lot of routing for messages to arrive to the block producer. The network plugin helped us identify what the problem was by looking at the topology.
- **State synchronisation:** at random, nodes failed to perform their roles. This resulted in missing votes even on small test-nets, and sometimes a chain halt where no blocks were produced for the slot. We observed the likelihood of this happening grows in correlation with network size. However, it was infeasible to debug the state of all nodes in a large network. Visualising the state of nodes at a given slot we observed that states were not always synchronized and hence, some nodes did not learn about their consensus role.

We conclude that visualisation is an important tool in design and implementation of decentralized, and distributed systems. The methods serve a complementary role to existing debugging methods, and are very powerful at observing unexpected behaviour of the system as a whole. Visualisation techniques are specifically important in detecting stochastic faults that are non-trivial to reproduce. Our tools are open-source and available for researchers and engineers to use. They are suitable for testing any kind of voting-based consensus protocol with little effort.

For future work we would like to further develop our tools to accommodate other consensus protocols and help developers visualize and debug other types of issues related to distributed systems. Also, we would like to explore other types of visualizations and other existing tools that can help developers as well. Since Grafana is rapidly evolving, our developed plugins can be updated and new technologies can be integrated with our tools to improve their performance.

6 ACKNOWLEDGMENTS

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REFERENCES

[1] Beschastnikh, I., Wang, P., Brun, Y., and Ernst, M. D. Debugging distributed systems. *Commun. ACM 59*, 8 (jul 2016), 32–37.
[2] Chakraborty, M., and Kundan, A. P. Grafana. In *Monitoring Cloud-Native Applications*. Springer, 2021, pp. 187–240.
[3] Creţu-Ciocârlie, G. F., Budiu, M., and Goldszmidt, M. Hunting for problems with artemis. In *Proceedings of the First USENIX Conference on Analysis of System Logs* (USA, 2008), WASL'08, USENIX Association, p. 2.
[4] Garduno, E., Kavulya, S. P., Tan, J., Gandhi, R., and Narasimhan, P. Theia: Visual signatures for problem diagnosis in large hadoop clusters. In *Proceedings of the 26th International Conference on Large Installation System Administration: Strategies, Tools, and Techniques* (USA, 2012), lisa'12, USENIX Association, p. 33–42.
[5] Geels, D., Altekar, G., Maniatis, P., Roscoe, T., and Stoica, I. Friday: Global comprehension for distributed replay. vol. 7.
[6] Geels, D., Altekar, G., Shenker, S., and Stoica, I. Replay debugging for distributed applications. In *2006 USENIX Annual Technical Conference (USENIX ATC 06)* (Boston, MA, May 2006), USENIX Association.
[7] Lamport, L. The part-time parliament. *ACM Transactions on Computer Systems 16, 2 (May 1998), 133-169. Also appeared as SRC Research Report 49. This paper was first submitted in 1990, setting a personal record for publication delay that has since been broken by [60].* (May 1998). ACM SIGOPS Hall of Fame Award in 2012.
[8] Naqvi, S. N. Z., Yfantidou, S., and Zimányi, E. Time series databases and influxdb. *Studienarbeit, Université Libre de Bruxelles 12* (2017).
[9] Ongaro, D., and Ousterhout, J. In search of an understandable consensus algorithm. In *Proceedings of the 2014 USENIX Conference on USENIX Annual Technical Conference* (USA, 2014), USENIX ATC'14, USENIX Association, p. 305–320.
[10] Sanjappa, S., and Ahmed, M. Analysis of logs by using logstash. In *Proceedings of the 5th International Conference on Frontiers in Intelligent Computing: Theory and Applications* (Singapore, 2017), S. C. Satapathy, V. Bhateja, S. K. Udgata, and P. K. Pattnaik, Eds., Springer Singapore, pp. 579–585.
[11] Turnbull, J. *Monitoring with Prometheus*. Turnbull Press, 2018.
[12] Xu, W., Huang, L., Fox, A., Patterson, D., and Jordan, M. Online system problem detection by mining patterns of console logs. In *2009 Ninth IEEE International Conference on Data Mining* (2009), pp. 588–597.
[13] Xu, W., Huang, L., Fox, A., Patterson, D., and Jordan, M. I. Detecting large-scale system problems by mining console logs. In *Proceedings of the ACM SIGOPS 22nd Symposium on Operating Systems Principles* (New York, NY, USA, 2009), SOSP '09, Association for Computing Machinery, p. 117–132.

Using Machine Learning for Anti Money Laundering

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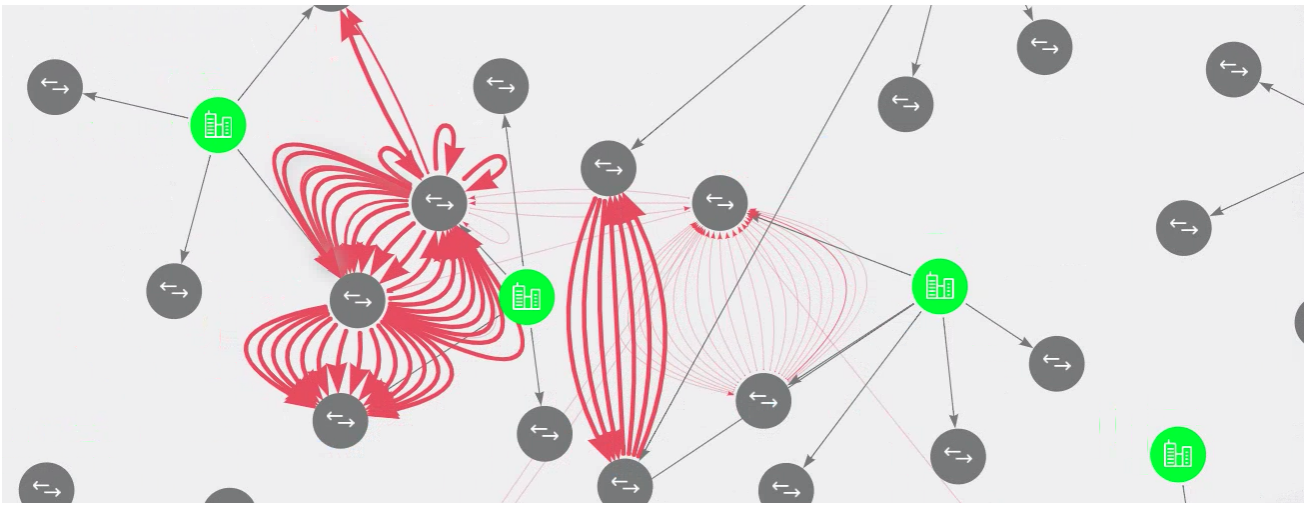

Figure 1: Example transaction network visualization

ABSTRACT

Here we present early results of a network component for anomaly detection in an attributed heterogeneous financial network. Utilizing both externally provided features and generated topological features, we train different models for a simple link prediction task. We then evaluate the models using initial dataset corruption. We show that gradient boosting and multi-layer perceptron generally have the best anomaly detection performance, despite graph neural network models initially showing better results in the link prediction task.

KEYWORDS

Anti Money Laundering (AML), machine learning, networks, link prediction

1 INTRODUCTION

Observing complex real-world graphs, be it a social, financial, biochemical, or physics-related network, is an interesting task. Given a time-evolving network and rich information about the nodes and edges, can we assume that there are some regular dynamics in the network?

Fraud and financial crime are important issues of our time. According to the United Nations Office on Drugs and Crime, an estimated 2-5 % of the world GDP is laundered each year. To keep pace with evolving trends, the European Union has decided to strengthen its anti money laundering and terrorist financing regulatory framework and expects the same from financial institutions and supervisory authorities.

Given a pseudonymized dataset of financial transactions, can we use machine learning to detect interesting, perhaps novel, patterns that should be inspected manually? In this paper, we try to answer this question.

2 RELATED WORK

Both supervised [7, 6, 12] and unsupervised or self-supervised [2, 14] learning approaches have been proposed to deal with the task of detecting money laundering. Due to the lack of labelled data and the closed nature of financial data and, therefore, the lack of standardised datasets, approach evaluation can be difficult. Despite that, cryptocurrency datasets such as [13] have been published, explored, and labelled to some extent.

Usually, synthetic oversampling or other strategies of sampling need to be employed in cases where labelled entities are used for evaluation [12, 13].

3 DATA

In this study, we use a snapshot of the transaction data processed through the international payment system *Target2-Slovenija* [11]. The dataset spans from November 2007 to December 2017, containing around 8 million financial transactions. No live data was used when performing this research - only archived datasets were used.

For some nodes, the data about the sending or receiving party is additionally linked to data from the Slovenian Business Register (ePRS) [1] and the Slovenian Transaction Account Registry (eRTR) [3] in order to provide additional context about each transaction.

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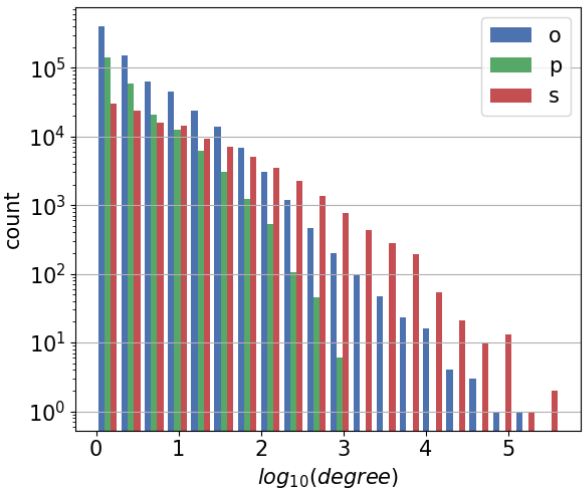

Figure 2: Degree distribution by node type.

Due to the sensitive nature of the data, all personal and confidential data about individuals and legal entities provided to JSI is pseudonymized.

4 DATA REPRESENTATION AS A HETEROGENEOUS GRAPH

There are large differences in the availability of data across different entities performing the transactions. In order to fully utilize all available features, we model the network as a heterogeneous temporal graph. Here, we treat the snapshot of the transaction graph from t_0 to t_1 $G = G(t_0, t_1)$ as a heterogeneous graph consisting of 3 discrete node types representing each entity's legal status. The types of accounts are those belonging to companies (node type *s*), natural persons (node type *p*), and all other accounts (node type *o*). Each transaction is represented as a directed edge from its source account to its destination account.

4.1 Network statistics

Due to different legislative bases for different types of entities, inherent differences regarding data availability are expected. Naturally, it is also expected that different categories usually act differently in a network - for example, companies usually transact more than individuals. While the degree distribution (Figure 2) closely resembles the power law, significant differences in distributions between different node types can be observed, which can be attributed to varying amounts of data available for our specific data source across account profiles.

It can be seen from Figure 2 that companies (node type *s*) perform most of the transactions.

4.2 Feature generation

Categorical features are one-hot encoded. Rare categories with $< 2\%$ incidence are marked as *other*. Additionally, node features encoding the role of a node in the network (Table 1) are generated. The node-level features for each node are computed on the whole network as well as for the subgraph induced by the node's own type.

feature	level
degree $\deg(A) = \lvert N(A) \rvert$	node-level
PageRank [9] $PR(A) = \frac{1-d}{N} + d \sum_{J \in N_{in}(A)} \frac{PR(J)}{\lvert N_{out}(J) \rvert}; d = 0.85$	node-level
Jaccard coefficient $J(A,B) = \frac{\lvert N(A) \cap N(B) \rvert}{\lvert N(A) \cup N(B) \rvert}$	edge-level
Adamic-Adar Index $A(x,y) = \sum_{u \in N(x) \cap N(y)} \frac{1}{\log \lvert N(u) \rvert}$	edge-level

Table 1: The structural features used for the link prediction task. $N(\cdot)$ represents the set of neighbours of the given node. N_{in} and N_{out} represent the sets of the nodes from which there is an edge to the given node (*in*), or to which there is an edge from the given node (*out*). $\lvert \cdot \rvert$ represents cardinality of the given set.

5 ANOMALY DETECTION PROBLEM DEFINITION

We corrupt the original graph by rewiring the total of $p = 1\%$ randomly picked edges of each edge type.

Let $f : V \times V \rightarrow [0, 1]$ be a binary link prediction classifier that is trained to predict the probability that a directed edge between the two given nodes exists.

We define the anomaly score of edge $(i, j) \in E$ as

$$\phi(i, j) = 1 - f(i, j) \tag{1}$$

The intuition behind equation 1 is that links that are typical to the model would have a smaller anomaly score than links for which the model predicts they would not exist (and are, thus, anomalous).

6 RESULTS

We train several models for the downstream task of link prediction and then use the predictions for anomaly detection.

6.1 Experiment details

The traditional (non-GNN) machine learning approaches are trained to predict whether the given edge exists or not. For each edge, the feature vector fed into the model is constructed by concatenating source node features, destination node features, and edge features. For traditional models, a model for each edge type is constructed separately, while the graph neural network-based models are the same across all edge types.

The GNN (graph neural network) models are constructed of 2 layers of GraphSAGE aggregations [8, 5] using parametric ReLU activations and embedding dimensions of 128 for the first and 64 for the second layer. As messages are passed in the direction of edges, we construct another model to facilitate information diffusion both ways. We do this by adding edges of opposite directionality than existing edges and marking them as a separate edge types. We still, however, only train for the downstream link prediction objective only on the existing (non-transposed) edges. We mark this approach as GNN$^+$.

The traditional ML models used are gradient boosting (GradBoost), decision tree (DecTree), multi-layer perceptron (MLP) and logistic regression (LogReg). The hidden layer sizes of the MLP are 20 and 10, using ReLU activation in all layers except the last one, where softmax activation is used. Different combinations of

reasonable hidden layer sizes were tested (32+16, 64+32, 256+128, 128+128, 20+10) and the best one was selected. The training of MLP models was performed with a batch size of 200.

6.2 Link prediction

Traditional ML models for link prediction map concatenated source and destination node features and edge features to the probability that a link between such nodes exists. The models are implemented using scikit-learn [10] and are trained and evaluated using 5-fold cross-validation.

As a preprocessing step, each feature is scaled individually using a standard scaler such that it has a mean of 0 and a standard deviation of 1 across the training set.

When training and evaluating each model, an approximately equal number of positive and negative links is given to the classifier. The provided edge features such as transaction amount are sampled randomly for negative edges.

Additionally, we train a 2-layer graph neural network (GNN) for link prediction. The GNN model is trained jointly for all edge types using weighted binary cross-entropy loss. The model has ReLU activations in all layers except the last one, where it has softmax activation. The hidden layer sizes are 64 and 32. The graph neural network is implemented using PyTorch Geometric [4].

We use a random link split for link prediction and not a temporal one, as our end goal is not to predict future links, but rather to learn what kinds of transactions are typical in the given network.

Table 2 shows the aggregated link prediction results. Bold results highlight the best performance across observed methods. The GNN does slightly improve link prediction performance in some cases. See Appendix A for more detailed non-GNN method results. The data here is computed across multiple year-long time windows.

edge	non-GNN	no str. f.	GNN	GNN$^+$
ss	0.92 ± 0.01	0.89 ± 0.01	0.92 ± 0.02	**0.94 ± 0.01**
oo	**0.80 ± 0.02**	0.57 ± 0.01	0.79 ± 0.02	0.53 ± 0.04
so	0.83 ± 0.01	0.75 ± 0.01	**0.88 ± 0.02**	0.74 ± 0.04
os	0.76 ± 0.01	0.64 ± 0.01	0.81 ± 0.01	**0.83 ± 0.02**
sp	**0.85 ± 0.02**	0.69 ± 0.03	0.78 ± 0.05	0.73 ± 0.02
ps	0.74 ± 0.02	0.67 ± 0.01	**0.87 ± 0.02**	0.75 ± 0.04
po	0.78 ± 0.02	0.66 ± 0.01	**0.84 ± 0.04**	0.54 ± 0.08
op	**0.89 ± 0.01**	0.53 ± 0.01	0.78 ± 0.05	0.50 ± 0.05
all	0.84 ± 0.01	0.72 ± 0.01	0.86 ± 0.02	**0.89 ± 0.01**

Table 2: Link prediction performance comparison measured in area under the receiver operating characteristic curve (AUC) (mean ± standard deviation). Edge types are marked with two letters, representing the source and destination node type in this order. Best non-GNN score, as well as best non-GNN score without using any structural features, are reported next to the GNN results.

6.3 Anomaly detection

For comparison between different methods, the 2% of edges with the highest anomaly scores are flagged as positive. Precision and recall are calculated by using the corrupted 1% of edges as true positives.

To summarize precision and recall in a single metric, F_1 score (2) is calculated and reported.

edge	non-GNN	no str. f.	GNN	GNN$^+$
ss	**0.19 ± 0.02**	0.16 ± 0.02	0.01 ± 0.00	0.01 ± 0.00
oo	**0.11 ± 0.02**	0.02 ± 0.01	0.05 ± 0.02	0.03 ± 0.02
so	**0.11 ± 0.02**	0.06 ± 0.01	0.01 ± 0.01	0.01 ± 0.01
os	**0.14 ± 0.02**	0.06 ± 0.01	0.01 ± 0.00	0.01 ± 0.01
sp	**0.08 ± 0.04**	0.02 ± 0.02	0.02 ± 0.01	0.02 ± 0.02
ps	**0.05 ± 0.02**	**0.05 ± 0.02**	0.01 ± 0.01	0.01 ± 0.01
po	**0.07 ± 0.04**	0.07 ± 0.05	0.02 ± 0.02	0.01 ± 0.02
op	**0.18 ± 0.04**	0.02 ± 0.01	0.02 ± 0.01	0.03 ± 0.02

Table 3: Anomaly detection performance comparison in F_1 score (mean ± standard deviation). Best non-GNN score, as well as best non-GNN score without using any structural features, are reported next to the GNN results. Bold results highlight the best performance across observed methods.

$$F_1^{-1} = \frac{\text{precision}^{-1} + \text{recall}^{-1}}{2} \tag{2}$$

A naive classifier that assigns the same positive score (recall 1) to each edge has F_1 score of ≈ 0.02. However, the underrepresented edge types typically have higher variance in F_1 score and performance insignificantly different from the naive baseline, as seen from Table 3. The same goes for the GNN-based models. See Appendix A for more detailed non-GNN model results.

7 DISCUSSION AND FUTURE WORK

We have constructed and evaluated a self-supervised approach to anomaly detection in financial networks. Due to the lack of labelled data, this is in most cases the most straightforward approach to tackle the problem with machine learning. There are significant differences in performance across different edge types. Using this approach yields almost comparable results with both raw features and structural features when evaluated on company-to-company transactions only. This may be explained by companies in our dataset having the most insightful features of all node types such as the broader sector and also more precise company industry type classification.

This paper has mainly focused on the use of unsupervised learning for anomaly detection. In the future, we plan to extend our work to supervised and semi-supervised learning approaches to try to utilize the few labelled data points. The following machine learning strategies (or a combination of them) could be tested:

- **Active learning.** Human-assisted active learning approach is a natural way to incorporate domain knowledge into the decision-making process.
- **Synthetic oversampling.** Due to a small number of the positive examples, we could sample new examples that are similar to them and assign them positive labels.
- **Model pretraining and few-shot learning.** Update model parameters with a self-supervised pretraining strategy first, and then optimize it further on the few labeled data points.

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REFERENCES

[1] 2022. AJPES - ePRS. (September 2022). https://www.ajpes.si/prs/.

[2] Claudio Alexandre and João Balsa. 2016. Client Profiling for an Anti-Money Laundering System. https://arxiv.org/abs/1510.00878.

[3] 2022. eRTR. (September 2022). https://www.ajpes.si/eRTR/JavniDel/Iskanje.aspx.

[4] Matthias Fey and Jan E. Lenssen. 2019. Fast Graph Representation Learning with PyTorch Geometric. In *ICLR Workshop on Representation Learning on Graphs and Manifolds*.

[5] William L. Hamilton, Rex Ying, and Jure Leskovec. 2017. Inductive Representation Learning on Large Graphs. *arXiv:1706.02216 [cs, stat]*. arXiv: 1706.02216. Retrieved 06/18/2021 from http://arxiv.org/abs/1706.02216.

[6] Mikel Joaristi, Edoardo Serra, and Francesca Spezzano. 2019. Detecting suspicious entities in Offshore Leaks networks. *Social Network Analysis and Mining*, 9, 1, 1–15. Publisher: Springer Vienna. ISSN: 1327801906. DOI: 10.1007/s13278-019-0607-5. https://doi.org/10.1007/s13278-019-0607-5.

[7] Martin Jullum, Anders Løland, Ragnar Bang Huseby, Geir Ånonsen, and Johannes Lorentzen. 2020. Detecting money laundering transactions with machine learning. *Journal of Money Laundering Control*, 23, 1. DOI: 10.1108/JMLC-07-2019-0055. https://www.emerald.com/insight/1368-5201.htm.

[8] Thomas N. Kipf and Max Welling. 2017. Semi-Supervised Classification with Graph Convolutional Networks. *arXiv:1609.02907 [cs, stat]*, (February 2017). arXiv: 1609.02907. Retrieved 06/18/2021 from http://arxiv.org/abs/1609.02907.

[9] Larry Page, Sergey Brin, R. Motwani, and T. Winograd. 1998. The PageRank Citation Ranking: Bringing Order to the Web. (1998).

[10] F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, J. Vanderplas, A. Passos, D. Cournapeau, M. Brucher, M. Perrot, and E. Duchesnay. 2011. Scikit-learn: machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830.

[11] 2022. TARGET2 in TARGET2-Slovenija. si. (September 2022). Retrieved 09/21/2022 from https://www.bsi.si/placila-in-infrastruktura/placilni-sistemi/target2-in-target2-slovenija.

[12] Dominik Wagner. 2019. Latent representations of transaction network graphs in continuous vector spaces as features for money laundering detection. *Gesellschaft für Informatik*, 1–1.

[13] Mark Weber, Giacomo Domeniconi, Jie Chen, Daniel I Karl Weidele, Claudio Bellei, Tom Robinson, and Charles E Leiserson. 2019. Anti-Money Laundering in Bitcoin: Experimenting with Graph Convolutional Networks for Financial Forensics. Technical report.

[14] Jiaxuan You, Tianyu Du, Fan-yun Sun, and Jure Leskovec. 2021. Graph Learning in Financial Networks. (September 2021). https://snap.stanford.edu/graphlearning-workshop/slides/stanford_graph_learning_Finance.pdf.

A DETAILED RESULTS

A.1 Link prediction (AUC)

edge	DecTree	GradBoost	LogReg	MLP
ss	0.87 ± 0.01	0.90 ± 0.01	0.79 ± 0.01	**0.92 ± 0.01**
oo	0.80 ± 0.01	**0.80 ± 0.02**	0.51 ± 0.01	0.74 ± 0.01
so	0.82 ± 0.01	**0.83 ± 0.01**	0.65 ± 0.01	0.82 ± 0.01
os	0.75 ± 0.01	**0.76 ± 0.01**	0.58 ± 0.02	0.73 ± 0.01
sp	0.81 ± 0.02	**0.85 ± 0.02**	0.55 ± 0.02	0.83 ± 0.02
ps	0.70 ± 0.02	**0.74 ± 0.02**	0.54 ± 0.02	0.69 ± 0.01
po	0.72 ± 0.02	**0.78 ± 0.02**	0.54 ± 0.02	0.67 ± 0.01
op	0.85 ± 0.01	**0.89 ± 0.01**	0.51 ± 0.03	0.87 ± 0.01
all	0.81 ± 0.01	**0.84 ± 0.01**	0.66 ± 0.02	0.82 ± 0.01

A.2 Anomaly detection (F_1 score)

edge	DecTree	GradBoost	LogReg	MLP
ss	0.12 ± 0.01	0.13 ± 0.02	0.04 ± 0.01	**0.19 ± 0.02**
oo	0.07 ± 0.01	**0.11 ± 0.02**	0.01 ± 0.01	0.10 ± 0.02
so	0.08 ± 0.01	0.10 ± 0.02	0.04 ± 0.01	**0.11 ± 0.02**
os	0.06 ± 0.01	0.12 ± 0.02	0.04 ± 0.01	**0.14 ± 0.02**
sp	0.06 ± 0.01	0.07 ± 0.04	0.02 ± 0.02	**0.08 ± 0.04**
ps	0.04 ± 0.01	**0.05 ± 0.02**	0.01 ± 0.01	**0.05 ± 0.02**
po	0.04 ± 0.01	**0.07 ± 0.04**	0.02 ± 0.03	0.04 ± 0.03
op	0.09 ± 0.01	0.14 ± 0.04	0.01 ± 0.01	**0.18 ± 0.04**

Forecasting Sensor Values in Waste-To-Fuel Plants: a Case Study.

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ABSTRACT

In this research, we develop machine learning models to predict future sensor readings of a waste-to-fuel plant, which would enable proactive control of the plant's operations. We developed models that predict sensor readings for 30 and 60 minutes into the future. The models were trained using historical data, and predictions were made based on sensor readings taken at a specific time. We compare three types of models: (a) a näive prediction that considers only the last predicted value, (b) neural networks that make predictions based on past sensor data (we consider different time window sizes for making a prediction), and (c) a gradient boosted tree regressor created with a set of features that we developed. We developed and tested our models on a real-world use case at a waste-to-fuel plant in Canada. We found that approach (c) provided the best results, while approach (b) provided mixed results and was not able to outperform the näive consistently.

CCS CONCEPTS

• **Computing methodologies** → **Machine learning**; • **Applied computing**;

KEYWORDS

Smart Manufacturing, Machine Learning, Feature Engineering

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1 INTRODUCTION

There is a wide range of applications of ML (machine learning). One of them is the modeling and control of chemical processes, such as the production of biodiesel. Introducing machine learning to such processes can improve quality and yield and help engineers predict anomalies to control the factory better.

We modeled the JEMS waste-to-fuel plant, which produces high-quality diesel from organic waste. The plant has numerous sensors that measure temperature, and pressure, among other variables. It is operated by experts who must control the process. Since the chemical process is complex and, therefore, difficult to control, we built forecasting models that can predict future sensor readings based on historical data and the current state of the plant.

The model will be used to give plant operators additional information about the future state of the plant, which will allow them to make an informed decision about changing the plant's parameters and, therefore, adjust the process before it is too late.

2 RELATED WORK

Organic wastes in energy conversion technologies are an active area of research aimed at reducing dependence on fossil fuels, optimizing production costs, improving waste management, and controlling emissions. Biochemical, physiochemical, and thermochemical processes produce different biofuels, such as bio-methanation, biohydrogen, biodiesel, ethanol, syngas, and coal-like fuels, which are studied by Stephen et al. [8]. Work is also being done on optimization, such as catalyst selection, reactor design, pyrolysis temperature, and other important factors [5].

Many ML methods have been developed to address waste management and proper processing for biofuel production, focusing on energy demand and supply prediction [3]. Aghbashlo et al. [2] provided a systematic review of various applications of ML technology with a focus on ANN (Artificial Neural Network) in biodiesel research. They provided an overview of the use of ML in modeling, optimization, monitoring, and process control. Models that predict the conditions of the biofuel production process that have the highest yield were created by Kusumo et al. [6] and Abdelbasset et al. [1]. The models used in these studies were kernel-based extreme learning machines, ANN, and various ensemble models.

3 USE CASE

The JEMS waste-to-fuel plant produces synthetic diesel (SynDi) from any hydrocarbon-based waste, such as wood, biomass, paper, waste fuels and oils, plastics, textiles, rubber, and agricultural residues. The plant uses a chemical-catalytic de-polymerization process, the advantage of which is that the temperature is too low

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to produce carcinogenic gasses. It operates continuously and produces about 150 liters of fuel per hour. Although it uses the latest software available and allows remote control, there is no anomaly detection, prediction, or optimization. As a result, there is a great need for better understanding, optimization, and decision-making, given data availability. The company plans to sell and install over 1.500 SynDi systems over the next ten years. In practice, this means many SynDi plants in different locations worldwide.

There are three main chambers in the pipeline, which are named B100, B200, and B300. The plant can be conceptually split into four stages

(1) Feedstock inspecting and feeding;
(2) Drying and mixing (chamber B100);
(3) Processing (chamber B200);
(4) Distilling (chamber B300).

Since there are no sensors in the feedstock inspecting and feeding stage, we focused on the later stages, each of which takes place in one of the main chambers.

In the drying and mixing stage (B100), the starting material is mixed with process oil, lime, and catalyst and is heated. During mixing, the material is broken down into smaller particles, and the water is evaporated. The primary chemical reaction occurs in the processing stage (B200). The material is fed to a turbine, and the reaction product evaporates through the diesel distillation column. If the diesel obtained is not of sufficient quality, it is redistilled in the second distillation stage (B300).

Currently, the plants are operated with highly skilled personnel and high costs for personnel training. Implementing automation, remote control, optimization, and interconnection among the plants would greatly facilitate their operation. Therefore, the main challenge to be solved by integrating AI is the self-control of the chemical process and the plant itself by minimizing the human resources required to operate the plants. Furthermore, operating many SynDi plants also means a significant challenge for ensuring remote control for troubleshooting, maintenance, and repair. AI integration aims to minimize the workforce required to operate the plants, minimize the resulting downtime due to human interaction, enable self-control and predictive maintenance of the SynDi plants, and achieve less downtime and higher production efficiency.

In modeling the waste-to-fuel processes, we decided to model each chamber separately. No model was developed for chamber B300 because it was not active during the period for which we obtained the data. As described above, a second distillation of the fuel is performed in chamber B300 only if the fuel in chamber B200 is not pure enough.

4 METHODOLOGY

4.1 Data analysis

The sensor measurements are from the experimental JEMS plant, which is located in Canada. The data consists of 154 sensors from January 2016 to January 2017. The measurements are taken at one-minute intervals and mostly measure temperature or pressure, but there are also sensors for motor current and valve position, among others. Since the data is from the prototype version of the waste-to-fuel plant, it contains many missing values. Our data set contained an average of 61.607 data points per sensor. We discarded all sensors with less than 6.000 data points and kept only those that corresponded to chambers B100 and B200, giving us data from 39 sensors.

Analysis of the dataset we received revealed that many values were missing. In particular, we noted that there were day-long intervals with a tiny number of measurements. We also noticed that specific sensor values remained constant at low temperatures - a condition best described by the waste-to-fuel plant's inactivity. We, therefore, decided to remove such values. Because there were many ten-minute gaps, we decided to resample the data at fifteen-minute intervals, taking the last value of each interval and assuming that conditions had not changed in the short time since the last measurement - a reasonable assumption for sensor values. The resulting data set contained an average of 7.884 data points per sensor.

We divided the dataset into a train and a test dataset, split on October 31st 2016. The resulting train set included a total of 11.000 samples, and the test set included 3.000 samples.

4.2 Model training

In this research, we compare models that we develop using two different approaches. We first tried the neural network approach, in which the model makes predictions based only on sensor readings from the last five hours. Since the model did not perform better than the baseline, we began the second approach, developing features to describe the time series and capture its patterns. We used linear regression and gradient-boosted tree regressor. All the developed models were compared with the last-value model, which we used as a benchmark.

4.2.1 Neural network approach. We used the model developed for forecasting Tüpras' sensor values. Tüpras is an oil refinery, which is very similar to the JEMS use case. The model was used to forecast sensor values in different units of LPG production. Some of Tüpras' units are distillation columns, similar to JEMS' chamber B200. The model takes only past sensor values as input and predicts values for the future together with the prediction interval. More specifically, it predicts 10th, 50th and 90th percentile, which is the case in all our models that give prediction interval.

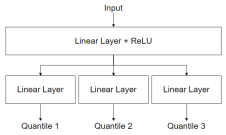

Figure 1: Architecture of the neural network model, which gives the prediction interval.

Figure 1 shows the architecture of the neural network. The model is a feedforward neural network with two layers. First, there is a linear layer with ReLU activation. The second layer has a separate linear layer for each quantile. The hidden dimension of the model is calculated from the number of features and the number of targets using the formula $\lfloor \frac{n_{\text{features}}}{2} \rfloor + n_{\text{targets}}$.

During training, we used the quantile loss function, which is defined as

$$\max\left\{q \cdot \left(y_{\text{true}} - y_{\text{pred}}\right), (1-q) \cdot \left(y_{\text{pred}} - y_{\text{true}}\right)\right\},$$

where q is the observed quantile (in our case, it can be 0.1, 0.5 or 0.9), y_{true} is the true target value and y_{pred} is the corresponding quantile of the prediction. In the case of $q = 0.5$, the loss is equal to the mean absolute error divided by two. When calculating the loss of 10^{th} percentile ($q = 0.1$), a prediction that is greater than the true value is heavily penalized, while a prediction that is lower than the true value has a smaller loss and is therefore encouraged.

The model is implemented in the PyTorch library [7]. Since sensors measure different quantities, the values have to be scaled before learning. Here we used Min-Max scaler from the scikit-learn library, scaling all values between zero and one.

4.2.2 Feature engineering. The neural network model described above did not outperform the benchmark model. As a result, we decided to try another approach, where we developed features that better describe past sensor values and capture their patterns. One of the problems of the neural network model was that it had too many features. We decided to build a separate model for each sensor to tackle this problem. Each model uses only features calculated from the values of the sensor being predicted.

With the help of plant operators, we decided to consider at most five hours of data before the prediction point to issue a forecast. Since the latest data is usually more important in determining future sensor values, we created features on seven different time windows: 30, 45, 75, 120, 180, 240, and 300 minutes. For each time window, we computed the following features:

- average sensor value,
- fraction of peaks in the window,
- percentage change between first and last value in the time window,
- slope (coefficient of the least squares line through the points in the window),
- simple prediction (extension of the least squares line to the future),
- slope ratio (slope on the smaller window divided by the slope on the bigger window).

Besides features mentioned above, which depend on the window size, we also included features that were calculated only on the biggest time window (300 minutes):

- last value,
- maximal value,
- last value relative to the maximal value.

The features above attempt to capture different time series characteristics:

- *trend*: described by percentage change and slope;
- *growth pattern*: described by the fraction of peaks, which indicate whether the growth is steady or it has ups-and-downs. Furthermore, the slope indicates how aggressive such growth is;
- *expected value*: an approximation of the expected value is given through the average, last value, maximal value, and simple prediction.

Using developed features, we trained a linear regression model, and a gradient boosted tree regressor from the CatBoost library [4]. We used root mean squared error (RMSE) for the loss function.

5 RESULTS AND ANALYSIS

We built models for main chambers B100 and B200 with two forecasting horizons (30 and 60 minutes). Tables 1 and 2 show mean squared error (MSE) and mean absolute error (MAE) on chambers B100 and B200, respectively. There are three different neural network models (NN), which differ in the size of the window from which it gets the data.

	horizon = 30min		horizon = 60min	
	MSE	MAE	MSE	MAE
last-value model	21.0533	**1.4320**	50.6636	2.5128
NN, window = 5h	21.7525	1.6512	47.0545	2.5413
NN, window = 3h	19.7441	1.6109	45.3450	2.4127
NN, window = 2h	18.9717	1.6023	46.5047	2.5357
Linear regression	19.4264	1.4634	49.2268	2.5145
Catboost	**16.9030**	1.4478	**38.3066**	**2.3164**

Table 1: MSE and MAE on the test set of models when predicting for chamber B100.

	horizon = 30min		horizon = 60min	
	MSE	MAE	MSE	MAE
last-value model	52.3380	**2.0577**	124.9735	**3.3768**
NN, window = 5h	69.4678	3.8227	129.0330	4.9927
NN, window = 3h	57.9902	3.3601	121.1315	4.7431
NN, window = 2h	55.8769	3.1797	117.4154	4.7146
Linear regression	55.0218	3.2293	115.7457	4.5888
Catboost	**49.3329**	2.5305	**109.5303**	3.9745

Table 2: MSE and MAE on the test set of models when predicting for chamber B200.

From the tables 1 and 2 we can see that the five-hour window's neural network performed worse than the benchmark. The main reason for such poor results was too many features for the amount of data that we have. More precisely, the neural network model uses the values of all sensors in the chamber we are predicting. This means that there are six hundred features resulting in more than two hundred thousand trainable parameters for the model of chamber B200. We also have to consider that the neural network predicts future sensor values and prediction intervals. Therefore, there are too many features and target values for the amount of data that we have.

We included results of two more neural network models with three hours and two-hour windows since reduced window size results in a smaller number of features and trainable parameters. For example, the neural network model with a two-hour time window for chamber B200 had two hundred and forty features and almost fifty thousand trainable parameters. Neural network models with smaller window sizes performed better, which confirms that we had too many features.

The features that we developed using the second approach were used with two models, linear regression and the Catboost model. Comparing those two models, the Catboost model performed better because it can capture more than just linear relationships between the features and the target. The Catboost model also outperformed the neural networks, where one of the main differences is that the neural network uses all sensors from the chamber while the Catboost model uses only sensor values of the sensor which is being predicted. This results in forty-five features for the model that predicts one sensor, which solves the problem of too many features. In addition, the Catboost model produced better results than the benchmark when comparing the mean squared error (MSE). During the training, we used RMSE as a loss function, meaning that RMSE was minimized and, therefore, also MSE.

The tables show that although most models outperform the benchmark regarding MSE, almost all of them do not surpass the benchmark when considering MAE. When measuring MSE, predictions with strong spikes where such spikes do not take place are penalized more. Therefore, models with a competitive MSE are considered to rarely predict spikes when such spikes do not take place. This is a key feature for our use case, given that we are interested to understand whether an irregularity will take place or not. Therefore, the models give valuable information even though the average prediction is not entirely accurate.

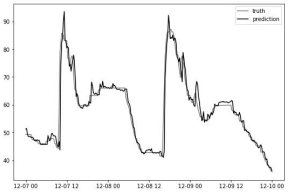

Figure 2: True value and prediction of the Catboost model for a temperature sensor in chamber B100.

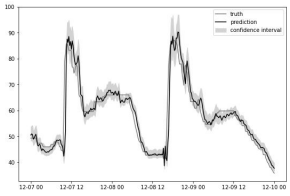

Figure 3: True value and prediction with a confidence interval of the neural network model with a two-hour window for a temperature sensor in chamber B100.

Figure 2 shows the Catboost model prediction on the test set together with the true values of the temperature sensor in chamber B100. The neural network model's prediction of the same sensor is presented in Figure 3. Since the neural network model also outputs prediction interval, it is shown in the abovementioned Figure.

From the plots, we can see that both models can closely predict future sensor values. In the case of the neural network model, the actual value is mainly inside the predicted confidence interval, except when there is a significant change in the sensor value. However, there is no problem with models not being able to predict significant changes resulting from a manual change in plant setpoint parameters, which our data does not capture. Overall, we consider the best model was the Catboost model, given in all cases it outperformed the rest of the models when considering MSE, and also achieved the best MAE when predicting chamber B100 with a time horizon of 60 minutes.

6 CONCLUSION

We compared a set of models to predict sensor values for a waste-to-fuel plant: a neural network, linear regression, gradient-boosted tree regressor, and the last-value model. The last-value model was used as a benchmark. We developed three neural network models which were different in time window size. The neural network models were built based on the hypothesis that a simple neural network and raw sensor readings as features are enough to model the process. The results showed that this is not the case because the process is too complicated for the amount of data that we obtained. Lastly, we used feature engineering to develop features that better describe the time series. Features were used for learning linear regression, and the gradient boosted tree regressor, where the latter produced the best results in our case.

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REFERENCES

[1] Walid Kamal Abdelbasset, Safaa M Elkholi, Maria Jade Catalan Opulencia, Tazeddinova Diana, Chia-Hung Su, May Alashwal, Mohammed Zwawi, Mohammed Algarni, Anas Abdelrahman, and Hoang Chinh Nguyen. 2022. Development of multiple machine-learning computational techniques for optimization of heterogenous catalytic biodiesel production from waste vegetable oil. *Arabian Journal of Chemistry* 15, 6 (2022), 103843.

[2] Mortaza Aghbashlo, Wanxi Peng, Meisam Tabatabaei, Soteris A Kalogirou, Salman Soltanian, Homa Hosseinzadeh-Bandbafha, Omid Mahian, and Su Shiung Lam. 2021. Machine learning technology in biodiesel research: A review. *Progress in Energy and Combustion Science* 85 (2021), 100904.

[3] Hemal Chowdhury, Tamal Chowdhury, Pranta Barua, Salman Rahman, Nazia Hossain, and Anish Khan. 2021. *Biofuel production from food waste biomass and application of machine learning for process management.* 96–117. https://doi.org/10.1016/B978-0-12-823139-5.00004-6

[4] Anna Veronika Dorogush, Vasily Ershov, and Andrey Gulin. 2018. CatBoost: gradient boosting with categorical features support. *arXiv preprint arXiv:1810.11363* (2018).

[5] Bidhya Kunwar, HN Cheng, Sriram R Chandrashekaran, and Brajendra K Sharma. 2016. Plastics to fuel: a review. *Renewable and Sustainable Energy Reviews* 54 (2016), 421–428.

[6] F Kusumo, AS Silitonga, HH Masjuki, Hwai Chyuan Ong, J Siswantoro, and TMI Mahlia. 2017. Optimization of transesterification process for Ceiba pentandra oil: A comparative study between kernel-based extreme learning machine and artificial neural networks. *Energy* 134 (2017), 24–34.

[7] Adam Paszke, Sam Gross, Francisco Massa, Adam Lerer, James Bradbury, Gregory Chanan, Trevor Killeen, Zeming Lin, Natalia Gimelshein, Luca Antiga, Alban Desmaison, Andreas Kopf, Edward Yang, Zachary DeVito, Martin Raison, Alykhan Tejani, Sasank Chilamkurthy, Benoit Steiner, Lu Fang, Junjie Bai, and Soumith Chintala. 2019. PyTorch: An Imperative Style, High-Performance Deep Learning Library. In *Advances in Neural Information Processing Systems 32*, H. Wallach, H. Larochelle, A. Beygelzimer, F. d'Alché-Buc, E. Fox, and R. Garnett (Eds.). Curran Associates, Inc., 8024–8035. http://papers.neurips.cc/paper/9015-pytorch-an-imperative-style-high-performance-deep-learning-library.pdf

[8] Jilu Lizy Stephen and Balasubramanian Periyasamy. 2018. Innovative developments in biofuels production from organic waste materials: a review. *Fuel* 214 (2018), 623–633.

Machine Beats Machine: Machine Learning Models to Defend Against Adversarial Attacks.

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ABSTRACT

We propose using a two-layered deployment of machine learning models to prevent adversarial attacks. The first layer determines whether the data was tampered, while the second layer solves a domain-specific problem. We explore three sets of features and three dataset variations to train machine learning models. Our results show clustering algorithms achieved promising results. In particular, we consider the best results were obtained by applying the DBSCAN algorithm to the structured structural similarity index measure computed between the images and a white reference image.

CCS CONCEPTS

• **Information systems → Data mining**; • **Computing methodologies → Computer vision problems**; • **Applied computing**;

KEYWORDS

Cybersecurity, Adversarial Attacks, Machine Learning, Automated Visual Inspection

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1 INTRODUCTION

Artificial Intelligence (AI) solutions have penetrated the Industry 4.0 domain by revolutionizing the rigid production lines enabling innovative functionalities like mass customization, predictive maintenance, zero defect manufacturing, and digital twins. However, AI-fuelled manufacturing floors involve many interactions between the AI systems and other legacy Information and Communications Technology (ICT) systems, generating a new territory for malevolent actors to conquer. Hence, the threat landscape of Industry 4.0 is expanded unpredictably if we also consider the emergence of adversary tactics and techniques against AI systems and the constantly increasing number of reports of Machine Learning (ML) systems abuses based on real-world observations. In this context, Adversarial Machine Learning (AML) has become a significant concern in adopting AI technologies for critical applications, and it has already been identified as a barrier in multiple application domains. AML is a class of data manipulation techniques that cause changes in the behavior of AI algorithms while usually going unnoticed by humans. Suspicious objects misclassification in airport control systems [7], abuse of autonomous vehicles navigation systems [11], tricking of healthcare image analysis systems for classifying a benign tumor as malignant [15], abnormal robotic navigation control [23] are only a few examples of AI models' compromise that advocate the need for the investigation and development of robust defense solutions.

Recently, the evident challenges posed by AML have attracted the attention of the research community, the industry 4.0, and the manufacturing domains [20], as possible security issues on AI systems can pose a threat to systems reliability, productivity, and safety [2]. In this reality, defenders should not be just passive spectators, as there is a pressing need for robustifying AI systems to hold against the perils of adversarial attacks. New methods are needed to safeguard AI systems and sanitize the ML data pipelines from the potential injection of adversarial data samples due to poisoning and evasion attacks.

We developed a machine learning model to address the above-mentioned challenges, detecting whether the incoming images are adversarially altered. This enables a two-layered deployment of machine learning models that can be used to prevent adversarial attacks (see Fig. 1): (a) the first layer with models determining whether the data was tampered, and (b) a second layer that operates with regular machine learning models developed to solve particular domain-specific problems. We demonstrate our approach in a real-world use case from *Philips Consumer Lifestyle BV*. This paper explores a diverse set of features and machine learning models to detect whether the images have been tampered for malicious purposes.

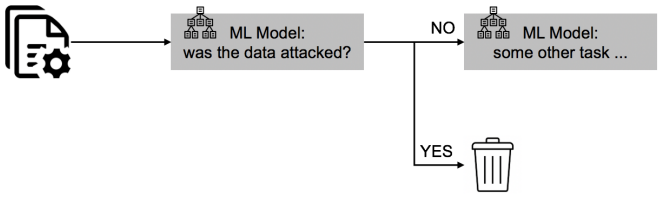

Figure 1: Two-layered deployment of machine learning models can be used to prevent adversarial attacks.

This paper is organized as follows. Section 2 outlines the current state of the art and related works, Section 3 describes the use case, and Section 4 provides a detailed description of the methodology and experiments. Finally, Section 5 outlines the results obtained, while Section 6 concludes and describes future work.

2 RELATED WORK

AML attacks are considered a severe threat to AI systems, and, that is, the research community seeks new robust defensive methods. Image classifiers, those analyzed in this work, are the focal point of the vast majority of the AML literature, as those have been proved prone to noise perturbations. According to the literature, prominent solutions focus on denoising the image classifiers, training the target model with adversarial examples, known as adversarial training, or applying standalone defense algorithms.

Yan et. al. [21] proposed a new adversarial attack called Observation-based Zero-mean Attack, and they evaluated the robustness of various deep image denoisers. They followed an adversarial training strategy and effectively removed various synthetic and adversarial noises from data. In [17], pre-processing data defenses for image denoising are evaluated, highlighting the advantages of such approaches that do not require the retraining of the classifiers, which is a computationally intense task in computer vision.

However, the robustness of adversarial training via data augmentation and distillation is advocated by the majority of the works in the domain. Specifically, Bortsova et al. [3] have focused on adversarial black-box settings, assuming that the attacker does not have full access to the target model as a more realistic scenario. They tuned their testbed to ensure minimal visual perceptibility of the attacks. The applied adversarial training dramatically decreased the performance of the designed attack. Hashemi and Mozaffari [8] trained CNNs with perturbed samples manipulated by various transformations and contaminated by different noises to foster robustness using adversarial training.

On top of the above, several standalone solutions have been proposed. CARAMEL system in [13] offered a set of detection techniques to combat security risks in automotive systems with embedded camera sensors. Hybrid approaches and more general alternatives intrinsically improve the robustness of AI models. A defensive Distillation mechanism against evasion attacks is proposed in [16] being able to reduce the effectiveness of adversarial sample creation from 95% to less than 0.5% on a studied DNN. Subset Scanning was presented in [19] to give the ability to DNNs to recognize out-of-distribution samples.

3 USE CASE

The Philips factory in Drachten, the Netherlands, is an advanced factory for mass manufacturing consumer goods (e.g., shavers, OneBlade, baby bottles, and soothers). Current production lines are often tailored for the mass production of one product or product series in the most efficient way. However, the manufacturing landscape is changing due to global shortages, manufacturing assets and components are becoming scarcer [1], and a shift in market demand requires the production of smaller batches more often. To adhere to these changes, production flexibility, re-use of assets, and a reduction of reconfiguration times are becoming more critical for the cost-efficient production of consumer goods. One of the topics currently investigated within Philips is quickly setting up automated quality inspections to make reconfiguring quality control systems faster and easier. Next to working on the technical challenges of doing this, safety and cyber-security topics are explored, aiming to implement AI-enabled automated quality systems with state-of-the-art defenses, the latter of which is the focus point discussed in this paper.

The dataset used contains images of the decorative part of a Philips shaver. This product is mass-produced and important for the visual appearance of the shavers. Next to that, the part is very close to or in direct contact with the user's skin, where any deviations in its quality could impact shaver performance or even shaver safety. The dataset contains 1.194 images classified into two classes: (a) attacked with the Projected Gradient Descent attack [5], and (b) not attacked.

4 METHODOLOGY

We framed adversarial attack detection as a classification problem. We experimented with three kinds of features: (a) image embeddings (obtained from the Average Pooling Layer of a pre-trained ResNet-18 model ([9])), (b) histograms reflecting grayscale pixel frequencies (with pixel values extending between zero and 255), and (c) structural similarity index measure (SSIM) computed against a white image. While the embeddings provide information about the image as a whole, we considered the histograms and SSIM metric could be useful given the apparent difference between the original and perturbed images. Furthermore, we computed the features across three different datasets (see Fig. 2 for sample images): (a) original set of images, (b) images cropped considering an image slice extending from top to bottom (coordinates (160, 0, 200, 369) - we name this dataset set "Cropped (v1)"), and (c) images cropped

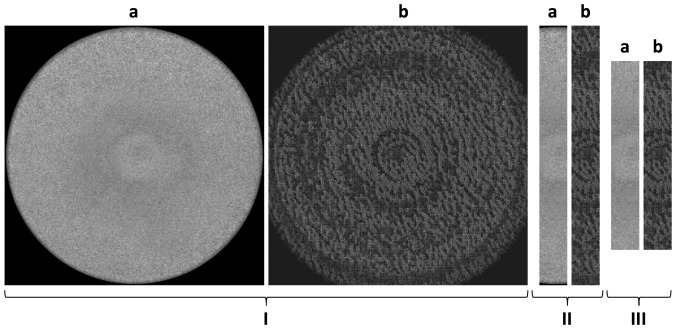

Figure 2: Three sets of images: (a) indicates the original image, while (b) indicates the images attacked with the Projected Gradient Descent attack. The subsets I, II, and III indicate (I) the whole image, (II) cropped image (v1 (considering coordinates (160, 0, 200, 369))), and cropped image (v2 - (considering coordinates (160, 50, 200, 319))).

considering a slice of the central part of the image (coordinates (160, 50, 200, 319) - - we name this dataset set "Cropped (v2)"). By comparing the original image dataset against those obtained by slicing the central part, we sought to understand if the models' predictive power increased by looking at a specific area of the image rather than the whole.

We first trained three machine learning models: Catboost [18] with Focal Loss [14] (trained over 150 iterations, and considering a tree depth of ten, while evaluating the performance during training with the logloss metric), Logistic Regression (the dataset was scaled between zero and one, considering the train set, and transformed to ensure zero mean and unit variance), and KMeans (the dataset was transformed to ensure zero mean and unit variance, and the model initiated with random initialization and seeking to generate two clusters). We evaluated our experiments with a ten-fold stratified cross-validation ([12, 22]), using one fold for testing and the rest of the folds to train the model. Furthermore, to avoid overfitting, we performed a feature selection using the mutual information to evaluate the most relevant ones and select the *top K* features, with $K = \sqrt{N}$, considering N to be equal to the number of data instances in the train set [10]. Finally, we measured our models' performance with a custom metric (DP_{AUCROC}) that summarizes the discriminative power as computed from the area under the receiver operating characteristic curve (AUC ROC, see [4]) (see Eq. 1). The metric ranges from zero (no discriminative power) to one (perfect discriminative power) and it preserves the AUC ROC desirable properties of being threshold independent and invariant to *a priori* class probabilities.

$$DP_{AUC_ROC} = 2 \cdot |(0.5 - AUCROC)| \quad (1)$$

Based on the good results obtained in the clustering setting, we decided to conduct additional experiments, running the DBSCAN algorithm [6] over all existing data. The advantage of such an algorithm is that it can estimate the clusters with no prior information regarding the number of expected clusters. Therefore, if working well, it would be useful to generalize the approach toward detecting new cyberattacks where no labeled data exists yet. We consider such a characteristic to be fundamental to production environments. For the models resulting from the three abovementioned datasets, we measured the estimated number of clusters, estimated number of noise points, homogeneity (whether the clusters contain only samples belonging to a single class), completeness (whether all the data points members of a given class are elements of the same cluster), V-measure (harmonic mean between homogeneity and completeness), adjusted Rand index (similarity between clusterings obtained by the proposed and random models), and the Silhouette Coefficient (estimates the separation distance between the resulting clusters). We ran the DBSCAN algorithm measuring the distance between clusters with the Euclidean distance, considering the maximum distance between two samples for one to be considered as in the neighborhood of the other to be 0,3. Furthermore, we considered that at least ten samples in a neighborhood were required for a point to be considered as a core point.

5 RESULTS AND ANALYSIS

Model		Catboost	KMeans	Logistic regression
Embeddings	**Original image**	0.0167	**1.0000**	*0.0228*
	Cropped (v1)	*0.0014*	**1.0000**	0.0003
	Cropped (v2)	0.0181	**1.0000**	*0.0213*
SSIM	**Original image**	0.0152	**1.0000**	*0.0184*
	Cropped (v1)	*0.0008*	**1.0000**	0.0004
	Cropped (v2)	0.0179	**1.0000**	*0.0195*
Histograms	**Original image**	0.0016	**1.0000**	*0.0030*
	Cropped (v1)	0.0003	**1.0000**	*0.0011*
	Cropped (v2)	0.0018	**1.0000**	*0.0031*

Table 1: Results obtained across classification experiments. We measure models' performance with Eq. 1. Best results are bolded, *second-best are italicized.*

We present the results obtained in our classification experiments in Table 1. We found the KMeans models achieved perfect discrimination in all cases, while the second-best model was the Logistic regression, which had second-best results in all but two cases. Nevertheless, the Logistic regression and the Catboost models achieved a low discriminative power, almost unable to distinguish between tampered and non-tampered images. Regarding the features, we found that the best average performance was obtained when training the models on the *Cropped (v2)* dataset, followed by those trained on the whole images.

When running the DBSCAN algorithm (see results in Table 2), we found the best results were obtained considering the SSIM measure. Furthermore, using the SSIM issued excellent results in all cases. The best ones were obtained considering the *Cropped (v1) dataset*, while the second-best was achieved with the *Cropped (v2) dataset*. Using the SSIM only, the DBSCAN algorithm was able to correctly group the instances into two groups and misclassified at most a single instance. However, the performance achieved either with embeddings or histograms was not satisfactory. When considering histogram features, the DBSCAN algorithm was not able to discriminate between instances, creating a single cluster. On the other hand, when considering embeddings, DBSCAN created three clusters that issued a bad performance, considering most of the

	Embeddings			SSIM			Histograms		
	Original image	**Cropped (v1)**	**Cropped (v2)**	**Original image**	**Cropped (v1)**	**Cropped (v2)**	**Original image**	**Cropped (v1)**	**Cropped (v2)**
Number of clusters	3	1	1	**2**	**2**	**2**	1	1	1
Number of noise points	1010	794	887	1	**0**	1	621	603	606
Homogeneity	0.1770	0.4550	0.3170	**1.0000**	**1.0000**	**1.0000**	0.8550	0.9290	0.9150
Completeness	0.2090	0.4940	0.3860	*0.9910*	**1.0000**	*0.9910*	0.8560	0.9290	0.9150
V-measure	0.1920	0.4740	0.3480	*0.9960*	**1.0000**	*0.9960*	0.8550	0.9290	0.9150
Adjusted Rand index	0.0710	0.4350	0.2540	*0.9980*	**1.0000**	*0.9980*	0.9020	0.9600	0.9500
Silhouette coefficient	0.0750	0.4310	0.2660	0.8980	**0.9590**	*0.9070*	0.8330	0.8970	0.8800

Table 2: Results obtained across clustering experiments. Best ones are bolded, *second-best are italicized.*

points to be noisy. We, therefore, conclude that the only promising results were those obtained considering the SSIM. Nevertheless, we consider further research is required to understand whether this kind of feature can be useful across a wide range of attacks and in the real-world. SSIM provides metadata describing the images. Given high-quality attacks aim to reduce the visual footprint on the images, it remains an open question to which extent can the SSIM capture weak footprints and therefore enable similar discriminative capabilities on machine learning models.

6 CONCLUSION

In this work, we explored multiple sets of features and machine learning models to determine whether an image has been tampered with for the purpose of an adversarial attack. While the difference between attacked and non-attacked images is evident to the human eye, it is not to the machine learning algorithms. We found that the Catboost and Logistic regression models could almost not discriminate between both cases. On the other hand, the clustering algorithms (KMeans and DBSCAN) had a stronger performance. While the KMeans models did so perfectly, regardless of the features, the DBSCAN model only performed well using the SSIM. We consider the strength of such a model the fact that no *a priori* information regarding the classes is required, therefore saving the annotation effort and providing greater flexibility towards future adversarial attacks. Our future research will focus on testing a wider range of cyberattacks while ensuring the attack will not be discernable to the human eye.

ACKNOWLEDGMENTS

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REFERENCES

[1] [n.d.]. European Economic Forecast. Autumn 2021. https://economy-finance.ec.europa.eu/publications/european-economic-forecast-autumn-2021_en. Accessed: 2022-08-05.

[2] Adrien Bécue, Isabel Praça, and João Gama. 2021. Artificial intelligence, cyber-threats and Industry 4.0: Challenges and opportunities. *Artificial Intelligence Review* 54, 5 (2021), 3849–3886.

[3] Gerda Bortsova, Cristina González-Gonzalo, Suzanne C. Wetstein, Florian Dubost, Ioannis Katramados, Laurens Hogeweg, Bart Liefers, Bram van Ginneken, Josien PW Pluim, and Mitko Veta. 2021. Adversarial attack vulnerability of medical image analysis systems: Unexplored factors. *Medical Image Analysis* 73 (2021), 102141. Publisher: Elsevier.

[4] Andrew P. Bradley. 1997. The use of the area under the ROC curve in the evaluation of machine learning algorithms. *Pattern Recognition* 30, 7 (1997), 1145 – 1159. https://doi.org/10.1016/S0031-3203(96)00142-2

[5] Yingpeng Deng and Lina J Karam. 2020. Universal adversarial attack via enhanced projected gradient descent. In *2020 IEEE International Conference on Image Processing (ICIP)*. IEEE, 1241–1245.

[6] Martin Ester, Hans-Peter Kriegel, Jörg Sander, Xiaowei Xu, et al. 1996. A density-based algorithm for discovering clusters in large spatial databases with noise.. In *kdd*, Vol. 96. 226–231.

[7] Dan-Ioan Gota, Adela Puscasiu, Alexandra Fanca, Honoriu Valean, and Liviu Miclea. 2020. Threat objects detection in airport using machine learning. In *2020 21th International Carpathian Control Conference (ICCC)*. IEEE, 1–6.

[8] Atiyeh Hashemi and Saeed Mozaffari. 2021. CNN adversarial attack mitigation using perturbed samples training. *Multim. Tools Appl.* 80 (2021), 22077–22095.

[9] Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. 2016. Deep residual learning for image recognition. In *Proceedings of the IEEE conference on computer vision and pattern recognition*. 770–778.

[10] Jianping Hua, Zixiang Xiong, James Lowey, Edward Suh, and Edward R Dougherty. 2005. Optimal number of features as a function of sample size for various classification rules. *Bioinformatics* 21, 8 (2005), 1509–1515.

[11] A. Kloukiniotis, A. Papandreou, A. Lalos, P. Kapsalas, D.-V. Nguyen, and K. Moustakas. 2022. Countering adversarial attacks on autonomous vehicles using denoising techniques: A Review. *IEEE Open Journal of Intelligent Transportation Systems* (2022). Publisher: IEEE.

[12] Max Kuhn, Kjell Johnson, et al. 2013. *Applied predictive modeling*. Vol. 26. Springer.

[13] Christos Kyrkou, Andreas Papachristodoulou, Andreas Kloukiniotis, Andreas Papandreou, Aris Lalos, Konstantinos Moustakas, and Theocharis Theocharides. 2020. Towards artificial-intelligence-based cybersecurity for robustifying automated driving systems against camera sensor attacks. In *2020 IEEE Computer Society Annual Symposium on VLSI (ISVLSI)*. IEEE, 476–481.

[14] Tsung-Yi Lin, Priya Goyal, Ross Girshick, Kaiming He, and Piotr Dollár. 2017. Focal loss for dense object detection. In *Proceedings of the IEEE international conference on computer vision*. 2980–2988.

[15] Xingjun Ma, Yuhao Niu, Lin Gu, Yisen Wang, Yitian Zhao, James Bailey, and Feng Lu. 2021. Understanding adversarial attacks on deep learning based medical image analysis systems. *Pattern Recognition* 110 (2021), 107332.

[16] Nicolas Papernot, Patrick D. McDaniel, Xi Wu, Somesh Jha, and Ananthram Swami. 2015. Distillation as a Defense to Adversarial Perturbations against Deep Neural Networks. *CoRR* abs/1511.04508 (2015). arXiv:1511.04508 http://arxiv.org/abs/1511.04508

[17] Marek Pawlicki and Ryszard S. Choraś. 2021. Preprocessing Pipelines including Block-Matching Convolutional Neural Network for Image Denoising to Robustify Deep Reidentification against Evasion Attacks. *Entropy* 23, 10 (2021), 1304. Publisher: MDPI.

[18] Liudmila Prokhorenkova, Gleb Gusev, Aleksandr Vorobev, Anna Veronika Dorogush, and Andrey Gulin. 2018. CatBoost: unbiased boosting with categorical features. *Advances in neural information processing systems* 31 (2018).

[19] Skyler Speakman, Srihari Sridharan, Sekou Remy, Komminist Weldemariam, and Edward McFowland. 2018. Subset scanning over neural network activations. *arXiv preprint arXiv:1810.08676* (2018).

[20] Entso Veliou, Dimitrios Papamartzivanos, Sofia Anna Menesidou, Panagiotis Gouvas, and Thanassis Giannetsos. 2021. *Artificial Intelligence and Secure Manufacturing: Filling Gaps in Making Industrial Environments Safer*. Now Publishers. 30–51 pages. https://doi.org/10.1561/9781680838770.ch2

[21] Hanshu Yan, Jingfeng Zhang, Jiashi Feng, Masashi Sugiyama, and Vincent YF Tan. 2022. Towards Adversarially Robust Deep Image Denoising. *arXiv preprint arXiv:2201.04397* (2022).

[22] Xinchuan Zeng and Tony R Martinez. 2000. Distribution-balanced stratified cross-validation for accuracy estimation. *Journal of Experimental & Theoretical Artificial Intelligence* 12, 1 (2000), 1–12.

[23] Fangyi Zhang, Jürgen Leitner, Michael Milford, Ben Upcroft, and Peter Corke. 2015. Towards vision-based deep reinforcement learning for robotic motion control. *arXiv preprint arXiv:1511.03791* (2015).

Addressing climate change preparedness from a smart water perspective

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ABSTRACT

Observing the world on a global scale can help us understand better the role of water and water resource management utilities in a climate change context that engage us all. The usage of machine learning algorithms on open data measurements and statistical indicators can help us understand the behavioral changes in seasons and better prepare. These are complemented by powerful text mining algorithms that mine worldwide news, social media, published research and patented innovation towards best practices from success stories. In this paper, we propose a data-driven global observatory that puts together the different perspectives of media, science, statistics and sensing over heterogeneous data sources and text mining algorithms. We also discuss the implementation of this global observatory in the context of epidemic intelligence, monitoring the impact of climate change, and the value of this global solution in local contexts and priorities.

CCS CONCEPTS

• Real-time systems • Data management systems • Life and medical science

KEYWORDS Climate Change Preparedness, Data-driven Decision-making, Water Resource Management, Smart Water, Observatory, Water Digital Twin, Deep Learning, Text Mining, Interactive Data Visualization

1 Introduction

In the present decade, Climate Change has become positioned as one of the world priorities, a global problem with great socio-economic impact. It has been in the focus of European and Worldwide strategies, rapidly changing priorities towards sustainability and environmental efficiency, transversely to most domains of action. The European Commission's Green Deal [5] is a good example of this, aiming for a climate neutral Europe in 2050, and boosting the economy through green technology over a new framework to understand and position water resource management in the context of the challenges of tomorrow [1]. In the context of the NAIADES project [3] we repurpose and customize the NAIADES Water Observatory, adding a measurements dimension to its text mining capabilities to allow for forecasts on, e.g., water level and temperature to complete the perspective on the impact of climate change for the preparedness both of water management utilities and users as in, e.g., smart agriculture. This will improve the climate change preparedness of water resource management facilities and local authorities in a global context, in particular in European regions where water scarcity or extreme weather events are predicted. The water-related climate change topics that we are already addressing include, e.g., water reuse, wastewater management, saline intrusion and groundwater contamination.

In this paper we will discuss our contribution to this cause, through the NAIADES Water Observatory (accessible at naiades.ijs.si) [12], focusing on water-related aspects, allowing the user to explore a combination of perspectives offered over layers of information sourced in statistics, historical measurements, multilingual news and social media to published science, weather models and indicators. It is also being used in the context of extreme weather events to analyze worldwide trends and best practices in water topics like, e.g., floods, landslide, and contamination [9], building business intelligence from the available open data in combination with data streams [11].

The NAIADES Water Observatory is not only contributing to the improvement of European sustainability in water-related activities and business intelligence but it is also providing an active role to local actors in improving together with municipalities and water resource management utilities the efficient use of resources [13]. This local perspective is especially important for providing information at the local granularity, which enables communities or municipalities to build solutions that are relevant for their specific cases.

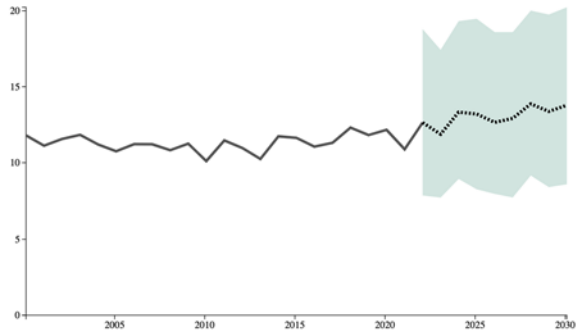

Figure 1: **Long-term forecast of 10 years (average per year) built on 20 years of data to understand the behavior of air temperature, water levels and temperature and the consequent changes within seasons.**

2 Understanding behaviors from data

In the era of Big Data where technologies and sensors are every day cheaper and more efficient, a wide range of useful measurements is available and can be used to forecast weather and water resource behaviors and to identify environmental trends with local granularity.

With the motivation to grasp a realistic perspective on the impact of climate change in the region of Carouge, Switzerland, we obtained 20 years of water levels and water temperature data (sourced by Meteoswiss Data Portal IDAWEB), and we were able to build a 10-year forecast that allows us to see a signal of the global trend.

For this aim, we have developed a Long Short Term Memory (LSTM) neural network, which is a type of Recurrent Neural Network, widely used for predicting sequential data. In order to optimize the performance and accuracy of the LSTM, we used some results from Differential Geometry and Chaos Theory such as Takens' Embedding Theorem, Shannon Entropy, Conditional Shannon Entropy, Markov Chains, etc. This theoretical support was key for obtaining the optimal number of timesteps [4] and to produce a long-term forecast aiming to observe the weather behavior across the historical data collected and a perspective on the future seasons based on the derived prediction, represented by the three parameters - temperature, humidity and rainfall - or the water levels in rivers, lakes and basins in the area determined by the geolocation provided by the NAIADES use cases. The time series of historical data in Figure 1 indicates that already the air temperature yearly averages are increasing, and this increase is predicted also for the next 10 years. Comparing our model with the Meteoswiss model for the area, the differences were minimal. To emphasize the changes throughout the year, we added a per year visualization (Figure 2), where one can compare the seasonal trends for the local weather and water parameters.

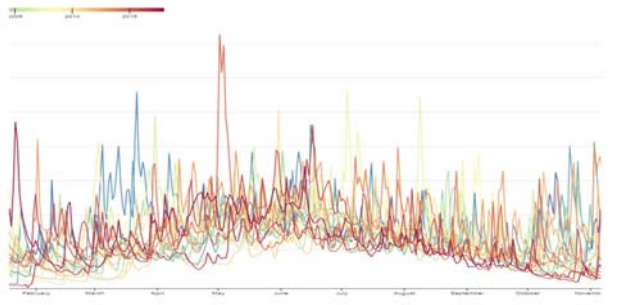

Figure 2: **The weather across seasons over the past 20 years distinguished by seasons, exhibiting high temperature periods earlier in the year.**

To further explore the relations of multivariate timeseries data, we have developed the State analysis tool [14]. With this technology we automatically abstract data as states of the Markov chain and transitions between them. This allows for ingestion of large datasets, and due to hierarchical clustering the data can be observed on several levels. This tool works especially well for observing long term behavior and exposing recurrent patterns. In the context of climate change preparedness, the aim was to better understand the reality of the seasons as defined by the weather parameters as well as the water level and temperature over the past 20 years. Depicted in Figure 3 are the transitions between seven states we can already depict in the municipality of Carouge, Switzerland and the surrounding area. Five of those states correspond to a passage between Spring-Summer and Summer-Autumn, and to Summer itself, characterized by the states indicating a high water temperature. With the impact of climate change in redefining seasons this tool can help to plan ahead, having in mind the granularity of the data that can be customized to predefined geographic regions where relevant water resources are located.

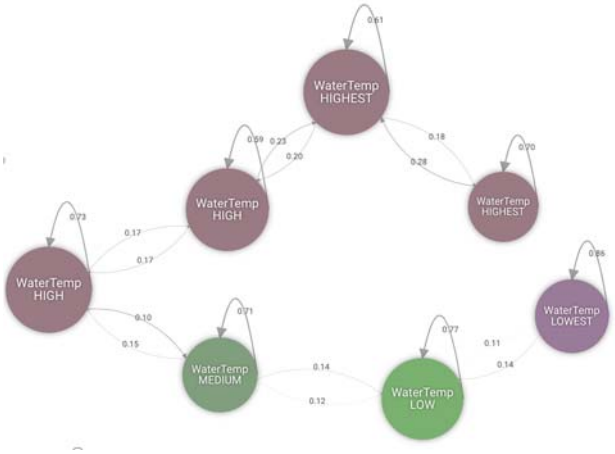

Figure 3: **The analysis of the impact of climate change on water levels and temperature across seasons using Markov chains**

3 Enrichment with local indicators

Water is fundamental to all human activity and ecosystem health, and is a topic of rising awareness in the context of climate change. Water resource management is central to those concerns, with the industry accounting for over 19% of global water withdrawal, and agricultural supply chains are responsible for 70% of water stress [10]. In 2015 the UN established "clean water and sanitation for all" as one of the 17 Sustainable Development Goals, aiming for eight targets to be achieved by 2030 [2].

To exploit the functionality for the customization at the level of local regional providers, news monitoring, and exploration of scientific research can be customized to observed problems, e.g., groundwater contamination. Moreover, ingestion of local indicators can be customized also. These agencies (e.g. Aguas de Alicante) are collecting data on their water resource management services to improve the customer satisfaction and optimize their system, aiming for a smart water [6] approach for the optimization of resources and means, often deploying intelligent systems close to the idea of a water digital twin [7].

Together with the municipality of Carouge, Switzerland, and with the water management utilities of Alicante, Spain, and Braila, Romania, we have collected open data from national data portals and environmental agencies with a regional granularity to be able to assess the comparative progress of regions through the visual data representation of indicators (see Figure 4). Through this interactive data visualization we can investigate the progress on a variety of topics (with three simultaneous parameters represented over a bubble chart) that are much relevant to the analysis of climate change, including water availability, reused and treated water, or water usage by populations and industry. With the appropriate combination of variables in comparison, the user can identify the most efficient regions over the country.

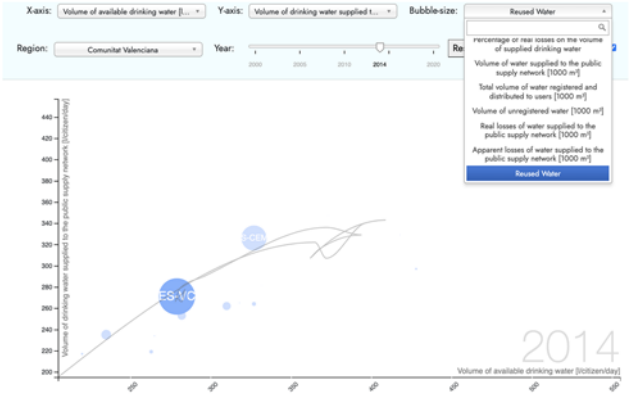

Figure 4: **The comparison of indicators in the Spanish regions across time**

To better understand the comparative progress of each region on the selected water-related topics, we also enable the representation of the time-series curves (see Figure 5) to identify transitions, peaks and other behaviors (per parameter in analysis) that are otherwise not seen in the bubble chart animation.

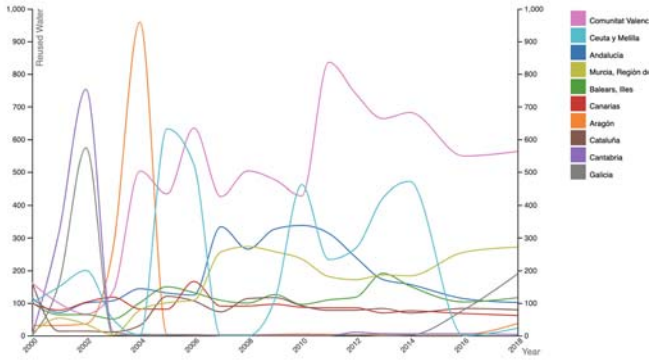

Figure 5: **The curves comparing regional indicators on water topics (as, e.g., reused water in Spain)**

4 Knowledge extracted from news, social media and scientific research

The NAIADES Water Observatory also allows for a news monitoring perspective with global and local coverage on topics like, e.g., water scarcity and water quality. It is particularly relevant in the surrounding regions of the water resource management agencies, but also at a worldwide level recurring to its multilingual capacity to access success stories and best practices form similar scenarios happening worldwide. This is based on the Event Registry news engine [8] that collects over 300 thousand news articles daily in over 60 languages. In the past 3 months we were able to capture almost 33 thousand articles relating both with water and with the climate crisis, 1500 of them happening in Spain and relating to concepts such as, e.g., draught, wildfire heat wave, irrigation and extreme weather.

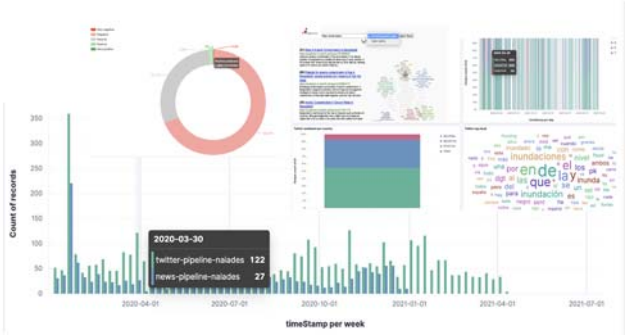

Figure 6: **The combined perspective of multilingual news, social media and scientific research on water scarcity and extreme weather aiming to identify best practices and success stories**

This global system is also capturing the filtered Twitter feed on 10% of the signal, to identify posts related to heat wave and drought (see Figure 6).

The scientific research on climate change topics can bring an important complement in this context, providing success stories and best practices that can be extracted from the textual data, and explored with complex data visualization technology allowing the user to powerful Lucene-based queries over the article's metadata and to relate that research across time suggesting related topics (see Figure 7). These data analytics technologies are able to analyze simultaneously multiple time-series providing interactive exploration tools to understand trends in climate change research and water topics related to it.

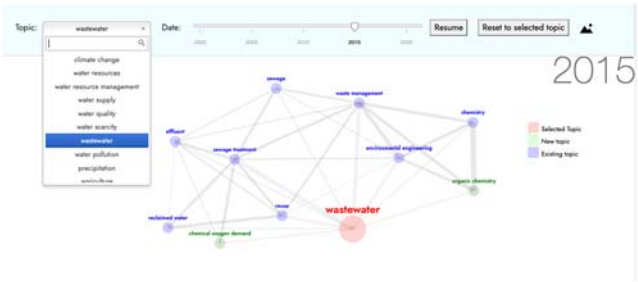

Figure 7: **The trends over time that relate to the topic Climate Change in the scientific literature**

5. Conclusions and further work

Adapting to climate change is an important topic for water management services, since their work is quintessential for the well-being of people. Understanding the seasonality changes and forecasting the availability of resources at the local levels is therefore crucial to enable relevant adaptation at the correct granularity.

Although the predictions are in accordance with IPCC's and Meteoswiss forecasting, this preliminary work needs to be extended with ingesting several other data variables and compared to the existing widely used models to bring more accurate insight specially for the weather data, but also the water-relevant resources.

ACKNOWLEDGMENTS

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REFERENCES

[1] A. Akhmouch, C. Delphine and P. G. Delphine Clavreul. Introducing the OECD principles on water governance. Water International, 43: 5–12, 2018
[2] V. Blazhevska. United Nations launches framework to speed up progress on water and sanitation goal. United Nations Sustainable Development, 2020
[3] CORDIS, "NAIADES Project". [Online]. Available: https://cordis.europa.eu/project/id/820985 [Accessed 1 9 2020].
[4] Costa J., Kenda K., Pita Costa J. (2021). Entropy for Time Series Forecasting. In: Slovenian Data Mining and Data. Warehouses conference (SiKDD2021)
[5] European Commission, "European Green Deal," 2019. [Online]. Available: https://ec.europa.eu/info/strategy/priorities-2019-2024/ european-green-deal_en. [Accessed 1 9 2020].
[6] C. Sun, V. Puig, G. Cembrano. (2020). Real-Time Control of UrbanWater Cycle under Cyber-Physical Systems Framework. Water: 12, 406.
[7] Di Nardo et al. (2018). On-line Measuring Sensors for Smart Water Network Monitoring. EPiC Series in Engineering. 3: 572-581
[8] G. Leban, B. Fortuna, J. Brank and M. Grobelnik, "Event registry: learning about world events from news," Proceedings of the 23rd International Conference on World Wide Web, pp. 107-110, 2014.
[9] M. Mikoš, N. Bezak, J. Pita Costa, M. Besher Massri, M. Jermol, M. Grobelnik (2021) Natural-hazard-related web observatories as a sustainable development tool in Progress, in Landslide Research and Technology, Springer, Vol. 1, No. 1, 2022.
[10] Our World in Data (2022). Water Use Stress. https://ourworldindata.org/water-use-stress. [Accessed 1 8 2022]
[11] J. Pita Costa (2022). Business intelligence built from open data. Water World Magazine. [Online]. Available: https://www.waterworld.com/water-utility-management/smart-water-utility/article/14234325/2203wwint [Accessed 1 8 2022]
[12] J. Pita Costa (2021). Observing water-related events to support decision-making. Smart Water Magazine. [Online]. Available: https://smartwatermagazine.com/news/naiades-project/observing-water-related-events-support-decision-making [Accessed 1 8 2022]
[13] J. Pita Costa, I. Casals del Busto, A. Guček, et al (2022). Building A Water Observatory From Open Data. Proceedings of the IWA 2022.
[14] L. Stopar, P. Škraba, M. Grobelnik, and D. Mladenić (2018). StreamStory: Exploring Multivariate Time Series on Multiple Scales. IEEE transactions on visualization and computer graphics 25. 4: 1788-1802.

SciKit Learn vs Dask vs Apache Spark Benchmarking on the EMINST Dataset

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***Abstract*—As datasets for machine learning tasks can become very large, more consideration to memory and computing resource usage has to be given. As a result, several libraries for parallel processing that improve RAM utilization and speed up computations by parallelizing ML jobs have emerged. While SciKit Learn is the typical go to library for practitioners, Dask is a parallel computing library that can be used with SciKit and Apache Spark is an analytics engine for large-scale data processing that includes some machine learning techniques. In this paper, we benchmark the three solutions for developing ML pipelines with respect to data merging and loading and subsequently for training and predicting on the extended MNIST (eMNIST) dataset under Linux and Windows OS. Our results show that Linux is the better option for all of the benchmarks. For low amounts of data plain SciKit learn is the best option for machine learning, but for more samples, we would choose Apache Spark. On the other hand, when it comes to dataframe manipulation Dask beats a normal pandas import and merge.**

***Index Terms*—Apache Spark, Dask, machine learning, Pandas, import**

I. Introduction

As datasets for machine learning tasks can become very large, more consideration to memory and computing resource usage has to be given. As a result, several libraries for parallel processing that improve RAM utilization and speed up computations by parallelizing ML jobs have emerged. While SciKit Learn [1] is the typical go to library for practitioners, Dask [2] is a parallel computing library that can be used with SciKit to improve memory and CPU utilization. Dask improves memory utilization by not immediately loading all the data, but only pointing to it. Only part of the data is loaded on a per need basis. It also enables using all available cores on a system to train a model. Apache Spark is an analytics engine written in Java and Scala for processing large-scale data that incorporates some machine learning techniques and is tightly integrated with the Spark architecture.

While there are other libraries [3] that enable parallelization of ML, when it comes to distributed computing tools for tabular datasets, Spark and Dask are the most popular choices today. Even though Spark is an older, more stable solution, Dask is part of the vibrant Python ecosystem and both technologies excel at parallelization. While the two solutions have been already been benchmarked on big data pipelines [4] and on various image processing and learning scenarios [5]–[7]. The work in [7] is the closest to this one, however they focused on evaluating the tradeoffs in parellelizing feature extraction and clustering while this work focuses on evaluating data loading and merging and subsequent classification.

In this paper, we benchmark the three solutions for developing ML pipelines with respect to data merging and loading and subsequently for training and predicting on the extended MNIST (eMNIST) dataset under Linux and Windows OS. Our results show that Linux is the better option for all of the benchmarks. For low amounts of data plain SciKit learn is the best option for machine learning, but for more samples, we would choose Apache Spark. On the other hand, when it comes to dataframe manipulation Spark is behind Dask, and Dask beats a normal pandas import and merge. The contribution of this paper is the benchmarking of three ML libraries across various data sizes and two operating systems on two parts of the ML model development pipeline.

The remainder of the paper is structured as follows. Section II discusses related work. Section III presents the methodology used in the benchmarking. Section IV evaluates the comparison. Finally, Section V presents our conclusions.

II. Related work

Chintapalli et al. (2016) [8] compared streaming platforms Flink, Storm and Spark. The paper focuses on real-world streaming scenarios using ads and ad campaigns. Each streming platform was used to build a pipeline that identifies relevant events, which were sources from Kafka. In addition, Redis was used for storing windowed count of relevant events per campaign. The test system contained 40 nodes, where each node contained 2 CPUs with 8 cores and 24GB of RAM. All nodes were interconnected using a gigabit ethernet connection. The experiment encompassed Kafka producing events at set rate with 30 minutes interval between each batch was fired. The results showed that both Flink and Storm were almost equal in terms of event latency, while Spark turned out to be the slowest of the three.

Dugré et al. (2019) [4] compared Dask and Spark on the neuroimaging big data pipelines. As neuroimaging requires a large amount of images to be processed, Spark and Dask were in the time of writing the best suited Big Data engines. The paper compares the technologies with three different pipelines. First is incrementation, second is histogram and the final

This work was funded by the Slovenian Research Agency ARRS under program P-0016.

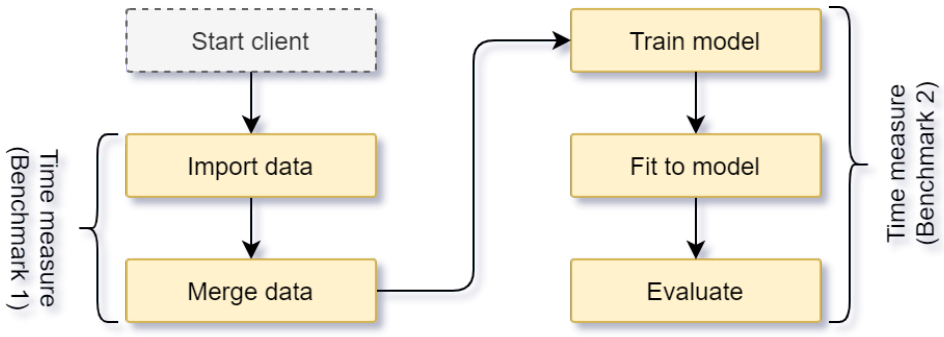

Fig. 1. Workflow of the Machine learning test example used for benchmarking.

one is a BIDS app example (a map-reduce style application). All comparisons were done on BigBrain and CoRR datasets, with sizes of 81GB and 39GB respectively. The authors have concluded that all platforms perform very similarly and that the incrementation of worker nodes is not always the optimal solution due to the transfer times and overall overhead. While all platforms yielded similar results, the Spark is claimed to be the fastest out of the three platforms.

Nguyen et al. (2019) [6] evaluated SciDB, Myria, Spark, Dask and TensorFlow to figure out which system is best suited for image processing. Similarly to [4], the authors compared the systems using different pipelines. For comparison, the authors used 2 datasets, both over 100GB in size. The comparison reveled that Dask and Spark are comparable in the performacnce as well as the ease of use.

Mehta et al. (2016) [5] presented the satellite data processing pipeline. The pipeline consists of two steps, a feature extraction step and a clustering step. The baseline pipeline used the Caffe deep learning library and SciKit. The improved pipeline used Keras along with Spark and Dask for multi-node computation. They found that while Spark was the fastest in terms of computational time required per task, Dask used almost half the memory compared to Spark due to recalculation of the intermediate values. SciKit Learn was not able to complete the task and was excluded from the final comparison. It was concluded that Spark is the best performer, while Dask is the easiest to use.

Cheng et al. (2019) [7] presented a comparison of the RADICAL-Pilot, Dask and Spark for image processing. All three systems were tested using watershed and a blob detector algorithms. Each test was split into two parts, a weak scaling algorithm where the amount of data to be processed was increased alongside the number of nodes, and a strong scaling algorithm where the amount of data stayed the same and the number of nodes increased. The evaluation showed that Dask outperformed Spark on weak scaling, while Spark excelled in the strong scaling part.

III. Methodology

To benchmark the three solutions, namely SciKit learn, Dask and Spark, we single out two parts of the end-to-end model development process depicted in Figure 1. We first time the data importing and merging process, referred to as Benchmark 1 in the figure, followed by model training and evaluation denoted by Benchmark 2. While the time required to train the model is usually the most important metric because it takes up most of the computation time, importing and merging the input data cannot be ignored. As described in Algorithm 1, for Benchmark 1, training data was imported and then merged. For SciKit Learn dataframes were used all along and no parallelization was used while for Dask and Spark parallelization was turned on.

Algorithm 1: Import and merge benchmarking process.

Enable parallelization
Require: data_a and data_b
Merge the DataFrames
Convert data to a pandas DataFrame

Algorithm 2: Train/fit and evaluate benchmarking process.

Enable parallelization
Import and **setup** data
train = [80% of the samples], **test** = [20% of the samples]
Define ML algorithm
Fit the data
Predict the samples
Evaluate - F1

As described in Algorithm 2, for Benchmark 2 in Figure 1, an example of machine learning with a decision tree classifier depicts the workflow of the machine learning test example. First, parellelization is enabled for Dask and Spark and immediately after that the data is imported and modified accordingly to fit the test scenario. Next, the decision tree classifier is trained using various training data size, dividing the data set into a training subset and a test subset. The training subset represents 80% of the original dataset and for the training subset the remaining data is used, representing 20% of the original dataset. Each task is run with 5 different sample sizes, ranging from 50k to 250k samples, with a step of

50k samples. Finally, the execution report with the calculation times of each task is generated.

To realize these benchmarks[1], we used the extended MNIST or EMNIST dataset[2]. The data set contains approximately 250k samples of handwritten digits, resulting in total size of 516MB. The size of all images is exactly the same, 28 by 28 pixels and each pixel has a value ranging from zero to 255. The dataset is represented in the CSV (Comma Separated Values) format with the first column being the label and the rest of the columns representing 784 pixels. For the benchmarks, different data set sizes, ranging from 50k to 250k samples with a 50k step were generated.

In addition, each data set size was tested on Dask and Spark with 1, 2 and 4 workers. Therefore, the programs used to test computation time on Windows and Linux operating systems have the same complexity. All tests were performed on equivalent Windows and Linux virtual machines running on the 6 CPU core machine with 10 GB of RAM.

IV. Results

In this section we provide the results of the benchmarks collected using the methodology described in Section III.

A. Import and merge

First, we present in Figure 2 the import and merge times for 100k samples on Linux without parallelization across the the three platforms. In the first bar, it can be seen that importing (i.e. loading the data into memory) takes most of the time with Pandas. Merging (i.e. concatenation) is relatively negligible while computation is not relevant in this case as after merging it already returns the desired data structure. The total import and merge time is slightly above 4s.

From the second bar, it can be seen that importing and merging is negligible with Dask as doesn't load anything into memory at these steps, rather it prepares only recipes that will be executed during the most time consuming compute phase. During compute, Dask turns a lazy collection into its in-memory equivalent, in our case, the Dask dataframe turns into a Pandas dataframe. Overall, it can be seen that on a single node, Dask is comparable to Pandas, with a total import and merge time slightly below 4s.

Finally, from the last bar, it can be seen that Spark import and merge are very fast and efficient, taking below 2s. However, when transforming the internal data structure of Spark into pandas (i.e. during the compute phase in this case) is very time consuming. We added this step so that the final outcome is consistent with the other two (i.e. Pandas data structure), however in the end-to-end ML pipeline the ML algorithm will be trained directly using Spark's internal data structure.

Figure 3 shows how the import and merge times fare as a function of worker nodes for Dask across Linux and Windows. As expected, a decreasing tendency of the import/merge times with the increase of the working nodes can be seen. When testing Spark on the import and merge benchmark, both Windows and Linux ran out of memory with two and four workers. Swap memory could be used to overcome this shortcoming, however, the resulting comparison would not be fair because the Dask benchmarks didn't need the swap memory.

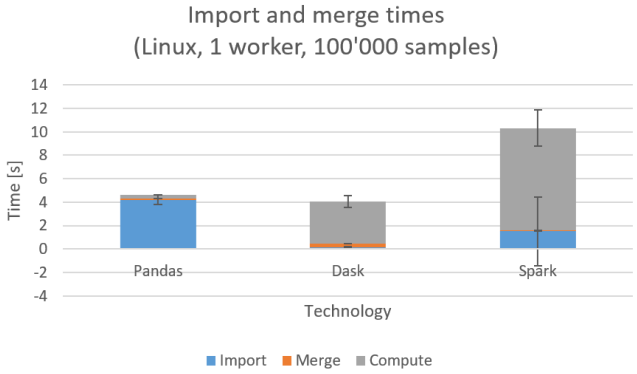

Fig. 2. Benchmark results of import and merge times at 100k samples: raw data to Pandas.

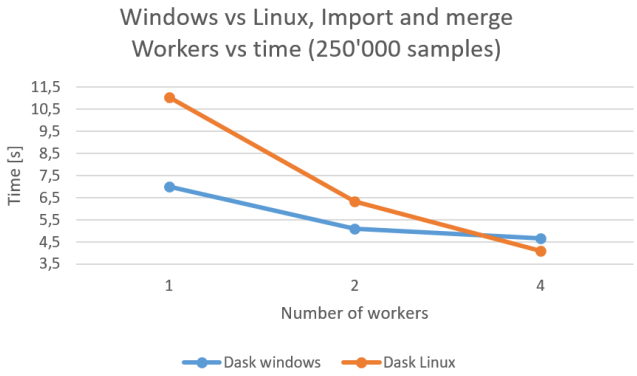

Fig. 3. Benchmark results two operating systems, Dask with import and merge on 250k samples.

B. Machine learning

Figure 4 shows the comparison of computation time between Dask, Spark, and SciKit on the Windows operating system for different dataset sizes. Each column in the figure represents the average computation time of 5 test runs. The results show that Dask and Spark are almost equivalent when the input dataset size is around 150k samples. Dask performs better on smaller datasets, while Spark's performance is best on larger datasets. Interestingly, SciKit outperforms both Dask and Spark on all dataset sizes, although it is not able to parallelize tasks. This is most likely because of the transfer times between nodes and the overall overhead of Dask and Spark. Since the datasets fit completely into the computer's memory, SciKit has no problems computing them, while Dask and Spark only cause unnecessary overhead. However, Dask and Spark are meant for large clusters with hundreds or even

[1]Scripts for the benchmarks, https://github.com/sensorlab/parMLBenchmarks

[2]EMINST dataset - https://www.kaggle.com/crawford/emnist (accessed: 30.07.2022)

thousands of nodes, while SciKit is meant for computations on a single computer.

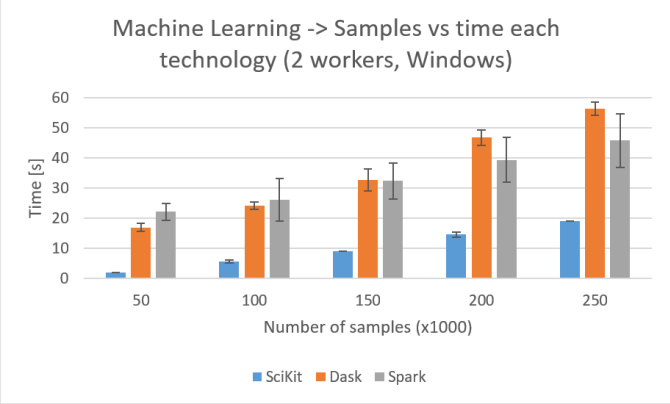

Fig. 4. Computational time for different dataset sizes on Windows operating system.

Figure 5 shows the results of the same experiment performed on the Linux operating system. Compared to the Figure 4, the results are very similar, with only difference that on Linux operating system Dask performs better then Spark even when input data set contains 150k samples.

Table I shows the F1 scores. An F1 score is the harmonic mean (alternative metric for the arithmetic mean) of precision and recall. The precision gives information on how many of the predicted samples that have been predicted as positive are correct. The recall gives information on how many of all positive samples the model managed to find.

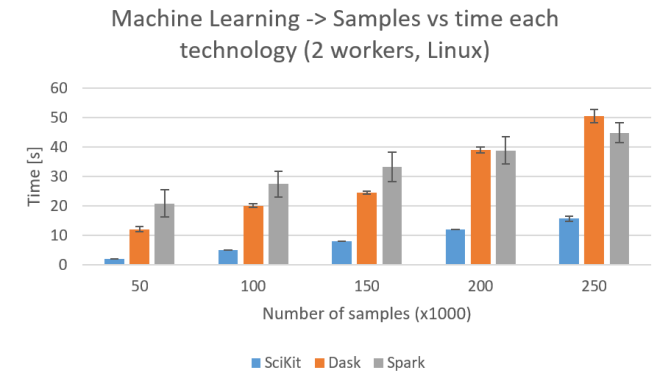

Fig. 5. Computational time for different dataset sizes on Linux operating system.

TABLE I
TABLE OF F1 SCORES FOR WINDOWS BENCHMARKS FOR VARIOUS SAMPLE SIZES (SIMILAR FOR LINUX).

	Number of samples (x1000)				
	50	100	150	200	250
Spark	0.71	0.73	0.73	0.71	0.71
Dask	0.71	0.72	0.73	0.71	0.70
Scikit	0.70	0.71	0.70	0.71	0.73

The machine learning benchmark measured the time to cast all columns into smaller data types. It seems that Dask has a dedicated function to cast all of the columns of a Dask dataframe at once whereas with the Spark function you have to cast each column one by one. The Dask casting was faster (0.06s) than Sparks (7.2s).

V. CONCLUSIONS

In this paper we benchmarked two parallel computing technologies, Dask and Apache Spark, against each other and against the single node SciKit Learn. The benchmarks were computed on the EMNIST dataset for various subsets from 50k to 250k samples on different operating systems and various degrees of parallelization. The results show a slight advantage on running the training pipeline on Linux rather than on Windows. Dask is seen as superior in dataframe manipulation while Apache Spark has a superior end-to-end processing performance on larger datasets with comparable final F1 scores.

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REFERENCES

[1] F. Pedregosa, G. Varoquaux, A. Gramfort, V. Michel, B. Thirion, O. Grisel, M. Blondel, P. Prettenhofer, R. Weiss, V. Dubourg, *et al.*, "Scikit-learn: Machine learning in python," *the Journal of machine Learning research*, vol. 12, pp. 2825–2830, 2011.

[2] M. Rocklin, "Dask: Parallel computation with blocked algorithms and task scheduling," in *Proceedings of the 14th python in science conference*, vol. 130, p. 136, Citeseer, 2015.

[3] S. Celis and D. R. Musicant, "Weka-parallel: machine learning in parallel," in *Carleton College, CS TR*, Citeseer, 2002.

[4] M. Dugré, V. Hayot-Sasson, and T. Glatard, "A performance comparison of dask and apache spark for data-intensive neuroimaging pipelines," in *2019 IEEE/ACM Workflows in Support of Large-Scale Science (WORKS)*, pp. 40–49, 2019.

[5] P. Mehta, S. Dorkenwald, D. Zhao, T. Kaftan, A. Cheung, M. Balazinska, A. Rokem, A. Connolly, J. Vanderplas, and Y. AlSayyad, "Comparative evaluation of big-data systems on scientific image analytics workloads," vol. 10, p. 1226–1237, VLDB Endowment, aug 2017.

[6] M. H. Nguyen, J. Li, D. Crawl, J. Block, and I. Altintas, "Scaling deep learning-based analysis of high-resolution satellite imagery with distributed processing," in *2019 IEEE International Conference on Big Data (Big Data)*, pp. 5437–5443, 2019.

[7] M. T. S. J. William Cheng, Ioannis Paraskevakos, "Image processing using task parallel and data parallel frameworks," pp. 1–7, 2019.

[8] S. Chintapalli, D. Dagit, B. Evans, R. Farivar, T. Graves, M. Holderbaugh, Z. Liu, K. Nusbaum, K. Patil, and B. J. Peng, "Benchmarking streaming computation engines: Storm, flink and spark streaming," 2016.

An Efficient Implementation of Hubness-Aware Weighting Using Cython

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ABSTRACT

Hubness-aware classifiers are recent variants of k-nearest neighbor. When training hubness-aware classifiers, the computationally most expensive step is the calculation of hubness scores. We show that this step can be sped up by an order of magnitude or even more if it is implemented in Cython instead of Python while the accuracy is the same in both cases.

KEYWORDS

nearest neighbor, hubs, cython

1 INTRODUCTION

Nearest neighbor classifiers are simple, intuitive and popular, there are theoretical results about their accuracy and error bounds [6]. However, nearest neighbors are affected by *bad hubs*. An instance is called a bad hub, if it appears surprisingly frequently as nearest neighbor of other instances, but its class label is different from the labels of those other instances. Bad hubs were shown to be responsible for a surprisingly large fraction of the total classification error [10].

In order to reduce the detrimental effect of bad hubs, hubness-aware classifiers have been introduced, such as Hubness-Weighted k-Nearest Neighbor (HWKNN) [9], Naive Hubness Bayesian Nearest Neighbor (NHBNN) [16] and Hubness-based Fuzzy Nearest Neighbor (HFNN) [14]. Hubness has also been studied in context of collaborative filtering [8], regression [3], clustering [15], instance selection and feature selection [13]. Recently, hubness-aware ensembles have been proposed [17] and used for the classification of breast cancer subtypes [12].

Other prominent applications of hubness-aware methods include music recommendation [7], time series classification [11], drug-target prediction [4] and classification of gene expression data [2]. Last, but not least, we mention that even neural networks may benefit from hubness-aware weighting [5].

Hubness-aware classifiers may be implemented in various programming languages, one of the most prominent implementation is probably the Java-based HubMiner[1] library.

[1]https://github.com/datapoet/hubminer

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In case of the aforementioned hubness-aware classifiers, the computationally most expensive step of the training is to determine the *hubness scores* of training instances, i.e., how frequently they appear as (bad) nearest neighbors of other instances. In this paper, we address this issue by a Cython-based implementation. Cython [1] aims to combine the advantages of Python (rapid prototyping and clarity thanks to concise code) with the efficiency of C. In particular, we implement the computation of hubness scores in Cython. Compared with a standard implementation in Python, we observed up to 25 times speedup on the Spambase dataset[2] from the UCI repository (and the speedup is likely to be even more in case of larger datasets).

2 BACKGROUND: HUBNESS-AWARE WEIGHTING

We say that an instance x is a *bad neighbor* of another instance x' if (i) x is one of the k-nearest neighbors of x' and (ii) their class labels are different. In case of hubness-aware weighting [9], first we determine how frequently each instance x appears as bad neighbor of other instances. This is denoted as $BN_k(x)$. Subsequently, the normalized bad hubness score $h_b(x)$ of each instance x is calculated as follows:

$$h_b(x) = \frac{BN_k(x) - \mu(BN_k)}{\sigma(BN_k)} \quad (1)$$

where $\mu(BN_k)$ and $\sigma(BN_k)$ denote the mean and standard deviation of the $BN_k(x)$ values over all instances of the training data. HWKNN performs weighted k-nearest neighbor classification, the weight of each training instance is $w(x) = e^{-h_b(x)}$. For a detailed illustration of HWKNN we refer to [13].

3 CYTHON-BASED IMPLEMENTATION OF HUBNESS CALCULATIONS

Python code is usually run by an interpreter which makes the execution relatively slow. Much of the inefficiency originates from dynamic typing: for example, the actual semantic of the '+' symbol depends on the types of the operands. It may stand for addition of numbers, concatenation of strings or lists, element-wise addition of arrays, etc. Which of the operations to perform, will be determined by the interpreter at execution time.

The core idea of Cython[3] is to annotate variables according to their types and to compile the resulting code into C which will further be compiled into binary code for efficient execution. In case of computationally expensive functions, this may results in

[2]https://archive.ics.uci.edu/ml/datasets/spambase
[3]https://cython.org/

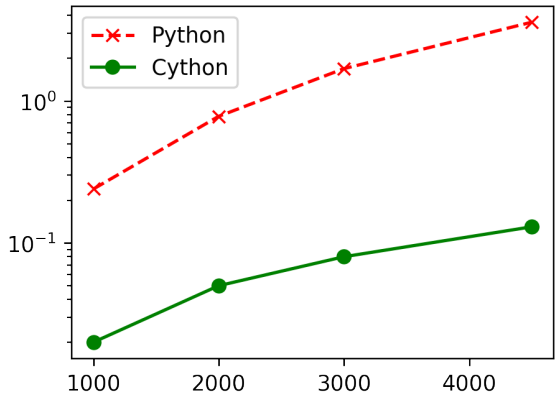

Figure 1: Runtime (in second, vertical axis) of hubness score calculation in case of Python-based (dashed line with 'x') and Cython-based (solid line with bullets) implementations for various number of instances (horizontal axis).

several orders of magnitude speedup. At the same time, functions implemented in Cython can be called from Python code just like Python functions.

We implemented the calculation of hubness scores both in Python and Cython, and made the code available in our github repository:

https://github.com/kr7/cython .

We evaluated both implementations on the Spambase dataset from the UCI repository. The dataset contains 4601 instances and 57 features (without the class label). Each instance corresponds to an e-mail. For each e-mail, the same features were extracted. The associated classification task is to decide whether the e-mail is spam or not.

We used 100 instances as test data and 4500 instances as training data. We run the experiments in Google Colab.[4] We used $k = 10$ nearest neighbors both for the calculation of hubness scores and the final classification. According to our observations, the Cython-based calculation of hubness scores was more than 20 times faster than the standard implementation in Python. Both versions produced the exactly same $BN_k(x)$ scores. As the weight of an instance x only depends on its $BN_k(x)$ score, both versions produce the same predictions. Therefore the accuracy (0.94) is equal in both cases.

We repeated the experiments with using only 1000, 2000 and 3000 instances as training data. As Fig. 1 shows, the Cython-based implementation was consistently faster than the implementation in Python. Note that logarithmic scale is used on the vertical axis. The difference showed an increasing trend when more training data was used: whereas in case of 1000 training instances, the Cython-based implementation was only about 12 times faster than the Python-based implementation, in case of 4500 training instances, the speedup factor was approximately 25. This may be attributed to the non-linear complexity of hubness score calculations. Assuming a naive implementation, determination of the nearest neighbors of an instance is linear in the size of the training data. However, in order to calculate the hubness scores, the nearest neighbors of *all* the training instances have to be determined. Thus the resulting overall complexity is quadratic.

We note that, both in case of Cython and Python, indexing techniques may be used to speed up the determination of the nearest neighbors. However, we omitted indexing in our implementation for simplicity.

[4]https://colab.research.google.com

4 DISCUSSION

In order to calculate distances effectively, we used pairwise distances from scikit-learn in our experiment. However, in case of *large* datasets, it may be necessary to calculate distances on the fly, as the distance matrix may be too large to be stored in RAM. In such cases, it may be worth considering to implement the distance calculations in Cython as well. In our previous works, we observed that the calculation of dynamic time warping distance was several orders of magnitudes faster when we implemented it in Cython instead of Python.

In case of *very large* datasets, straight forward calculation of hubness scores may be infeasible due to its quadratic complexity even if the calculations are implemented in Cython. In such cases, the aforementioned indexing techniques and/or calculation of approximate hubness scores (e.g. using a random subset of the data) may be necessary.

As future work, we plan an exhaustive evaluation of both implementations with respect to various datasets with different sizes and number of features.

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REFERENCES

[1] Stefan Behnel, Robert Bradshaw, Craig Citro, Lisandro Dalcin, Dag Sverre Seljebotn, and Kurt Smith. 2010. Cython: The best of both worlds. *Computing in Science & Engineering* 13, 2 (2010), 31–39.
[2] Krisztian Buza. 2016. Classification of gene expression data: A hubness-aware semi-supervised approach. *Computer methods and programs in biomedicine* 127 (2016), 105–113.
[3] Krisztian Buza, Alexandros Nanopoulos, and Gábor Nagy. 2015. Nearest neighbor regression in the presence of bad hubs. *Knowledge-Based Systems* 86 (2015), 250–260.
[4] Krisztian Buza and Ladislav Peška. 2017. Drug–target interaction prediction with Bipartite Local Models and hubness-aware regression. *Neurocomputing* 260 (2017), 284–293.
[5] Krisztian Buza and Noémi Ágnes Varga. 2016. Parkinsonet: estimation of updrs score using hubness-aware feedforward neural networks. *Applied Artificial Intelligence* 30, 6 (2016), 541–555.
[6] Luc Devroye, László Györfi, and Gábor Lugosi. 2013. *A probabilistic theory of pattern recognition*. Vol. 31. Springer Science & Business Media.
[7] Arthur Flexer, Monika Dörfler, Jan Schlüter, and Thomas Grill. 2018. Hubness as a case of technical algorithmic bias in music recommendation. In *2018 IEEE International Conference on Data Mining Workshops (ICDMW)*. IEEE, 1062–1069.
[8] Peter Knees, Dominik Schnitzer, and Arthur Flexer. 2014. Improving neighborhood-based collaborative filtering by reducing hubness. In *Proceedings of International Conference on Multimedia Retrieval*. 161–168.
[9] Miloš Radovanović, Alexandros Nanopoulos, and Mirjana Ivanović. 2009. Nearest neighbors in high-dimensional data: The emergence and influence of hubs. In *Proceedings of the 26th Annual International Conference on Machine Learning*. 865–872.
[10] Milos Radovanovic, Alexandros Nanopoulos, and Mirjana Ivanovic. 2010. Hubs in space: Popular nearest neighbors in high-dimensional data. *Journal of Machine Learning Research* 11, sept (2010), 2487–2531.
[11] Miloš Radovanović, Alexandros Nanopoulos, and Mirjana Ivanović. 2010. Time-series classification in many intrinsic dimensions. In *Proceedings of the 2010 SIAM International Conference on Data Mining*. SIAM, 677–688.

[12] S Raja Sree and A Kunthavai. 2022. Hubness weighted svm ensemble for prediction of breast cancer subtypes. *Technology and Health Care* 30, 3 (2022), 565–578.

[13] Nenad Tomašev, Krisztian Buza, Kristóf Marussy, and Piroska B Kis. 2015. Hubness-aware classification, instance selection and feature construction: Survey and extensions to time-series. In *Feature selection for data and pattern recognition*. Springer, 231–262.

[14] Nenad Tomašev, Miloš Radovanovic, Dunja Mladenic, and Mirjana Ivanovic. 2011. A probabilistic approach to nearest-neighbor classification: Naive hubness bayesian knn. In *Proc. 20th ACM Int. Conf. on Information and Knowledge Management (CIKM)*. 2173–2176.

[15] Nenad Tomasev, Milos Radovanovic, Dunja Mladenic, and Mirjana Ivanovic. 2013. The role of hubness in clustering high-dimensional data. *IEEE transactions on knowledge and data engineering* 26, 3 (2013), 739–751.

[16] Nenad Tomašev, Miloš Radovanović, Dunja Mladenić, and Mirjana Ivanović. 2014. Hubness-based fuzzy measures for high-dimensional k-nearest neighbor classification. *International Journal of Machine Learning and Cybernetics* 5, 3 (2014), 445–458.

[17] Qin Wu, Yaping Lin, Tuanfei Zhu, and Yue Zhang. 2020. HIBoost: A hubness-aware ensemble learning algorithm for high-dimensional imbalanced data classification. *Journal of Intelligent & Fuzzy Systems* 39, 1 (2020), 133–144.

Semantic Similarity of Parliamentary Speech using BERT Language Models & fastText Word Embeddings

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ABSTRACT

The main objective of this paper is to present the work done on comparing the two methods for measuring semantic similarity of parliamentary speech between coalition and opposition regarding the adoption of the first COVID-19 epidemic response package. We first measured sentence similarity using four BERT-based language models (Language agnostic BERT Sentence Encoder - LaBSE model, Sentence-LaBSE, Sentence-BERT, multilingual BERT - mBERT) and compared the results amongst them. Using the word embedding method, fastText, we then measured the semantic similarity of full-text parliamentary speech and presented the results using descriptive analysis. Lastly, we compared the usage of both methods and highlighted some of the advantages and disadvantages of each method for measuring the semantic similarity of parliamentary speech.

KEYWORDS

parliamentary speech, semantic similarity, sentence similarity, BERT language models, fastText

1 INTRODUCTION

"National parliamentary data is a verified communication channel between the elected political representatives and society members in any democracy. It needs to be made accessible and comprehensive - especially in times of a global crisis." [13] In parliamentary discourse, politicians expound their beliefs and ideas through argumentation and to persuade the audience, they highlight some aspect of an issue. If we are to understand the role of parliamentary discourse practices, we need to explore the recurring linguistic patterns and rhetorical strategies used by MPs that help to reveal their ideological commitments, hidden agendas, and argumentation tactics [11]. One of the ways to study the aforementioned linguistic patterns can be done by researching similarities of parliamentary speeches using different methods for measuring semantic similarity of text.

The aim of this paper is to present the work done on comparing the two methods for measuring semantic similarity of parliamentary speech between coalition and opposition regarding the adoption of the first COVID-19 epidemic response package. We measured sentence similarity with four BERT-based language models (Language agnostic BERT Sentence Encoder - LaBSE model [7], Sentence-LaBSE [8], Sentence-BERT [14], multilingual BERT – mBERT [1]) and compared the scores of most similar and least similar sentences.

To facilitate the intended scope of our initial research, i.e., researching similarity of full-text parliamentary speech, we used fastText [5] and presented results using descriptive analysis to gain additional insight into the characteristics of coalition and opposition parliamentary speech. Lastly, we highlighted some of the advantages and disadvantages of each method for measuring semantic similarity of parliamentary speech.

The paper is structured as follows: Section 2 contains an overview of the related work on word embeddings and language models. Section 3 presents the methodology and we describe the experiment setting in Section 4. The experiment results are found in Section 5. Finally, we conclude the paper and provide ideas for future work in Section 6.

2 RELATED WORK

Two blocks of texts are considered similar if they contain the same words or characters. Techniques like Bag of Words (BoW), Term Frequency - Inverse Document Frequency (TF-IDF) can be used to represent text as real value vectors to aid calculation of Semantic Textual Similarity (STS) [3]. STS is defined as the measure of semantic equivalence between two blocks of text and usually give a ranking or percentage of similarity between texts, rather than a binary decision as similar or not similar [3]. Word embeddings are one of the methods developed to aid in measuring semantic similarity. They provide vector representations of words where vectors retain the underlying linguistic relationship between the similarities of the words. Word embeddings consist of two types: static and contextualized word embeddings. With static word embeddings, words will always have the same representation, regardless of the context where it occurs, while with contextualized word embedding, representation depends on the context of where that word occurs – meaning, that the same word in different contexts can have different representations.

FastText is an open-source, free, lightweight library that allows users to learn text representations and text classifiers [5]. It is a representative of the static word embedding technique, where a vector representation is associated to each character n-gram; words being represented as the sum of these representations [2]. The fundamental problem of word embeddings is that they generate the same embedding for the same word in different contexts, failing to capture polysemy [4].

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Language models are contextualized word representations that aim at capturing word semantics in different contexts to address the issue of polysemy and the context of words [4]. BERT, or Bidirectional Encoder Representations from Transformer, is a language model, designed to pre-train deep bidirectional representations from an unlabeled text by jointly conditioning on both left and right context in all layers [6]. BERT word representations are therefore contextual

3 METHODOLOGY

3.1 Dataset

Dataset contains 230 documents (speeches) from the Extraordinary Session 33 from the corpora of the Slovenian parliamentary debates (ParlaMint-SI) [9] from 2014 to mid-2020, linguistically annotated and represented in the CoNNL-U format (which include POS, lemmatized and NER tags**)**. We chose an extraordinary session in a time of crisis for two reasons: firstly, regular sessions deal with multiple problems (such as MP questions), which makes a comparison between speeches difficult. Similarly, we chose only one specific theme (the adoption of the first epidemic response package), which helped in the initial analysis and comparison of documents.

3.2 Data analysis and pre-processing

For the initial data analysis, we used the Orange data-mining tool [12] that helped us with the data understanding and initial dataset pre-processing.

For full speech measuring with fastText we removed speeches by Chairperson to avoid adding noise to the dataset in the form of procedural speech that would make measuring semantic similarities almost impossible. We also removed Slovene stopwords and manually added a list of four additional stopwords: *hvala*, *danes*, l*epa* and *beseda*, which excluded the very common phrase *Hvala za besedo* (eng. Thank you for the word) and its variations. Some of the documents were missing the *party_status* labels (values: *coalition* and *opposition*). The missing values (17 documents) were thus removed from the dataset. The pre-process gave us a total of 97 documents, presented in Table 1. Looking at the distributions of the speeches in the session, almost 1/3 of the speeches belongs to the opposition. Both coalition and opposition consists of four political parties: LMŠ, Levica, SAB and SD are part of the opposition, all of mostly left and centre-left political orientation. Similarly, the coalition consists of DeSUS, NSi, SDS and SMC political parties[1], all mostly right-winged and centre-right parties.

Table 1: Preprocessed dataset

Sample	Number of documents	Total
Coalition	30 (30.93%)	97
Opposition	67 (69.07%)	

[1] Technically, the opposition consists of 5 political parties, but SNS (Slovenska Nacionalna Stranka) does not have any speeches in the dataset.

We used the same settings for the second part of the experiment (comparing sentence similarity with the four BERT-based models) with one difference. Since all BERT-based models support *max_lenght* input in the size 512 tokens, we decided to filter out sentences that refer explicitly to the response package (keyword for selection being *zakon*). To facilitate the visualisations and balance out our dataset, we randomly chose 20 sentences for each group (coalition/opposition).

3.3 Experiment settings

As mentioned, BERT-based models have restrictions on the maximum length of input documents. For most, this is 512 tokens, and in the case of Sentence-BERT, this restriction is even more severe (128 word tokens). Most speeches in the dataset are longer than the maximum length – this limitation did not allow us to conclude semantic similarity measurement on full parliamentary speech. The first part of the experiment therefore focuses on sentence similarity. From previously described BERT-based models, three of the models were fine-tuned for sentence similarity tasks: Sentence-LaBSE [7], LaBSE [8], mBERT [1] and Sentence-BERT [14]. For easier comparison, we used mean pooling and cosine distance to measure the similarity.

To achieve the intended scope of our initial research (researching the semantic similarity of parliamentary speech), we used the fastText-based Orange widget *Document embedding* (using mean as the aggregation method) to embed our documents and calculate cosine similarity to achieve comparison between coalition and opposition parliamentary speech. With these two experiments, we can compare measuring semantic similarity with language models to the word embedding method (fastText). This comparison would be better with Longformer language model (which can take up to around 1000+ word tokens as *max_input*) as we could compare methods for measuring semantic similarity of full-text documents (speeches), but as of time of writing this paper, Longformer [10] does not yet support Slovene language.

4 RESULTS

4.1 Results of the sentence similarity measure with BERT-based models

As stated previously, we used four different BERT-based models to measure semantic similarity of 40 sentences (20 sentences for each group - coalition and opposition) and visualized the results using heat maps (example in Figure 1). Initially, we first selected well-known BERT-based models that were optimized for Slovene (trilingual model CroSloEngual BERT and monolingual model SloBERTa), that did not produce reliable results - as shown in Table 2, CroSloEngual [15] and SloBERTa [16] produce extremely high similarity scores, since, as we later discovered, were not fine-tuned for sentence similarity task.

Table 2: Similarity scores of language models for most similar and least similar sentences

Model	Most similar	Least similar
Sentence-LaBSE	0.6184	0.1235
LaBSE	0.7610	0.3649
mBERT	0.8930	0.5377
Sentence-BERT	0.6677	-0.0792
CroSloEngual	0.9931	0.9480
SloBERTa	0.9867	0.8899

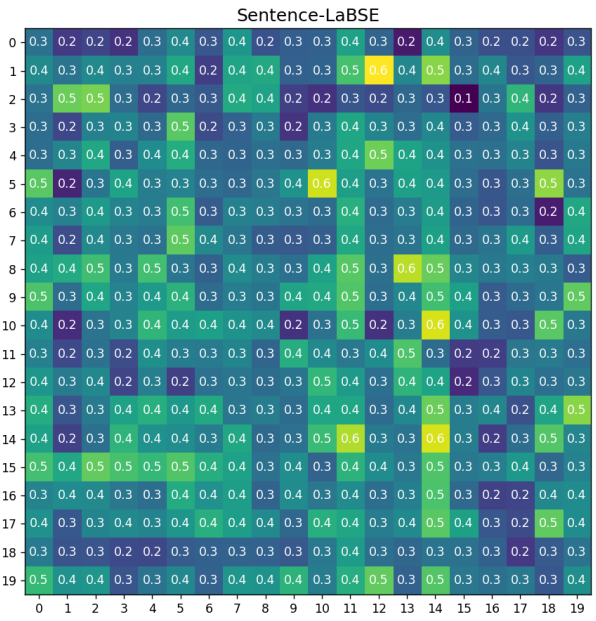

Figure 1: Example of heat map using Sentence-LaBSE model

When comparing the models, it does not surprise that Sentence-LaBSE and Sentence-BERT show very similar results (see Table 2), as they come from the same family of models and thus have similar model architecture (and are both fine-tuned for this specific task). What is interesting is the fact that Sentence-BERT is the only model that produced a negative score for the least similar sentence (similarity score of -0.0792), while mBERT model showed the highest similarity scores (outside of CroSloEngual and SloBERTa). Some of the highest scored sentences showed that speakers from different party statuses tend to use similar language patterns, for example:

Coalition*: "Ob hitrem sprejemanju zakona je potrebno zagotoviti, da ne bodo spregledane posamezne ranljive skupine posameznikov."*
(Eng. "With the rapid adoption of the law, it is necessary to ensure that individual vulnerable groups of individuals are not overlooked.")

Opposition*: "Še enkrat, ostaja še cela vrsta ranljivih skupin v zakonu, ki je nenaslovljena."*
(Eng. "Once again, there is a whole range of vulnerable groups in the law that remain unaddressed.")

4.2 Results of the document similarity with fastText

For the second part of our experiment, we used fastText for word embedding and measured cosine distance to get semantic similarity score of our documents. Figure 2 shows visualized results comparing speeches between coalition and opposition speakers:

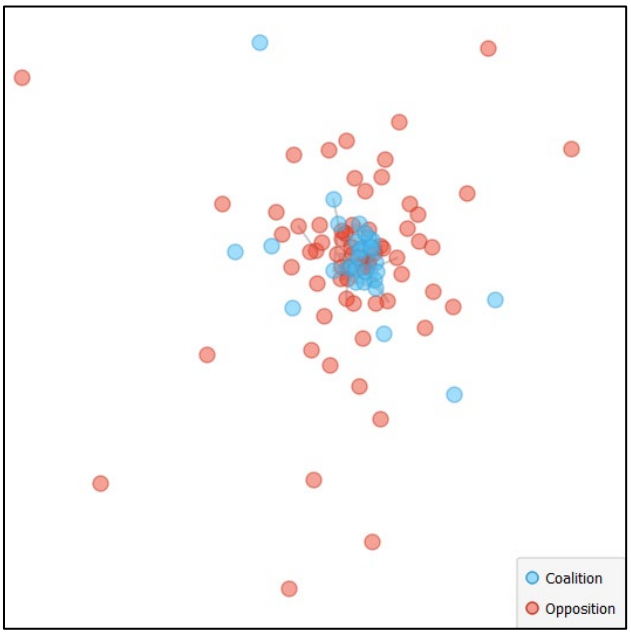

Figure 2: Document similarity with fastText, visualized using MDS

Documents (or speeches) are connected closely together – this could be attributed mostly to the fact that they are addressing the same issue – the adoption of the first epidemic release package. The most similar speeches were made by the members of the political party SDS (coalition) and SD (opposition), followed closely by SMC and Levica. All speeches are long and focus on the topic of the session – the proposed law (most speeches include keywords such as "*zakon*" (law), "*zakonski paket*" (law packet), "*amandma*" (amendment), "*ukrepi*" (measures).

Outlier detection analysis showed 8 speeches (7 made by the opposition, 1 by coalition), which are all very short and focus solely on parliamentary procedures. We also observed some trends in the usage of the words, concatenated from the word "*korona*": "*koronakriza*", "*koronazakon*", "*antikoronazakon*", "*koronaobveznica*", "*koronapomoči*", "*protikoronapaket*" etc. (used mostly by the opposition).

In Figure 3, we compared speech between the members of the opposition. The visualization showed a cluster of similar speeches. Members of Levica seemed to be most vocal during the session (by having more than 50% of all opposition speeches), while also having several similar speeches, with the central sub-topic being proposed amendments to the law and financial consequences of it. The least similar speech was made by Violeta Tomić, member of Levica, in regard to the date the epidemic was declared.

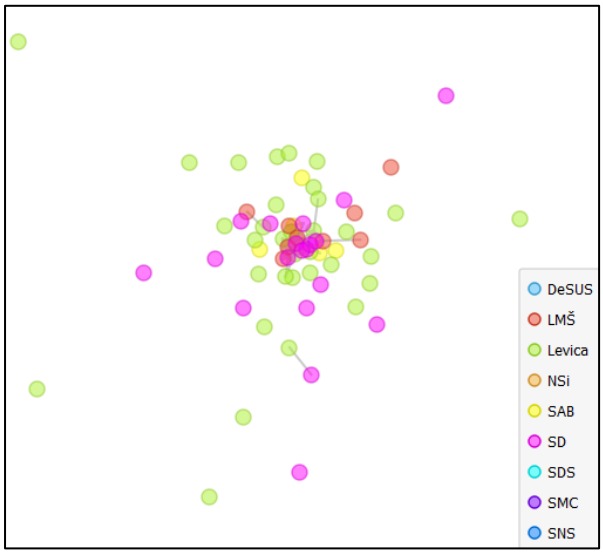

Figure 3: Document similarity with fastText (opposition)

In Figure 4, we compared speech between the members of coalition: speeches are less connected; with most similar divided among SDS members, closely connected to the SMC, NSI and DeSUS members. The common sub-topic to all of the speeches made is the financial crisis as a direct result of the epidemic. Two of the most far-away speeches belong to the member of DeSUS (Franc Jurša). Both speeches are among the shortest ones in the dataset, with a focus on the topic of pensions and registration of a parliamentary group, and thus are not explicitly connected to the central topic of the discourse.

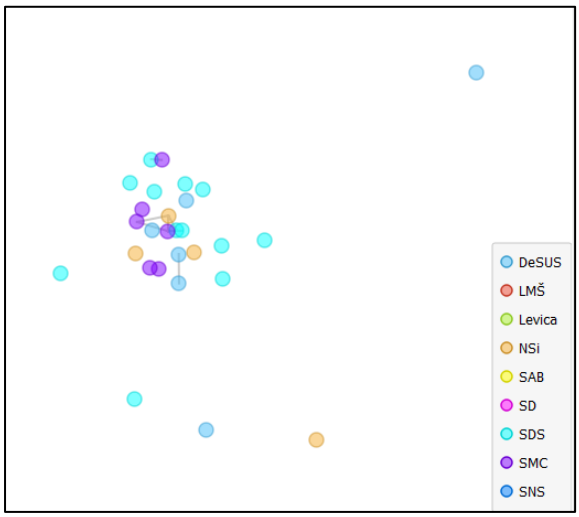

Figure 4: Document similarity with fastText (coalition)

5 CONCLUSIONS

In this paper, we were comparing language models and word embeddings as methods for measuring semantic similarity of parliamentary speech. In the initial stages, it turned out that there is not a lot of models that support Slovene as input language. Those that were made explicitly with Slovene in mind (such as SloBERTa and CroSloEngual BERT) were not fine-tuned for semantic similarity/sentence similarity tasks and thus do not produce accurate results. Limitation on maximum length of input text that most BERT-based models have is probably one of the biggest disadvantages of the language models for semantic similarity measures (this is being alleviated with new emerging language models, such as Longformer, that allow over 1000+ tokens as maximum input length). For sentence similarity task language models from Sentence-BERT family show the most accuracy and are easier to use as standard BERT models (such as mBERT).

Even though BERT contextualizes word embeddings (and therefore might produce better results because of it), fastText solved the problem of text-input length and combined with Orange data mining tool allowed us to explore similarities between speeches as we originally intended to do. From the document similarity analysis, we saw that most speeches were relatively connected (similar) to one another. Speeches amongst the members of the opposition were more similar in comparison to the speeches made amongst coalition members. There were a few outlier speeches in both opposition and coalition – they were all shorter speeches and less related to the original topic of the discourse. For future work, some limitations of this research should first be addressed (e.g., comparing language models to word embedding techniques on a full-text basis) and repeat the experiments with fine-tuned SloBERTa and CroSloEngual model on full ParlaMint-SI corpora.

REFERENCES

[1] BERT multilingual base model (cased): https://huggingface.co/bert-base-multilingual-cased

[2] Bojanowski, Piotr, Grave, Edouard, Joulin, Armand and Mikolov, Tomas. (2017). Enriching word vectors with subword information. In *Transactions of the Association for Computational Linguistics*, 5, 135-146. DOI: https://doi.org/10.1162/tacl_a_00051

[3] Chandrasekaran, Dhivya, and Vijay Mago. 2021. Evolution of Semantic Similarity—A Survey. In *ACM Computing Surveys,* 1-37.

[4] David S. Batista. 2018. Language Models and Contextualised Word Embeddings. https://www.davidsbatista.net/blog/2018/12/06/Word_Embeddings/

[5] FastText - Library for efficient text classification and representation learning. https://fasttext.cc/

[6] Jacob Devlin, Ming-Wei Chang, Kenton Lee and Kristina Toutanova. 2018. Bert: Pre-training of deep bidirectional transformers for language understanding. *arXiv preprint arXiv:1810.04805*.

[7] Language-agnostic BERT Sentence Encoder (LaBSE) (Sentence-Transformers): https://huggingface.co/sentence-transformers/LaBSE

[8] Language-agnostic BERT Sentence Encoder (LaBSE): https://huggingface.co/setu4993/LaBSE

[9] Linguistically annotated multilingual comparable corpora of parliamentary debates ParlaMint.ana 2.1. 2021. http://hdl.handle.net/11356/1431

[10] Longformer: https://huggingface.co/docs/transformers/model_doc/longformer

[11] Naderi, Nona, and Graeme Hirst. 2015. Argumentation mining in parliamentary discourse. In Principles and practice of multi-agent systems, 16-25. https://cmna.csc.liv.ac.uk/CMNA15/paper%209.pdf

[12] Orange: Data Mining Tool for visual programming. https://orangedatamining.com/

[13] ParlaMint: Towards Comparable Parliamentary Corpora. 2020. https://www.clarin.eu/content/parlamint-towards-comparable-parliamentary-corpora

[14] Sentence-BERT (sentence-transformers/distiluse-base-multilingual-cased-v2): https://huggingface.co/sentence-transformers/distiluse-base-multilingual-cased-v2

[15] Ulčar, Matej and Robnik-Šikonja, Marko, 2020, *CroSloEngual BERT 1.1*, Slovenian language resource repository CLARIN.SI, http://hdl.handle.net/11356/1330.

[16] Ulčar, Matej and Robnik-Šikonja, Marko, 2021, *Slovenian RoBERTa contextual embeddings model: SloBERTa 2.0*, Slovenian language resource repository CLARIN.SI, http://hdl.handle.net/11356/1397

Zbornik 25. mednarodne multikonference

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Zvezek D

Proceedings of the 25th International Multiconference

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10. oktober 2022 / 10 October 2022
Ljubljana, Slovenia

FOREWORD / PREDGOVOR

Seventh International Conference on Cognitonics - the Science about the Human Being in the Digital World (Cognit-2022)

Since October 2009, the international scientific conference on Cognitonics ("Kognitonika" in Slovenian) is a part of the international scientific multiconference INFORMATION SOCIETY (Slovenia, Ljubljana, Jozef Stefan Institute).

In the Preface to the Proceedings of the Sixth international conference Cognit-2019, we formulated the following expanded definition of Cognitonics: *it is the science about the trajectories of raising the human being to such level of intellectual and spiritual height where the scale of his/her personality becomes proportional to the scale of the digital world.*

The first objective of Cognitonics, or the Science about the Human Being in the Digital World, is to explicate the distortions in the perception of the world caused by the information society and globalization. The second, principal objective of Cognitonics is to cope with these distortions in different fields by means of elaborating systemic solutions for compensating the negative implications of the kind for the personality and society, in particular, for creating cognitive-cultural preconditions of the harmonic development of the personality in the information society and knowledge society and for ensuring the successful development of national cultures and national languages.

The goal of the conference is to combine the efforts of the scholars from numerous scientific fields and educators in order to establish a new synergy aimed at ensuring the harmonic, well-balanced development of the personality, national cultures, and national languages in the forming knowledge society (smart society) and, as a consequence, to compensate a number of broadly observed negative distortions.

From the standpoint of educational practice, Cognitonics suggests an answer to the following question: what precious ideas and images accumulated by the mankind, at what age, and in what a way are to be inscribed into the world's conceptual picture of a person in order to harmonize his/her intellectual and spiritually-coloured emotional development and to contribute to the successful development of national cultures and national languages?

Cognitonics formulates a new, large-scale goal for the software industry and Web science: to develop a new generation of culture-oriented computer programs and online courses (in the collaboration with educators, linguists, art historians, psychologists) - the computer programs and online courses intended for supporting and developing positively-oriented creativity, cognitive-emotional sphere, the appreciation of the roots of the national cultures, the awareness of the integrity of the cultural space in the information and smart society (knowledge society), and for supporting and developing symbolic information processing and linguistic skills, associative and reasoning abilities of children and university students.

Being a relatively young scientific discipline, Cognitonics both is of high social significance just now and has great prospects of the kind. It is due to the fact that it suggests new, deep and constructive ideas, new angles of look and original, effective solutions to a number of socially

significant problems emerged in adjacent fields, including education. The examples of such solutions are as follows.

During last decade, big international companies, fulfilling the casting of the specialists for vacant positions, have been paying a high attention to the level of emotional intelligence (EI) of the pretenders. Cognitonics suggested a highly effective system of teaching methods aimed at supporting and developing EI of the learners. This system includes, in particular, a many-staged method of early children's socialization in information and knowledge society and a method of developing creativity, figurative thinking, the skill of integrating information from numerous dispersed sources. Cognitonics enriched psychology by means of introducing the notion of Thought-Producing Self and of suggesting the most deep today (on the world level) model of developing conscious control in the childhood: control of thought, emotions, and actions.

Art cognitonics - one of the most developed branches of cognitonics - makes a considerable contribution to cultural studies and theory of up-bringing. It develops a complex method of using the works of art for positive development of the child's, adolescent's, and university student's personality. Art cognitonics suggests a new paradigm of delivering lectures on art.

Cognitonics is a quickly developing scientific discipline being ready to answer the emerging challenges of time. A new example is given by one of our papers below. It introduces the *Method of Cognitive Painting* as an effective tool for constructing a positive cognitive-emotional space for children and adolescents under conditions of the COVID-19 pandemic.

The Programme Committee accepted for the conference 6 papers from 5 countries: Croatia, Italy, Japan, Russia, Slovenia.

The editors would like to thank the authors of the papers for their contributions and the members of the Program Committee for their precious comments ensuring the high quality of the accepted papers and making the reading as well the editing of this volume a rewarding activity.

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Theoretical Foundations and Experience of Six All-Russian Creative Web-based School-contests “Portrait of Your Town”

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ABSTRACT

The paper sets forth the theoretical foundations and experience of six All-Russian creative school-contests (the years 2017 – 2022) “Portrait of your town” for children and adolescents at the age from 7 to 18 years. The methodological basis of this school-contest is the ideas of cognitonics, or the science about the human being in the digital world. This school-contest emerged as a civic initiative of this paper’s authors. The winners of the school-contest are awarded by a Letter of Gratitude signed by a senator of Russian Federation (RF) in accordance with a subject of RF. The number of the school-contest winners in 2022 is 518. A special attention in the paper is given to the tracks “Say thank you” and “World, nature, universe’s essence (Nature oriented behavior)”. In the year 2022, the school children from 58 subjects of RF (68% of all RF subjects) participated with the essays in this school-contest. It is concluded that every-year school-contest “Portrait of your town” can be interpreted as the third implementation of the student-self oriented learning model introduced by the authors several years ago and as smart learning environment of a new kind.

KEYWORDS

Creative school-contest, cognitonics, art cognitonics, smart learning environment, student-self oriented learning model, nature oriented behavior, creativity development, soft skills, transversal skills, personality development, system of emotional-imaginative teaching

1 INTRODUCTION

One of the significant social problems in modern Russia is as follows. The most gifted and highly motivated students of high schools enter the leading universities in biggest cities of the country (mainly, in Moscow and Saint-Petersburg), receive an excellent education and never return to their native towns and villages. A part of them finds jobs in abroad. As a consequence, the population of middle and small towns has been diminishing.

In the beginning of 2017, we launched an All-Russian Web-based creative school-contest for school children "Portrait of your town"; it took place for the sixth time in January - June 2022. It is a delicate opportunity for the child at the age from 7 to 18 years to tell about the beauty and peculiarity of her/his town being for the child the place of living, to feel the own roots, to perceive herself/himself as a link in the chain of generations, to have a sophisticated look at her/his world and find her/his personal look at the outstanding or usually not noticed facets of her/his town - such facets without which, according to her/his opinion, the complete portrait of the country can't be formed. The technical support (Web-platform) was provided to our school-contest by the Association of Living Cities, supported by the Public Chamber of the Russian Parliament.

The most bright, beautiful thoughts from the compositions of the winners of the school-contests 2017 - 2022 were presented at the first and second exhibitions "Country as an Orchestra" and the third and fourth exhibitions “Portrait of the country depicted by children with all their heart” in the Federation Council of Russian Federation (RF) - the upper chamber of the RF Parliament ("it is called "State Douma"). The authors of the essays presented (partially) at the first – fourth exhibitions were awarded by a Letter of Gratitude signed by a senator (a member of the RF Federation Council) in accordance with a region.

In the beginning of 2019, the new tracks "Say thank you" and “World, nature, universe’s essence” (it is a line from the poem “When it clears up” by Boris Pasternak) were included into the school-contest "Portrait of your town". The diapason of ages was considerably expanded: it is from 7 years to 18 years. The participants are to realize what persons from their native towns have made a difference in their life, who have influenced them a lot in their choice of future occupation, who has given the model of behavior children would like to emulate.

The participants of the track "Say thank you" submit the essays explicating their feeling of gratitude to the persons of the kind. Our first working hypothesis was that this track will be able to considerably contribute to developing in young people the sense of belonging to the native town. Then, after receiving an academic degree in a university, a part of young specialists will return to their native region or will regularly do something useful for their region.

The school-contest "Portrait of your town" has a methodical provision in the form of five written lectures posted on the Web. These lectures are prepared by the second author of this paper

and are oriented at the adult specialists (from a school or a library) helping children to prepare the sketches for the school-contest. This interaction with an adult helps children and adolescents a lot to better explicate their feelings.

Since the year 2017, we have found and successfully implemented two original ways of using modern information and communication technologies for developing a broad spectrum of soft skills in children and adolescents.

During last decade it has been broadly realized that education in knowledge society (or smart society) is to pay a particular attention to supporting and developing in the learners the significant, domain independent skills called soft skills [2, 30] or transversal skills [1, 31], first of all, analytical and critical thinking, creativity, out of box thinking, thinking and acting in terms of public good. The significance of creativity perceived by the world leading experts has been quickly increasing. The experts of the World Economic Forum (WEF) in Davos, Switzerland published in [25] the list of top 10 skills for the year 2015 and a forecast of the similar list for the year 2010. It is sufficient to say that the position of creativity shifted from the position No. 10 in 2015 to the position No. 3 in 2020. The forecast of the WEF list – 2020 includes also new skills in comparison with the WEF list 2015: emotional intelligence (the position No. 6) and cognitive flexibility (the position No. 10).

Our second working hypothesis was that the school-contest "Portrait of your town" and, in particular, the track "Say thank you" will contribute not only to developing the sense of belonging but also to supporting and developing a number of significant soft skills.

The analysis of the submitted best essays shows that the school-contest supports and improves emotional intelligence of the participants and develops such significant transversals (or soft skills) as analytical thinking, critical thinking, figurative thinking, creativity, out of box thinking, the ability to think and act in terms of public good. The first track "Say thank you" (February - June 2019) attracted the participants from 18 subjects of Russian Federation, including the subjects in Siberia, North and South of the country.

The next sections describe the scientific background and educational objectives of this school-contest.

The significant benefits for the personality development of children and adolescents – the participants of the All-Russian creative school-contest “Portrait of your town” have caused a quick growth of the school-contest’s popularity. The figure 1 shows the dynamics of the number of Russian Federation subjects participating in the school-contest during the years 2017-2022. It should be underlined that the growth of this number during the year 2022 reached 50%.

The result of the step-by-step evolution of the All-Russian creative school-contest “Portrait of your town” during six year is as follows. Now it is a unique education and up-bringing oriented platform realizing a dialogue between the bright, deeply feeling children and adolescents from even remote regions and the representatives of the state. The forms of the feedbacks received by children and participants are the comments of the teachers, the comments in analytical every-year reports prepared by the scientific advisors of the school-contest (the volume of each annual report is from two to four hundred pages), the comments in the mass media, and the words pronounced by the senators of Russian Federation during a festive reception in a region capital organized for the winners of the school-contest.

It is important that the school-contest contributes to coming back to the society of the perception of a bright, beautiful (but non-commercial) thought as a value.

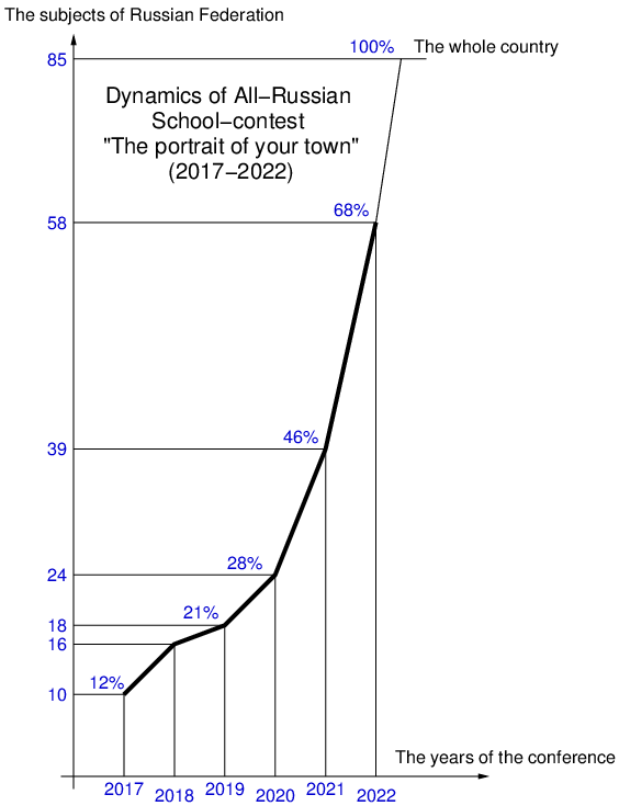

Figure 1: Dynamics of school – contest (2017 – 2022)

2 GENERAL INFORMATION ABOUT THE ALL-RUSSIAN CREATIVE SCHOOL-CONTEST “PORTRAIT OF YOUR TOWN” AND ITS TRACK “SAY THANK YOU”

The school-contest "Portrait of your town" has a methodical provision in the form of five written lectures posted on the Web. These lectures are prepared by the second author of this paper and are oriented at the adult specialists (from a school or a library) helping children to prepare the essays for the school-contest. This interaction with an adult helps children and adolescents a lot to better explicate their feeling.

The statistical results of the third school-contest “Portrait of your town” (January – June 2019) are as follows: the participants were from 18 subjects of Russian Federation, they lived in 39 places, including 27 towns and 12 settlements in country side. 240 sketches became the winners of the school-contest, including 72 sketches from the new track “Say thank you”.

In the year 2022, the school children from 58 subjects of RF (68% of all RF subjects) participated with the essays in this school-context. 518 participants received a letter of Gratitude from a senator of RF (in accordance with a region).

The fourth exhibition “Portrait of the country depicted by children with all their heart” in the Federation Council of the RF Parliament (June 2022) consisted of 56 pictures containing the fragments with the brightest ideas from the essays of the winners.

The analysis of the essays submitted to the track “Say thank you” enabled us to construct an unexpectedly rich classification of the persons receiving “Thank you” from the participants. This classification is as follows: 17% - friend; 15% - school teacher; 12% - mother; 10% - teacher of extra education; 10% - inspiring person; 7% - father; 7% - relatives; 7% - manager; 5% - grandmothers and grandfathers; 5% - unknown person; 3% - tutor; 2% - school employee. The constructed classification was used as a system of nominations.

Let’s consider several examples of home compositions.

Example 1 (analytical thinking). The 8 year old girl Kate writes: "One autumn day the parents led me to a ballet school. Yana K. became my teacher. She seemed to me being just, kind, and beautiful. She is teaching us good but rigorously. She wants everything to be OK in our life and that is why we are to undertake efforts. I've realized that it is necessary to make much efforts for achieving a result. I've realized that if one undertakes much efforts and works very much then the world and the people in this world will become better.

Thank you, my teacher, for evoking in me the belief that I will be able to cope with everything, and it means that I'll be able to do everything”.

Example 2 (empathy, mindfulness). A 11 years old girl Maria writes: “One spring day a young men opened a door of his car, intending to drive away. Suddenly he noticed a young girl who was crying, because her cat was unable to climb down to her from the top of a high tree. The young men reached the top of the tree, grasped the cat, and returned back with the cat. The young girl was happy”.

Example 3 (empathy, thinking and acting in terms of public good). A 8 years old boy Andrey writes: "I would like to say THANK YOU VERY MUCH to my teacher Maria K. She is a very kind person and a person of ready sympathy. One autumn day we with my class had an excursion in Kremlin. It was November, and it was cold. I lost my hat in school. At the moment when all the classmates were dressed and were waiting for me, I was looking for my hat, but all my efforts failed. Then my classmates started to help me to find my hat, but we failed to do it. Then our teacher gave me her hat and went on excursion without hat. Everything was good, we successfully went on excursion, and nobody from us became ill".

3 REALIZATION OF A NEW FUNDAMENTAL APPROACH TO UP-BRINGING

Since the year 2019, the school-contest “Portrait of your town” includes the track “World, Nature, Universe’s Essence”. The rationale for introducing this track is as follows.

The broad prospects of developing the personality of children and adolescents not understood, not used by modern education as a whole are opened by systematic, starting in early childhood, establishment of a correspondence between the situations observed in the nature and everyday situations.

Today the children throughout the world study the nature from the standpoints of botanic, biology, geography, chemistry, and physics. Our accumulated experience shows that this approach is too narrow, it is not assuming a philosophy of understanding the nature, of grasping the whole spectrum of knowledge about the world and about the behavior of a person in the world of people, this philosophy is encoded in the phenomena of nature.

Outstanding poets, writers, and painters give numerous examples of decoding deep meanings of nature’s phenomena, the examples of expressing these deep meanings by means of verbal and visual images being comprehensible for the human beings. We are convinced that it is possible and necessary to use the lessons of literature, poetry, and the arts as the possibilities of a dialogue between the person and the nature, while searching for the answers to acute questions during the period of personality’s maturing.

The habit to conduct a dialogue of the kind creates cognitive preconditions of forming a principally new level of ecological consciousness when the nature becomes your permanent dialogue partner which is able to listen to you and to give the answers. This is the true meaning of the broadly known phrase “It is necessary to be able to read the book of nature”.

The most important result of forming this new level of ecological consciousness is the creation of strong inner restrictions concerning the destroying impact of the human being on the nature: you can’t destroy something that is in your consciousness a life prompter and assistant.

Analyzing the essays submitted to the considered nomination in the years 2019 - 2022, we concluded that the idea of nature-oriented behavior was broadly perceived by young children and teenagers and became a part of their conceptual world’s picture.

Example 1 (the girl Alexandra E.). “Let’s consider the emergence of the leaves on the trees in spring and the shedding of leaves in autumn. I selected this phenomenon, because it is similar to the situation as people emerge in our life: some time they are close to you and then, in autumn, their interest in you fades, your relations are fading, and such people lose the connection with you, just as the leaves during the shedding. Only those people stay near you, who interlock with the tree and are fading together with it”.

Example 2 (the boy Ilya K.). “A leaf from a tree fell in the water of a river, the river grasped it and carried away. May be, it will stop on the beach of the river, but, may be, it will put on weight and sank. The same situation can be observed in the life. If a person has no own opinion, he/she will “flow” across the life, achieving nothing. It is necessary to have the own opinion”.

Taking the above said into account, we suggest a new fundamental approach to upbringing of young children and adolescents (considering up-bringing as directed socialization): to systematically establish the parallels between the phenomenon of nature and social agreements, life situations.

4 THE SCHOOL-CONTEST "PORTRAIT OF YOUR TOWN" AS THE THIRD IMPLEMENTATION OF THE STUDENT-SELF ORIENTED LEARNING MODEL

It is possible to indicate an interesting interpretation of the school-contest "Portrait of your town" in the context of the achievements of modern education theory. During last decade, the peculiarities of knowledge society have created the need for a new paradigm of educational process. One of the most significant peculiarities of the kind is the necessity to change a profession several times during the working period of life.

Proceeding from broadly accepted role of emotional intelligence (EI) in professional and personal life, we suggested a new learning model (LM) called Student-Self Oriented LM (SSOL-model). It is defined as the model being beneficial for self-cognition and self-construction through the prism of the acquired knowledge and life experience [15-17, 24].

The scientific literature describes two successful implementations of the SSOL-model. The first one is the *System of Emotional-Imaginative Teaching* (*the EIT-system*), based on the *Theory of Dynamic Conceptual Mappings (the DCM-theory).* The EIT-system is aimed at systematic development of EI, reasoning skills, sound creativity, figurative thinking, language skills, and communication culture at the lessons of language - mother tongue and SL, literature and poetry in two languages (on the example of Russian and English), symbolic languages of painting, sculpture, garden-park art, classic dance. We have accumulated the 32-year-long successful experience of using the EIT-system in extra education in Moscow, Russia. Many aspects of the DCM-theory and the EIT-system are described, in particular, in [4 – 17, 19 – 24].

The DCM-theory and the EIT-system belong to the constructive core of *cognitonics, or the science about the human being in the digital world* [11 – 24]. We organized as the co-chairs seven international conferences on cognitonics in conjunction with the international scientific multiconferences "Information Society" (Slovenia, Ljubljana, Jozef Stefan Institute, October 2009, 2011, 2013, 2015, 2017, 2019, 2022, see https://is.ijs.si/?page_id=903). Totally, the researchers from 24 counties participated with the papers in seven international conferences on cognitonics.

The ideas and methods of cognitonics underpinned a number of educational projects in several countries, in particular, in Croatia and Macedonia [29], Croatia [28], United Kingdom [26, 27], and Mexico, United Kingdom and PR China [3].

In [16, 18, 24], we formulated the following expanded definition of cognitonics: *it is the science about the trajectories of raising the human being to such level of intellectual and spiritual height where the scale of his/her personality becomes proportional to the scale of the digital world.*

The second successful implementation of the SSOL-model is *Art Cognitonics (AC)* [14 – 17, 24]. AC is one of the principal branches of cognitonics. AC aims at tuning the EI of the young children and adolescents with the help of well-known works of art. The goal is to create a bright semantic trace in the world's conceptual picture of the learner corresponding to an idea explaining or illustrating a moral value, communicative situation, a situation of making a decision, cognitive process itself, the process of self-cognition and consideration, the seething cocktail of emotions, a way of viewing the world around, etc.

AC establishes the links between the objects, situation, processes, views of a person (a beholder) and the work of art that becomes a metaphor or a vivid illustration (vivid mental representation) of something the beholder is considering about. That is why the consciousness of the beholder receives a considerable impulse to developing the ability of establishing diverse analogies and consequently to finding a new look at a situation.

Example. For enriching the colour of their canvases, the impressionists made use of what is known as division of colour and optical blending. E.g., to represent a green meadow, they put little tabs of blue and yellow on the canvas which are supposed to be combined to form green in the eye of the beholder – a far more intense green than one taken straight from the artist's palette. That is why it is impossible to understand the idea of a picture standing close to the canvas. We have to step aside and look at it from a certain distance to enjoy it and to have the desired effect.

The same situation we have in every-day life. "Multiple debs, reflections" prevent us from grasping the sense of what is happening. As in case with impressionists' canvases, we have to have a look at the situation from a distance, and distance in this case is equal to time distance. We need some time to better understand what has happened, and this will help us to cope with the situation.

The following principal factors provide the possibility to interpret the All-Russian creative school-contest "Portrait of your town" as the third implementation of the SSOL-model of educational process. As it was mentioned above, the main idea underpinned the creation of the SSOL-model was, while interacting with the learners, to take into account and to improve emotional intelligence of the learners.

We indicate a spectrum of the themes' facets but not the theme. The children and adolescents participating in the main track of the school-contest are to ask the question about the existence in their towns of such precious peculiarities that the portrait of the whole country would be incomplete without describing these peculiarities. Every participant of the track "Say thank you" is to ask herself/himself whether there are such people in her/his surroundings that the interaction with whom turned out to be a defining experience for the participant. Children discover the delighting traits of character, the manner of speech, the ability to attentively listen to for a long time, etc.

After having delighted, a child or an adolescent is to critically have a look inside herself/himself and ask herself/himself whether she/he possesses the traits of the character delighted her/him and whether she/he wants to improve her/his character. The participants of the track receive the possibility to understand and to appreciate what they do know. We create a thought-provoking situation which stimulates children and adolescents to analyze facts, to think over, to develop critical thinking (when a school girl or boy understands that she/he doesn't possess an attractive trait of the character).

The transfer of an experience from one situation to another situation contributes in many cases to developing *cognitive flexibility.*

5 GOODNET: THE GROWTH OF SELF-ESTIMATION IN PEOPLE OF USUAL, MASS PROFESSIONS

In every country, a great majority of people have the professions which don't attract public attention so much. This applies, in particular, to school teachers, hospital workers, nurses, bus drivers, postmen, gardeners. Such people usually believe that nothing in the country depends on them.

The victory of a school girl or boy in the track "Say thank you" becomes a thought-provoking event in a small settlement or town. In many cases, the local newspaper reports about both a child and an adult being the hero of her/his sketch.

As a result, many people in the country having usual, mass professions, have realized that they are able to make a difference for somebody at their working place. They become to be known in a small town or a village or in a district of a city. As a consequence, the self-assessment of these people increases. Children formulate new values; as a result, a new category of significant and distinguished people emerges.

Example (concierge). A 6 years old girl Vika writes: "It is monsieur Dima. He is a concierge in our home. Concierge is a man who defends us from bad people. Monsieur Dima is very kind. When I enter the home, I see him, and immediately my spirits are getting bright. Sometimes we are speaking, and sometimes he puts me on his shoulders and delivers me to the elevator, I am laughing. Monsieur Dima acts in this way, because he is kind hearted. Thank you, monsieur Dima, because you are kind and good".

The contest 'Say thank you" has shown the significance for children and adolescents of the notion "a hero of our time". Simple people from their surroundings thinking and acting in terms of public good become such heroes.

The significance of the track can be better grasped in case we compare it with the World Wide Web. The great peculiarity of the Web is that it reaches every family, every person (being not a very young child). The track "Say thank you" can be interpreted as *a digital platform for explicating estimation and distributing good. Then the track can be called GoodNet* - it reaches every family, connects the generations and receives a response in every heart. The track "Say thank you" is a platform where the demand, significance, and reality of respectable attitude to each other bridges the gap between generations, explicates and enhances intrinsic interest towards other people.

6 CONCLUSION

Five written lectures posted on the Web site of the school-contest "Portrait of your town" form its methodical provision. These lectures are underpinned by the ideas of cognitonics and are prepared by the second author of the present paper. The essays composed by the region stage winners are submitted by the responsible specialists in the bunches via e-mail to the team of scientific advisors. The analytical year reviews of the results and the peculiarities of the school-contest (prepared by the scientific advisors of the school-contest – the authors of this paper) are posted in June on the Web site of the school-contest. Additionally, the results and the peculiarities of the school-contest of the year 2022 are discussed in a video record prepared by second author of the paper and posted on the Web. The link to this lecture is distributed via e-mail by the responsible specialists from various subjects of Russian Federation.

That is why there are reasons to say that every year school-contest "Portrait of your town" can be interpreted as a small learning environment of a new kind.

REFERENCES

[1] Bottino, Rosa Maria, Chioccariello, Augusto, Freina, Laura, and Travella, Mauro. 2019. *"Digital Games in Primary Schools for the Development of Key Transversal Skills".* In *Sustainable ICT, Education and Learning. IFIP WG 3.4 International Conference, SUZA 2019*, Zanzibar, Tanzania, April 25–27, 2019, Revised Selected Papers, A. Tatnull and N. Mavengere, Eds. Cham, Springer, pp. 55-65.

[2] Buselic, Vjeran. 2019. "Information literacy and critical thinking freshman course experience". In the Proceedings of the 41st International Convention MIPRO 2018 (Opatija, May 20-24, 2019), Conference "Computers in Education", P. Biljanovic et al., Eds, Opatija, Croatia: Mipro and IEEE, pp. 920-925.

[3] Craig, Paul, Roa-Seiler, Nena, Martínez Diaz, Marcela, and Lara Rosano, Felipe. 2014. *"A cognitonics approach to computer supported learning in the Mexican state of Oaxaca",* Informatica. An International Journal of Computing and Informatics (Slovenia), No. 3:241-248.

[4] Fomichov, Vladimir. 2015. "Conscious Control during Childhood, Development of". In *International Encyclopedia of the Social and Behavioral Sciences, Second Edition, vol. 4.* Elsevier, Oxford, 666-672

[5] *Fomichov, Vladimir, and Fomichova, Olga. 1994.* "The Theory of Dynamic Conceptual Mappings and its Significance for Education, Cognitive Science, and Artificial Intelligence", *Informatica. An International Journal of Computing and Informatics, No. 2:31-148.*

[6] *Fomichov, Vladimir, and Fomichova, Olga. 1995.* "The artificial intelligence theory and highly effective methods of teaching young children foreign languages". *Cybernetica, No. 4:321-344.*

[7] Fomichov, Vladimir, and Fomichova, Olga. 1997. "An Informational Conception of Developing the Consciousness of the Child". Informatica. An International Journal of Computing and Informatics (Slovenia), vol. 21, pp. 371-390.

[8] Fomichov, Vladimir, and Fomichova, Olga. 1998a. "A new theoretical and practical approach to early positive developing child's consciousness". In R. Trappl (Editor), Cybernetics and Systems'98. Proceedings of the 14th European Meeting on Cybernetics and Systems Research. Vol. 1, Austrian Society for Cybernetic Studies, Vienna, pp. 276-281.

[9] Fomichov, Vladimir, and Fomichova, Olga. 1998b. "Early development of natural-language-processing abilities as a key to up-bringing of children without conflicts", In G. Ritschard, A. Berchtold, F. Duc, D.A. Zighed, Eds. Apprentissage: des principes naturels aux methodes artificielles. Editions HERMES, Paris, pp. 67-81.

[10] Fomichov, Vladimir, and Fomichova, Olga. 2000. *"The social responsibility of computer science specialists for the creative potential of the young generation"*. International Journal of Artificial Intelligence in Education, No. 2:208-219.

[11] Fomichov, Vladimir, and Fomichova, Olga. 2006. *"Cognitonics as a New Science and Its Significance for Informatics and Information Society".* Informatica. An Intern. Journal of Computing and Informatics (Slovenia), No. 4: 387-398.

[12] Fomichov, Vladimir, and Fomichova, Olga. 2012. *"A Contribution of Cognitonics to Secure Living in Information Society"*. Informatica. An International Journal of Computing and Informatics, No. 1:121-130.

[13] Fomichov, Vladimir, and Fomichova, Olga. 2014. *"An Imperative of a Poorly Recognized Existential Risk: Early Socialization of Smart Young Generation in Information Society"*, Informatica. An International Journal of Computing and Informatics, No. 1:59-70.

[14] Fomichov, Vladimir, and Fomichova, Olga. 2015. "Early Development of the Human Being Ideal Constituent and Art Cognitonics as the Answer to the Challenge of Knowledge Society". In: Informacijska druzba - IS 2015. Proc. of the 18th International Multiconference - IS 2015, Edited by V. A. Fomichov, O. S. Fomichova. Vol. F: Kognitonika/Cognitonics. Oct. 12th-13th, 2015, Ljubljana. Jozef Stefan Institute, pp. 27-32, 2015.

[15] Fomichov, Vladimir, and Fomichova, Olga. 2017. "The Student-Self Oriented Learning Model as a Paradigm for Supporting and Developing Emotional Intelligence and Creativity". In *Informacijska druzba - IS 2017. Proceedings of the 20th International Multiconference - IS 2017, Edited by V. A. Fomichov, O. S. Fomichova. Vol. Kognitonika/Cognitonics. October 9th-10th, 2017, Ljubljana, Slovenia*. Jozef Stefan Institute, Ljubljana, pp. 11-16.

[16] Fomichov, Vladimir, and Fomichova, Olga. 2018. *Cognitonics and Its Significance for Education in the Digital Age*. Moscow, Publishing House MAKS Press (in Russian).

[17] Fomichov, Vladimir, and Fomichova, Olga. 2019. *"The Student-Self Oriented Learning Model as an effective paradigm for education in knowledge society".* Informatica. An International Journal of Computing and Informatics, No. 1:95-107.

[18] Fomichov, Vladimir, and Fomichova, Olga. 2019. *"Predgovor/Foreword".* In Informacijska druzba - IS 2019. Zvezek E. Proc. of the 22nd Intern. Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, pp. 3-4.

[19] Fomichova, Olga. 2009. "*Humanitarian Education: an Answer to the Challenge of Time".* Moscow, Publishing House of Lomonosov Moscow State University (in Russian).

[20] Fomichova, Olga, and Fomichov, Vladimir. 1996. *"Theoretical Foundations of a New Method of Teaching Children Effective Information Processing".* Informatica. An Internatiional Journal of Computing and Informatics, No. 3:381-399.

[21] Fomichova, Olga, and Fomichov, Vladimir. 2000. *"Computers and the Thought-Producing Self of the Young Child".* The British Journal of Educational Technology, No. 3:213-220.

[22] Fomichova, Olga, and Fomichov, Vladimir. 2009. *"Cognitonics as an Answer to the Challenge of Time".* In Proceedings of the 12th International Multiconference Information Society - IS 2009, Slovenia, Ljubljana, 12 – 16 October 2009. The Conference Kognitonika/Cognitonics. Jozef Stefan Institute, Ljubljana, 431-434.

[23] Fomichova, Olga, and Fomichov, Vladimir. 2019. *The Pillars of Higher Personality Development of Net Generation in Smart Society.* In Informacijska druzba - IS 2019. Zvezek E. Proc. of the 22nd Intern. Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, 15-18.

[24] Fomichova, Olga and Fomichov, Vladimir. 2020. "*Education with the Focus on Up-bringing in Knowledge Society"*. Moscow, Publishing House MAKS Press (in Russian).

[25] Gray, A. 2016. *"The 10 skills you need to thrive in the fourth industrial revolution",* Accessed December 17h, 2019. https://weform.org/agenda/2016/01/the-10-skills-you need-to-thrive-in-the-fourth-industrial-revolution/

[26] Kane, Thomas. 2014. *"Using cognitive tunnels in a new approach to buildingsocial elevators in the information society".* Informatica. An International Journal of Computing and Informatics (Slovenia), No. 3:263-271.

[27] Kane, Thomas. 2017. "A Cognitonics methodology for artificial persons". In Zbornik 20. mednarodne multikonference INFORMACIJSKA DRUZBA - IS 2017. Zvezek D. Proceedings of the 20th International Multiconference INFORMATION SOCIETY - IS 2017, Volume D. Kognitonika/Cognitonics. Uredila / Edited by Vladimir A. Fomichov, Olga S. Fomichova. 9.-13. oktober 2017/ 9th - 13th October 2017, Ljubljana, Slovenia. Ljubljana, Jozef Stefan Institute, pp. 30-33.

[28] Panev, Ida. 2019. **"**Creating multimedia systems according to principles of cognitonics". In Informacijska druzba - IS 2019. Zvezek E. Proc. of the 22nd Intern. Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, pp. 50-53, 2019.

[29] Panev, Ida, Pogarcic, Ivan, and Gjergjeska, Ljubinka, 2017. **"**Goals of cognitonics in formal ICT education". In Informacijska druzba - IS 2017. Zvezek D. Proc. of the 20th Intern. Multiconference - IS 2017, Edited by V. A. Fomichov, O. S. Fomichova. Vol. D, Kognitonika/Cognitonics. October 9th-10th, 2017, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, pp. 61-65.

[30] Soft skills, 2019. Soft skills. TVETipedia Glossary, Accessed December 21, 2019. https://unevoc.unesco.org/go.php?q=TVETipedia+Glossary+A-Z&filt=all&id=602

[31] Transversal skills. 2019. TVETipedia Glossary, Accessed December 21, 2019. https://unevoc.unesco.org/go.php?q=TVETipedia+Glossary+A-Z&id=577

The Case of the Civic University of Landscape/Living Environment as a Model of Learning/ Process/ Action for Ternary Systems Human/Society/Life Environment

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ABSTRACT

The hypothesis expressed in this article is the possibility of linking in an evolutionary dynamic, beyond conflict, the world of nature to the world of digital information, whose entities are detached from natural constraints, distant from the reality of life and evolution but deeply rooted in it and now dominant. In spite of all this, Humanity - even though thus affected - remains an integral part of the Human/Society/Environment Ternary Systems, which are now facing the new Digital World, detached from Nature but capable of heavily influencing it, depriving them of their evolutionary prerogatives. All this is happening while increasingly dramatic crises affect the entire Biosphere, and while Science is getting closer to the deeper origins of Nature's dynamics and the self-creating roots of its evolution.

We propose to put in place Relational Structures of Research-Action and Learning, modelled on the complex disordered Systems of People, Human Societies and the Environment (in our case the H/S/E Ternary Systems) and the new Hybrid Human/Society// Living/Digital Environment Systems, where the disordered and complex World of Nature remains the protagonist of evolution, collaborating with the Digital World but not subordinating to it. We ground the concept of the Civic University of Landscape/Living Environment as a means of promoting and reconstructing relational and research-action in the disordered complex systems of our contemporary world.

KEYWORDS
Disordered complex systems, evolutionary processes, ternary relationships Man/Society/Life // Digital Environment, experiential learning

1 INTRODUCTION

The sense of belonging to one's own community and living environment is common to all living beings and constitutes the Relational Structure that enables the formation and evolutionary becoming of every Ecosystem (see, in particular, [1]).

In contemporary, increasingly exasperated Human and Thus the deep relational structure typical of any ecosystem is being replaced by mechanical and digital technological structures that now dominate most of their spontaneous dynamics.

The relationships spontaneously produced within the living world, thus weakened and overwhelmed by the external influence of the mechanical and digital world, also progressively disturb the learning dynamics and the transitional modes of all human and natural ecosystems on the planet.

In them, the accumulation, hetero-controlled preservation of "data" is opposed to their self- management and autonomous processing of natural learning that stimulates the evolutionary dynamics of the systems on which all life in our world depends.

Since the last century, the relational structure that Human/Society/Environment ecosystems have revealed to us through the approach of human ecology has been recognized as a structure common to all systems in our world, from physical to natural and human.

1.1 The Complex Disordered Systems

The Physics of *Complex Disordered Systems* has led us to discover the common roots of all the evolutionary dynamics of the world, and to recognize complexity and disorder as prerogatives shared by physical disordered systems, biological systems, and the most complex human and social ecosystems; all of which leads us today to recognize the world as a living totality in which all the dynamics of evolutionary transitions are mutually connected.

The latest outstanding achievements in Physics (Giorgio Parisi, Nobel Prize in Physics 2021) [7] teach us that the (evolutionary) transitions of nature's complex disordered Systems occur due to "various stimuli" due to certain parameters that in turn, during the system transitions, become more and more complex, depending on the characteristics of the systems with which they interact.

Today the parameters that have stimulated the transition dynamics of Human/Society/Living Environment

ecosystems, usually from the natural environment, are instead artificially produced in the digital environment and tend to dominate the evolutionary dynamics (which had previously brought systems to higher and higher levels of complexity) leading them to an increasing simplification their configurations, which become- paradoxically- more and more complicated.

In this new condition, it becomes urgent to keep these heterodirected mechanisms in control and to protect complex and disordered Systems by supporting their evolutionary processes, in contrast to the mechanical simplifications imposed by the Digital World.

1.2 Transition Dynamics of Human/Society/Living Environment

Taking all this as the foundation of our research/action within the ternary systems of Human/Society/Life Environment, we can reconstruct favourable conditions for multiple experiential learning processes, achievable through territorial Ecosystemic Laboratories.

These laboratories consist of a whole structure of relationships that support diverse experiences and non-hierarchical information exchanges. This whole in turn becomes an increasingly complex relational structure in which new knowledge and stimuli are processed and produced.

In this condition, information exchange occurs between the natural and digital environments, while this new environment accommodates the elaborations produced within the Laboratories and intensifies exchanges on a larger scale.

This whole in turn becomes a *relational structure* in which new knowledge is processed and new evolutionary dynamics towards new levels of ecosystem complexity are activated.

The case of the *Civic Landscape//University* can be emblematic as a research/process/action model for the ternary systems to which the participants belong. This can also be emblematic as a learning process model for ternary systems within which everyone can practice different types of action/research, strengthening the sense of belonging between participants and their living environments.[1]

This approach becomes strategic at a time when climate change is disrupting every environment, every human society and every living environment. At this step we can reformulate all ecosystem relationships and consequently all modes of social-

environmental learning in its becoming.

2 THE SIGNIFICANCE OF CIVIC LANDSCAPE UNIVERSITY

This university is an experiential learning structure that can operate in any civic society that feels an active part of its life environment.

In each of these environments the affections, memories and experiences (personal and social) originated in the multiplicity of human and natural dynamics that have characterized and transformed them over time.

Today all these environments have been pervaded by artificial dynamics (technological, cultural, financial) produced by the globalized/digital world that tends to dominate them all, creating in them another unexpected *hybrid living environment.* This environmental, economic, cultural and social crisis is reflected and leaves traces in individuals, societies and living environments, where processes of degradation and shattering are triggered from which new crises are generated and multiplied. Human/Society/Living Environment Ternary Systems gradually lose their capacity for self-control and their evolutionary autonomy, failing to counter the linear mechanics of the dominant globalized-technological-digital world and international finance.

The administrative, economic and territorial policies on which the transformations of H/S/E ecosystems are based are themselves conditioned by the pressures of the globalized world to which the Administrations fail to counteract the interests of citizens, who in turn are conditioned and overwhelmed by the uncontrollable intrigues of the dominant mechanics of globalization, down to the personal, behavioral and interpersonal level.

2.1 Ecological Dynamics versus Digital Mechanics

In these situations, there is no possibility of direct opposition between the ecological dynamics of Human/Society/Environment and the invasive technological, financial and digital mechanics that tend to dominate the planet, to the point of destruction.

At present, a global opposition to these phenomena is almost unthinkable, while it would instead be possible to sustain and promote multiple forms of resilience in ternary systems-already recognized as such-and activate new ones.

This can be realized through new forms of experiential practices addressed to different Ternary Systems, in a multiplicity of unpredictable *stimuli* and *relationships*. These can in turn give rise to new transitional phases and configurations in a succession of dynamic equilibria typical of all complex disordered systems, as occurs in Nature.

2.2. The Relational Fields

This open-ended relationality can create new and ever changing *Relational Fields*, whose dynamics go beyond the preconceived rules on which Artificial/Digital Games are usually structured (as opposed to the relational dynamics of Nature) toward new Plays of collective invention and joy, capable of stimulating new evolutionary transitions of ternary complex Systems composed of different interacting Entities, such as:

- People, with their desires, availability, competencies and active skills.
- Social groups interacting and practicing friendly mutual learning, a fundamental condition for the activation and self- regulation of processes;
- the Landscape/Living Environment identified from time to time as the Field in which the Action Research

[1] The *Landscape* is intended as *Life Environment*, according to European Landscape Convention , Florence, 2000

takes place and the evolutionary transformations are perceptible and directly appraisable by the participants. From their reciprocal and continuous dynamic interactions originate relational Fields, which give rise to new ternary Human/Society/Living Environment Ecosystems, still complex, disordered and in continuous transition.

2.3 The Relational Interface

The Civic Landscape University constitutes a relational Interface that, by interacting with these Ternary Systems, ensures that they maintain their own evolutionary dynamics in the face of the growing and oppressive abuses of power of the globalized/digital world.

Wholeness, circularity, dynamic H/S/Environment balances and equal interaction with the globalized/digital world are the basis of every activity of the Civic University of Landscape whose name already expresses the wholeness and multiplicity of Knowledge and Research Action differently expressed by its members:

- ***University,*** expresses the boundless wholeness of knowledge (with science, art and philosophy being part of it)
- ***Civic,*** expresses the totality of knowledge, values and desires present in every person, and in every society
- ***Landscape,*** expresses the totality of the living environment in all its natural, human, technological and even digital articulations.

2.4 The Common Good

These three components in turn express a concept of Common Good articulated in the different Environments of Life, a Field in which specific Research and Actions can be developed for the formation of stable participatory structures, differently rooted in each context, through specific methods to manage, protect and promote the different Environments of Life.

2.5 Where the Civic University can work

The conditions of discomfort, protest and awareness shared by the inhabitants of the many different environments of contemporary living, almost ignored or denied by political decisional structures, constitute fertile ground on which the activity of the Civic University can grow and articulate.

These conditions manifest themselves in different places and ways:

- *In mountain environments* already recognized by law but often usurped (excavation, theft of pastureland) or mismanaged by public agencies (municipalities, regions).
- In *usurped or privatized public lands*
-In the *sale of public housing* complexes valued as commodities in a speculative sense
-In the *poor planning of urban/metropolitan areas* that deny citizens civic services fundamental to their quality of life
-In the *abandoned agricultural areas* adjacent to population centers, exploited in favor of the development of private wellness centers and luxury sports facilities
-In the *denial of any prospect of management* of Services essential to the ecological vitality of densely populated areas (public transportation, food, sanitation, neighborhood cultivation, care and maintenance of ecosystem relationships typical of any living environment, self-management of interactive digital environments)
-In the *impossibility of recovering* degraded contexts by activating specific modes of lasting interaction between people and the environment
-In the *impossibility of producing* new ways of working and circular economies in connection between local societies and living environments.
- In the *political arrogance of "Large Public Works"* and the profound alterations they induce.

2.6 How can the University be useful to Ternary Ecosystems

In any condition of socio-environmental distress where interactive ecological processes are activated or formed and where new stimuli, energy and creativity can come into play, escaping the traditional planning methods and problem-solving procedures (sanitation, health, waste, public transportation, etc.) usually chosen by government departments, the University is welcome.

2.7 Who can be involved in its activities

Experts from different disciplines who contribute to the knowledge of the complex systems interacting in each ternary H/ S/ E System and participate in learning and action-research processes modeled on each specific context.

Participants who, on a personal and/or social level, have had spontaneous experiences of action or struggle for the environment with groups, associations and committees in various social realities.

Exponents of cultural, scientific, educational and support institutions, in their national and local articulations, willing to activate and/or contribute to Participatory Social Learning Processes on the various Life Environments of reference.

National-regional administrative institutions already present and active in local contexts and willing to support innovative participatory processes aimed at the management, protection and promotion of the living environments under their competence.

3 THE WORKING GROUPS

Within the Civic Landscape University, different working groups are formed from time to time to establish friendly and equal interactions among the heterogeneous actors involved in participatory processes.

They support and encourage mutual learning and project/laboratory experiences on the changing dynamics of human /society/living environments systems and to independently address and control the pervasive phenomena coming from the globalized digital world.

Thus, a new, unexpected Life Environment is formed in which the Digital World interacts-without overwhelming them-with the H/ S/ E ecosystems, which remain protagonists in their evolutionary processes.

In these new conditions multiple dynamic processes of ecological protection and promotion of the participants' living environments coexist, as well as self-management of the new living environments in connection with the Digital Environment.

In order to achieve more complex levels of mutual exchange and knowledge among all components of the new Living Environments, the Civic Landscape University is organized as a Structure of Relation and Propagation of scientific elaborations and experiences among concrete territorial realities that confront the abstraction of the digital world. All this can take place through the continuous interconnection between the theoretical elaborations, experiential realizations developed in the Ternary Systems and the digital components involved in this new "Hybrid Environment."

The University thus becomes a complex interface between Digital World and Ternary Ecosystems, in a continuous intertwining of digital/virtual and concrete realities that work in synergy and stimulate each other toward new stages of transition and dynamically balanced configurations.

4 THE MODEL OF THE ORGANIZATION AND OPERATION OF THE UNIVERSITY

This model can be summarized as follows.

0.0 General Introduction - Development of social participation in ecosystems and the entire relational sphere (cf. Italian Constitution - Article 9).

0.1 First round of meetings - general themes and lived cases

- Human Ecology and Democracy in the living environments of contemporary societies
- The principles and criteria of the Ecological Approach compared with the principles and criteria practiced by territorial Administrations and Public Managers established in the territories according to the current democratic and economic "rules."
- Presentation of experiences already practiced, in progress or proposed by local groups, compared with the opposite approaches of local Institutions and Inhabitants (Collective Domains; Simeto-Panaro River Contracts; Metropolitan Crisis Management and Alternatives - Florence Metropolitan Area).

0.2 Second cycle - Relational reactivation in complex (consolidated or exacerbated) Systems.

Experiences of rediscovering or reconstructing relationships in Ternary Microsystems to foster or highlight their evolutionary potential.

- Long-term (successful) experiential cases - La Pica Garden - Mirandola (Emilia Romagna).
- Experiences of contrasted participatory processes Palmaria Island (Liguria) the denial and destruction of the ecosystem.
- The usurped pastures of the Apennines (Abruzzo);
- the legal claim to collective ownership of their marble quarries (Apuan Alps, Tuscany).

0.3 Third round - General discussion on the contributions produced.

- Ecological/Systemic balance of contributions integrated and proposed in previous cycles.
- Fragility, stability, balance highlighted in the cases discussed.
- Comparative (critical) assessment of the state of Research-Learning Action in the presented cases.
- Proposals for the next cycle activities.

Online publication and extensive final discussion on the activities carried out.

Contributions and proposed problems discussed can be requested from experts and participants who have spoken or are interested in providing their suggestions and support for future activities.

5 CONCLUSION

We would like to emphasize that the Civic University structure we have devised can become a fertile Research - Learning - Action Environment aimed at implementing new frontiers of knowledge and experience, both towards the most significant scientific elaborations of the 20th and 21st centuries and the implementation of new forms of experiential democracy

REFERENCES

[1] O.S. Fomichova and V.A. Fomichov. The Web-based Lectures as Leverage for Developing the Sense of Belonging in the All-Russian Creative School- Contests. In: 2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO), September 28 – October 2, 2020, Opatija, Croatia. Proceedings. Rijeka: Croatian Society for Information, Communication and Electronic Technology - MIPRO, 2020, pp. 855-860.

[2] R.Micarelli, G.Pizziolo. *L'arte delle Relazioni* and *Dai margini del caos,l'ecologia del progettare,* it.ed., Alinea, Firenze, 2003.

[3] M.Pascucci. *Causa Sui*, it. ed.Ombre Corte, 2009 .

[4] M.Pascucci. *La Potenza della Povertà*, it. ed. Ombre Corte, Verona, 2006.

[5] M.Pascucci. *Macchina Capitale*, it Ombre Corte, Verona, 2022.

[6] K. Hiwaki, *Culture and Economics in the Global Community. A Framework for Socioeconomic Development.* UK and USA, Gower Publishing Company, 2011.

[7] G.Parisi. *In un volo di storni it.* Ed. Feltrinelli, Milano, 2021.

[8] E.Marinari. *La Fisica dei sistemi complessi*, by Corriere della Sera, Milano, 2022

[9] K. Hiwaki. From Growing to Maturing Integral Harmony and Global Integrity, *International Journal of Human Sciences and Education*, (IJHSSE), Vol.8, February 2021.

[10] The site of association GRASPTHEFUTURE.EU, www.graspthefuture.eu

Were the Principles of Cognitonics Met in Online Education During the Covid-19 Pandemic?

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ABSTRACT

Cognitonics is a scientific discipline developed with the aim of studying the human being in the digital world. The aim of this study is to investigate through survey and to analyse whether e-learning in which students suddenly found themselves, due to Covid - 19 pandemic, was conducted in accordance with some principles of cognitonics.

KEYWORDS

Cognitonics, e-learning, online education, distance education, Covid - 19, pandemic, lockdown, survey

1 INTRODUCTION

Cognitonics is the science about human being in the digital world [4]. “It is the science about the trajectories of raising the human being to such level of intellectual and spiritual height where the scale of his/her personality becomes proportional to the scale of the digital world” [5]. It, among other things, questions the impact of information and communication technology on the identity (personality) of an individual, a particular group, or a society as a whole. Cognitonics seeks to point out the need for development of person’s creativity and independent thinking, sense of harmony and beauty, awareness of belonging to a particular national culture or social heritage, language skills (primarily skills of quality use of the official language of the culture to which a person belongs), ethical behavior, abilities for self-regulation (i.e. monitoring and controlling one's own behavior),… within the society of rapidly developing information and communication technologies and globalization [10].

As we all witness, with the growing popularity of ICT – Information and Communications Technology, the popularity of online learning, especially in higher education, also arises [1]. Despite this, online (distance) education (e-learning) has not been involved in the educational process to such an extent. With the advent of the Covid - 19 pandemic, this changed so online education suddenly became the main mode of education. In general, educational institutions were not prepared for the sudden shift to online teaching, so as we witness this became a topic of many researches.

The question of this research was whether distance education during the Covid – 19 pandemic was conducted according to some principles of Cognitonics.

2 RESEARCH ABOUT IMPLEMENTING THE PRINCIPLES OF COGNITONICS IN ONLINE EDUCATION DURING COVID-19 LOCKDOWN

The aim of this research is to evaluate the realization of some of the Cognitonics' goals in online education during Covid - 19 lockdown in Croatia. With the closure of educational institutions, the need for a rapid and unexpected transformation from onsite to online learning emerged. The created survey shows to what extent online education due to Covid - 19 affected the mental and physical condition of students and was it conducted according to some principles of Cognitonics.

Created survey included 23 closed questions. The obligation of the respondents was to answer each question. The survey was created using Google Forms platform and distribution was conducted through the outreach of social media and messaging services. Clear instructions were provided to ensure that the respondents must be from a student population. No individual was forced against their will to fill in the survey and no identifying information was collected. When analyzing the results of the survey, descriptive statistical data analysis was used.

Total 50 answers were gathered through survey, so this paper can be a stimulus and can give an idea for further research.

2.1 Survey questions

1. Gender.
2. Age group.
3. Select your current level of education.
4. What is your perception of the situation in which you suddenly found yourself during the "lockdown" referring to the transition to distance education?
5. During distance education, was your creativity in different spheres mostly encouraged (e.g. creativity in expression, learning, communication, problem solving, etc.)?
6. If the answer to the 5th question was "Yes", choose in which spheres your creativity was encouraged during distance

education: creative expression, creative ways of using technology, creative ways of learning, creative ways of communication, creative task / problem solving, my creativity was not encouraged, I can't estimate.
7. If the answer to the 5th question is "Yes", evaluate whether your creativity was more stimulated during distance education than during classroom education?
8. During distance education, were you mostly encouraged to think independently and solve tasks / problems?
9. During distance education, was the development of your language skills mostly encouraged (was your spelling and grammatical correct expression in written/oral communication, creativity and task/problem solving encouraged)?
10. During distance education, was your ethical behavior mostly encouraged in communication, cooperation, solving tasks / problems?
11. During distance education, were you mostly encouraged to behave responsibly towards yourself and others when using information and communication technology?
12. Do you think that you have gained the same amount of knowledge and experience through distance education as you would have gained through classroom education?
13. Do you think that distance education has affected your mental state?
14. Do you think that distance education has affected your physical condition?
15. During distance education, did you experience a more individual approach to you as a student by the teacher than during classroom education?
16. During distance education, were you mostly a passive observer or were you encouraged to actively participate in the learning process?
17. During distance education, did you feel connected to the community in which you live (such as a community of fellow students; a community of friends; a community of residents of your city, etc.) or did you feel isolated?
18. During distance education, did you mostly encounter the understanding and empathy of the teacher for the situation you found yourself in?
19. Did you have enough prior knowledge to use technology during distance education?
20. During distance education, were you able to better organize your study time and free time?
21. During distance education, was your curiosity to acquire new information / knowledge / skills mostly encouraged?
22. How much time per day (during the working week) did you spend at the computer during distance education (to attend classes or to fulfil school / college obligations or to study)?
23. During distance education, were you as motivated to learn / complete your duties as during classroom education?

3 SURVEY RESULTS EXPLANATION

The results of the survey analysis show that there were 60% of male respondents, 32% of female respondents, while 8% of respondents did not want to make a statement about their gender.

The majority of the respondents (64%) were in the age group 19-24, 28% were in the age group 25 and more, and the rest of the respondents (8%) were younger than 19.

Regarding the current level of education, 72% of the respondents are in the higher level of education, 24% are in high school and 4% are in elementary school.

When stating what is their perception of the situation in which they suddenly found themselves during the "lockdown", and it refers to the transition to distance education, 56% of the respondents answered that it was positive perception. 24% of the respondents answered neither positive nor negative, and 20% answered that their perception was negative. These positive findings have also been confirmed in other researches [3] [13].

When talking about the creativity in different fields like creativity in expression, learning, communication, problem solving, etc., 48% of the respondents answered that their creativity was mostly encouraged during online education, 36% answered that their creativity was not encouraged, and 16% of the respondents could not estimate. Among respondents who answered that their creativity was mostly encouraged, 12% of them answered that their creative expression was encouraged, 44% answered that the creative ways of using technology were encouraged, 36% answered that the creative ways of learning were encouraged, 40% answered that the creative ways of communication were encouraged, 28% answered that the creative task / problem solving was encouraged, while the rest of the respondents where those who did not answer positively about creativity encouragement, or they could not estimate. It can be concluded that the creative ways of using technology were encouraged to the greatest extent and creative expression was least encouraged.

When asking whether students creativity was more stimulated during distance education than during classroom education, 40% of the respondents could not estimate, 32% of the respondents answered positive, 12% of them answered negative, and the rest of the respondents were in population which stated that their creativity was mostly not encouraged during distance learning.

When asking respondents were they mostly encouraged to think independently and solve tasks / problems independently during distance education, 68% of them responded positively, 28% of them responded negatively and 4% could not estimate. Other researchers also gathered the results which speak in favour that students were encouraged to take the responsibility for their own learning during distance education [13].

Interestingly, the same amount of the respondents (40%) stated positively and negatively to the question if during distance education the development of their language skills was mostly encouraged, and 20% of the respondents could not estimate.

When asking if during distance education their ethical behavior was mostly encouraged in communication, cooperation, solving tasks / problems, 52% of the respondents answered positively, 28% of them answered negatively, and 20% could not estimate. This is a positive indicator and points to the fact that it is possible to influence the ethical behavior of students so that, among other things, for example, the writing of online exams is in accordance with the principles of the educational system.

When asking if during distance education the respondents were mostly encouraged to behave responsibly towards themselves and towards others when using information and communication technology, 48% of the respondents answered yes, 28% of the respondents answered no, and 24% of the respondents could not estimate. For example, the need to

encourage responsible behavior among students during online communication is also emphasized in a paper written by Martinez [8].

In the next question, the respondents were asked do they feel that they have gained the same amount of knowledge and experience through distance education as they would have gained through classroom education. 56% of the respondents answered positively, 40% responded negatively and 4% could not estimate.

When talking about mental and physical state, 36% of the respondents stated that distance education had a negative impact on their mental state, the same percentage – 28% stated or that it had a positive effect, or that it did not have any impact on their mental state. 8% of the respondents could not estimate. This can support the statement that there is evident academic – related stress or anxiety which effects mental health and well - being of the students during distance learning caused by the pandemic [7][9][13]. Researchers also find out that although before mentioned issues, students were free of depression during distance education [13]. Interestingly, Zhou & Shang [13] stated in their study that students showed improved mental health during pandemic.

As for physical state, 44% of the respondents answered that distance education did not have impact on their physical state, 28% of the respondents answered that it had a positive impact, 24% of the respondents answered that it had negative impact, and 4% of the respondents could not estimate. This can be explained by the fact that the majority of respondents are in the age group that has already acquired habits related to physical activity, so the lockdown did not have a negative impact on that aspect of their lives.

When answering if during distance education respondents experienced more individual approach from the teacher to them as a student, than during classroom education, 48% of respondents answered no, 28% answered yes and 24% of the respondents could not estimate. This shows that, unfortunately, there are not enough human, time and material resources for an individual approach, which is often a problem with traditional education, let alone with online education. Similar results were found in other researches where the lack of interaction between student and teacher was found [3][13].

Furthermore, 60% of the respondents answered that they were passive observers during distance education, 32% of the respondents answered that they were encouraged to actively participate in the learning process during distance education and 8% of them could not estimate. This is the topic that must be addressed. Percentage in this answer has to be changed because one of the main goals of the online education must be to actively involve students to participate in the educational process. There are a lot of papers that specify how to actively engage students during distance education. For example: [12][14] etc.

When asking if the respondents felt connected to the community in which they live during distance education, 40% of the respondents answered positively, 28% responded that they felt isolated from the community, and 32% of the respondents could not estimate. Zhou and Zhang also stated in their research that students felt belongingness to their learning community during online education due to the pandemic [13].

When answering if during distance education respondents mostly encounter the understanding and empathy of the teachers for the situation they found themselves in, 60% of the respondents answered positively, 24% answered negatively and 16% of the respondents could not estimate.

The only question answered 100% positively was the question asking did the respondents have enough prior knowledge to use technology during distance education. This proves that today's students are digital natives. It means that they use technology as an integral part of their everyday lives where they use it for internet searching, socializing, and communication [2].

80% of the respondents answered that during distance education they were able to better organize their study time and their free time, 16% answered negatively to this question and 4% of the respondents could not estimate. In other researches the same result was given – students were able to study at their own pace [13]. However, this is supported by the fact that the majority of respondents are between 19 and 24, so they have already acquired working and organizational habits.

When asking the respondents has their curiosity to acquire new information / knowledge / skills been stimulated during distance education, 60% of the respondents answered yes, 32% of the respondents answered no and 8% of the respondents could not estimate.

As the answer to the question how much time per day (during the working week) did the respondents spend at the computer during distance education (to attend classes or to fulfill school / college obligations or to study), 60% of the respondents answered 1 – 4 hours a day, 28% of the respondents answered 5 – 8 hours a day, 8% of the respondents answered more than 8 hours a day and 4% of the respondents answered less than 1 hour a day.

The last question of the survey was asking the respondents were they as motivated to learn / do their homework during distance education as they were motivated during classroom education. 40% of the respondents answered that they were less motivated, 32% answered they were equally motivated, 20% of the respondents answered that they were more motivated and 8% could not estimate. As already emphasized, during online education it is necessary to make students active participants in the educational process, and it is also necessary to motivate them to participate and learn in an online environment.

4 CONCLUSION

In this study, the survey was conducted with the aim of reaching a conclusion as to whether online education was carried out in accordance with some principles of Cognitonics. Findings in big part show that it was. Students mostly had positive perception about distance learning, their creativity and curiosity were encouraged, they were encouraged to think independently, their ethical and responsible behavior was encouraged. Also, most of the respondents stated that distance learning did not have impact on their physical state, that they felt connected to their community despite online communication, that they encounter the understanding and empathy of the teachers and that they were able to better organize their study and free time. The negative sides of distance education in this study were: slightly negative impact on the mental state of the respondents and lack of teacher's individual approach. Also, the respondents mostly

perceived themselves as passive observers in educational process and less motivated to learn and do their educational obligations while attending online learning.

At the beginning of Covid-19 pandemic, educational institutions were not prepared for sudden need for distance education. Researchers [11] show that at the beginning of the lockdown due to Covid – 19 pandemic, educational institutions were not prepared regarding ICT infrastructure, grading policy, student support etc. Students were in a worry about the efficiency of distance education and were confronted with academic stress, anxiety and depression. However, with the time passing by and educational institutions catching up with all the academic needs during distance learning, students demonstrated positive learning experience [6][13]. This study also shows that students' overall learning experience was found to be mainly positive. Despite that, findings in this study indicated that the Covid - 19 pandemic has made a significant impact on students. This situation highlights key challenges, provides an opportunity to further evaluate alternate measures in the online education and indicates the need to prepare educators and students for eventual future necessity of online education.

REFERENCES

[1] S. Abbasi, T. Ayoob, A. Malik, & S. Memon (2020.). Perceptions of students regarding E-learning during Covid-19 at a private medical college. Pak J Med Sci. vol. 36, pp. doi: https://doi.org/10.12669/pjms.36.COVID19-S4.2766.

[2] D. A. Akuratiya & D. N. Meddage (2020, September). Students' Perception of Online Learning during COVID-19 Pandemic: A Survey Study of IT Students. International Journal of Research and Innovation in Social Science (IJRISS), pp. 755-758.

[3] R. Chang, Y. Hung, & C. Lin (2015). Survey of learning experiences and influence of learning style preferences on user intentions regarding MOOCs. Br. J. Educ. Technol., 46.

[4] O. Fomichova & V. Fomichov (2021). Cognitive Painting as a Broadly Applicable Method of Constructing a Positive Cognitive - Emotional Space for Young Children and Adolescents under Conditions of the Coronavirus Pandemic. Proceedings of MIPRO 2021 (pp. 659-664). Opatija, MIPRO.

[5] V. Fomichov & O. Fomichova (2019). Predgovor/Foreword. In Informacijska druzba - IS 2019. Zvezek E. Proceedings. of the 22nd International Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, pp. 3-4.

[6] T. Gonzalez, M. De La Rubia, K. Hincz, M. Comas-Lopez, L. Subirats, S. Fort et al. (2020). Influence of COVID-19 confinement on students' performance in higher education. PLoS ONE.

[7] A. Mahapatra, & P. Sharma (2020, September). Education in times of COVID-19 pandemic: Academic stress and its psychosocial impact on children and adolescents in India. International Journal of Social Psychiatry.

[8] C. Martinez (2021). Imagine the Person in Front of You: How Teachers Promote Responsible Online Communication in Swedish Leisure-Time Centers. Scandinavian Journal of Educational Research, 65.

[9] Y. Nishimura, K. Ochi, K. Tokumasu, M. Obika, H. Hagiya, H. Kataoka, & F. Otsuka (2021). Impact of the COVID-19 Pandemic on the Psychological Distress of Medical Students in Japan: Cross-sectional Survey Study. JOURNAL OF MEDICAL INTERNET RESEARCH.

[10] I. Panev, I. Pogarčić, & L. Gjergjeska (2017). Goals of cognitonics in formal ICT education. Proc. of the 20th Intern. Multiconference - IS 2017, Edited by V. A. Fomichov, O. S. Fomichova. Vol. D, Cognitonics (pp. 61-65). Ljubljana: Jozef Stefan Institute.

[11] J. Reich, C. Buttimer, A. Fang, G. Hillaire, K. Hirsch, L. Larke et al. (2020). Remote Learning Guidance from State Education Agencies During the Covid-19 Pandemic: A First Look. MIT Teaching Systems Lab.

[12] M. Valente, & M. MacMahon (2020). Virtual communication for student group projects: the COVID-19 effect. ALL IRELAND JOURNAL OF HIGHER EDUCATION, 3.

[13] J. Zhou, & Q. Zhang (2021). A Survey Study on U.S. College Students' Learning Experience in COVID-19. Educ. Sci. doi: https://doi.org/10.3390/educsci11050248

[14] D. Zuidema, & R. Zuidema (2021). From Passive Observers to Active Participants: Using Interactive Remote Demonstrations to Increase Student Involvement in Online Chemistry Instruction. Journal of Chemical Education, 3.

The Method of Cognitive Painting as an Effective Tool for Constructing a Positive Cognitive-Emotional Space for Children and Adolescents under Conditions of the COVID-19 Pandemic

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ABSTRACT

The paper expands the authors' theory of dynamic conceptual mappings by means of introducing an original, broadly applicable method of creating a highly useful online method (or prop) being appropriate for the particular situation when children and adolescents find themselves in the pandemic restrictions launched into the digital cosmos without being trained to bear a flight lasting almost half a year, being a member of a busy crew, though they have never had an experience of being together with for twenty four hours a day. This method is called cognitive painting. Within an original online course "Cognitive-emotional personality development" in addition to the usual tasks the authors started up a project dealing with creating a new year story underpinned by students' own perception of snow (in case of snowy winters), their love towards their favorite Christmas toys, their Christmas wishes and hopes and underpinned by sound reasoning about Christmas gift in general, Christmas miracles a and Santa Clause. 62 school children took part in this work (the age from 7 to 18 years). As a result, a 92-pages printed book is obtained as an output of that co-creative work. A very precious feature of the introduced method is that it can be effectively applied in arbitrary countries, taking into account the peculiarities of national culture and nature.

KEYWORDS

Cognitonics, constructing a positive cognitive-emotional space, cognitive painting, cognitive-colour scheme, cognitive maturity, emotional maturity, creativity, student-self oriented learning model, personality development, theory of dynamic conceptual mappings, little "C" creativity, big "C" creativity

1 INTRODUCTION

The interpretation of cognitonics as the science about the human being in the digital world emerged one and half decade before the COVID-19 pandemic. This global dangerous event added new significant facets to the concept of the human being in the digital world. The average number of hours spent every day for interaction with computer systems (including Web) not only by the adults but also by children and adolescents increased several times in comparison with previous value. This situation caused a number of negative impacts not only on physical health of the person but also on his/her emotional state and mental health.

During last year and the first months of the year 2021, many scholars from different countries analyzed the influence of the corona virus pandemic on moral state of children and adolescents, on the development of their negative attitude to the world. In particular, the papers [1], [2], [3] explicate, first of all, such negative phenomena as high rates of anxiety, depression, stress.

Proceeding from the fulfilled analysis of the situation, the authors of [1] indicate the necessity of creating the activities for improving "the individual health of children and adolescents and their families, the health of the community, and the intellectual and working capacity of these individuals over the long term, with positive economic and social results for each nation". Similarly, the authors of [2] underline the significance of helping children and adolescents to deal with mental health burden of the pandemic.

The study described in the present paper just satisfies these demands, the paper is of constructive character.

Our analysis has shown that cognitive danger of corona virus pandemic is a consequence of the following principal factors:

- Children and adolescents are bereft of their usual surroundings (school life, strolls with their friends, off-line education, extracurricular activity);
- They are bereft of co-creative off-line activity, which is underpinned with strong emotions, discussions, brainstorming sessions in which all the members of a group suggest the ideas and then discuss them;
- Children and adolescents are bereft of off-line group activities, such as round table discussions, sport events, creative contests, balls, parties, museums;
- Their interaction with the parents is an illusion, because parents are at home but in fact they are not. The are

working online all the day. It disappoints children's hopes and looks like the fraud, it doesn't meet their expectations. Children have to make peace with it, but it is difficult, even impossible in particular age.

In this connection let's try to have a look at the work of astronauts on board of the cosmos station during a long period of time (half a year, for example);

- Astronauts are grown-up people who know beforehand how long they would stay on board of the station;

- They are trained well how to cope with the restrictions of all kinds;

- The members of the crew are well matched psychologically and roughly equal in ability, they are well motivated and are inspired by what they are doing;

- Each of them is highly involved in the activity he/she is carrying out, and it helps to overcome the restrictions.

We may assume that children and adolescents were launched into the "digital cosmos" without any preparations and, due to their small age, they were lack of highly motivated creative activity and ability to initiate creative work which could be overwhelming.

Negative response to the situation of restrictions and the necessity to work hard without improved ability to think over and then put forward his/her own ideas, without being propped up by the creative surroundings makes it clear that children and adolescents need an emotional and creative prop.

We have invented a broadly applicable method of creating a highly useful online prop being appropriate for the particular situation, when children and adolescents find themselves in the pandemic restrictions launched into the digital cosmos without being trained to bear a flight lasting almost half a year, being a member of a busy crew, though they have never had an experience of being together with twentyfour hours a day. This method called *cognitive painting* is stated below.

The main impulse to the birth of cognitonics was given by our Theory of Dynamic Conceptual Mappings (the DCM-theory). During the first decade of its development the central idea was as follows: while thinking over how to inscribe a piece of theoretical materials into the conceptual world's picture (CWP) of a learner, it is useful to find (or to create during a lesson) in his/her CWP a bright, positively coloured fragment and to establish a correspondence between the entities and relationships from the considered piece of theory and the entities and relationships from this selected (or created) fragment of CWP [9, 10, 23-28].

Last year we faced a new problem: not to introduce a certain piece of theory but to initiate positive changes in the children's attitude to the world, in their moral state. That is why we transformed the central idea of the DCM-theory and suggested the following method called *the Method of Cognitive Painting:*

Starting situation: The learners (the children or adolescents) are morally suppressed by certain circumstances, their vision of the situation is negative or mainly negative.

Recommended way out (the most general formulation):

Step 1. Try to find in the CWP of the learners certain bright, positively coloured fragments.

Step 2. Invent a kind of intellectual, emotional activity closely linked with found bright, positive fragments of the CWP and transporting the positive colour of such fragments (or a fragment) to the perception of the current situation.

The next sections describe our successful implementation of this method by means of distance education. Besides, we set forth the theoretical foundations of our method in addition to the ideas stated above.

2 SCIENTIFIC FOUNDATIONS OF COGNITIVE PAINTING

2.1 The Method of Drawing Together Little "C" and Big "C" Creativity

The paper [4] presented a new look at little "C" and big "C" creativity. Big "C" creativity (BCC) is regarded in connection with the creative ability of outstanding scientists, musicians, painters, writers, poets [2]. Smart society demands little "C" creativity (LCC). It reveals the smart society's necessity of creative thinking [3, 4] and creative approach to solving the every-day tasks. LCC improves problem solving skill, which is one of most important skills.

BCC is defined by two main characteristics. It is regarded as original and highly significant creative activity for big groups of people. Creativity of children (LCC) usually is subjective and is defined by their previous knowledge. The main characteristics of LCC is their imagination [8]. Smart society demands the necessity of supporting and improving LCC in order to create the preconditions for increasing the proportion of the specialists in significant application domains who possess BCC.

Our paper [4] suggests a method of combining as early as possible LCC and BCC in the process aimed at realizing the Thought-Producing Self (see [9], [10]) of the child.

The first step of the method suggests the understanding by the children of the significance of thought. It helps to return the notion "value of thought" to the world's conceptual picture of the school children.

The second step suggests the awareness of the school children of the fact that their ideas, metaphors, way of viewing nature, communicative situations, the pictures, etc. may be highly significant for relatively big groups of people in case of sharing their ideas with the others. The reason is that they have given a sophisticated look at something and have revealed an example of serendipity (the ability to make pleasant and unexpected discoveries entirely by chance). It happens due to their natural ability to see out of the way things in usual things and usual things in out of the way things. It might be thought provoking for grown-up people.

Example (one of the examples of nature inspired behaviour). “The crown is sitting on the twig. The crown is heavy and big, the twig is thin. But the crown is no nervous. It is not afraid of the fact that the twig may break, because the bird doesn't think about the twig, it trusts its swings” (Anne, a seven year girl).

The third step is to make children aware of the beauty and wisdom they have discovered, because in most cases they do it without a second thought, intuitively. It just dawned upon them. They need encouragement to continue mental and spiritual work on that level. Their efforts and their inspiration should be discussed and appreciated by the community.

The fourth step is to show the examples of BCC revealing the same idea to make children believe that the value of thought doesn't depend on age and experience, but age and experience help us to penetrate the very essence of the thought, to comprehend it.

In the case considered in the present paper, we work with little “C” creativity, and, as a result, it reaches the level of the big “C” creativity. That means the situation when the written storis of the children, adolescents, and even grown-ups reveal the images and the way of consideration on such level that it is possible to put them together with images and ideas of such great poets as Alexander Pushkin and Boris Pasternak.

2.2 Student-Self Oriented Learning Model

Our method of cognitive painting introduced in the present paper is based on the Student-Self Oriented Learning Model (SSOL-model). The principal motive for its creation was the idea that educational processes in knowledge society (or smart society) should be based much more on taking into account and improving emotional intelligence (EI) of the learners.

The SSOL-model is defined as the model being beneficial for self-cognition and self-construction through the prism of the acquired knowledge and life experience [11], [12], [13], [14], [15]. The principal distinguished features of the SSOL-model are as follows: (a) it takes into account and bases educational process on EI of the learners; (b) it aims at reaching cognitive engagement of the learners; for this, it proposes a conceptual learning environment instead of the environment based on mechanical remembering (it means addition of emotional color to the studied notions and, as a consequence, makes much easier the comprehension of these notions).

2.3 The Role of Cognitonics

The SSOL-model is one of the fundamental results of a new scientific discipline called cognitonics, or *the science about the human being in the digital world* [13], [15], [16], [17], [18], [19], [20], [21], [22]. The birth of cognitonics was prepared by the authors’ papers [23], [24], [25], [26], [27], [28].

The authors organized as the co-chairs seven international conferences on cognitonics in conjunction with the international scientific multiconferences “Information Society” (Slovenia, Ljubljana, Jozef Stefan Institute, October 2009, 2011, 2013, 2015, 2017, 2019, 2022, see https://is.ijs.si/?page_id=903). Totally, the researchers form 24 countries participated with the papers in six international conferences on cognitonics.

In [13], [15], [22], the authors formulated the following expanded definition of cognitonics*: it is the science about the trajectories of raising the human being to such level of intellectual and spiritual height where the scale of his/her personality becomes proportional to the scale of the digital world.*

Cognitonics provides the methods to reach cognitive engagement of the learners at the lessons and to arise their curiosity.

The ideas and methods of cognitonics underpinned a number of educational projects in several countries, in particular, in Croatia and Macedonia [29], Croatia [30], United Kingdom [31], [32], and Mexico, United Kingdom and PR China [33].

3 THE METHOD OF COGNITIVE PAINTING

Let’s consider our successful implementation of this method. Within an online course “Emotional-imaginative personality development’ in addition to the usual tasks, we have started up a project dealing with creating a new year story underpinned by students’ own perception of snow (in case of snowy winters), their love towards their favorite Christmas toys, their Christmas wishes and hopes and underpinned by sound reasoning about Christmas gift in general, Christmas miracles and Santa Clause.

This story aimed at evoking their emotions, reminiscence of childhood, memories of Christmas and New Year parties, favorite Christmas decorations and toys, the recalling of past events and pleasant experiences, penetrance into the magic world of whirling snow and even the world of heavy Christmas snowfalls, Christmas holidays when children can enjoy the snow in lots of way, can put on skates and have a slide across the ice may somehow “outwit” the exhausted brain and let it have an inspiring rest, plunging into reminiscence of favorite things.

The similar idea underpins the well-known song “My favorite things from the wonderful film “The Sound of Music” (1965):

“Girls in white dresses with blue satin sashes,
Snowflakes that stay on my nose and eye-lashes,
Silver white winters that melt into spring,
These are a few of my favorite things.

When the dog bites, when the bee stings,
When I am feeling sad,
I simply remember my favorite things,
And then I don’t feel so bad”.

This approach has nothing to do with virtual reality, on the one hand, but it is used with the help of the opportunities provided by the digital space in general and online education, in particular. With the help of virtual reality, human try to outwit the brain, but they immediately face the danger of addiction (like drug addiction) with all possible consequences ahead.

In November, we distributed via e-mail an initial version of a new year story, it consisted of four pages and contained the slots on the themes listed below for inserting later the students' compositions. By the middle of December, we obtained a printed book "Wonderful New Year Story" composed by 62 students (from 7 to 18 years old) and consisting of over 90 pages. The book includes also several colourful Christmas pictures done by the students. Printing a book was aimed at showing vividly to the students and their parents the results of their intellectual and emotional efforts, the power of creativity, its possibility to transfigure the reality.

In the considered case, the children were given a four-page frame of a specially invented new year story with three slots introduced as follows:

- Describe the snow, snowflakes, snowfall, snow like a carpet of resplendent hue;
- Describe your favorite Christmas toy and explain why it is your favorite toy;
- Write about your Christmas wishes, what are you dreaming about at Christmas time.

The story itself describes one Christmas Eve when two children (brother and sister) were at home alone. They were looking at the window painted silver by frost and waiting for their parents. And outside it was solemn snowfall. Then children and adolescents were asked to write about the snow.

Children were given the poetical examples of viewing the snow when the rhythm of falling snow and whirling snow is compared with the pace of life: a solemn snowfall like the slow pace of life in the country; heavy snowfall when it is stormy outside, and the windows is roaring like the perception of life when it seems to quicken its space, and it is difficult to keep up with it.

The falling snow seems to reveal the pace of life which is going on with the same laziness or with the same swiftness keeping pace with heavy snowfall or walking in step with the falling or whirling snow.

Boris Pasternak made an assumption that the year is following the year like the snow is falling or like a word is following another word in the poem. In one of the poems Pasternak gave the following metaphor: "In the gate a snowstorm is knitting the net out of the swiftly following snowflakes".

It is possible to say that the children were given some space drawn by the world known poet Boris Pasternak (big "C" creativity) to express their way of viewing and perceiving the snow to reveal little "C" creativity. The idea is to inspire children and adolescents to hover about the reality and give birth to some other ways of viewing the usual things (out of box thinking based on putting together little "C" and big "C" creativity.

We received 62 descriptions of snow.

Example 1 (Katja G., 11 years old).

"… You are keeping a snowflake on your palm It is not melting, because it trusts you. If it doesn't melt, it means that you have tamed it. And it has nothing to do with the fact that you are wearing a glove".

Example 2 (Katja F., 10 years old).

"In the morning I looked out of the window. The whole sky was covered with snowflakes, they were whirling as if they were dancing. I went out to enjoy the snow. I stepped on the snowflake, and it took me up to the heaven above the clouds. I looked up and saw the blue dome of the infinite sky where the snowflakes were born".

Example 3 (Alyona V., 17 year sold).

"The snowfall is crying quietly

Whipping off the face of the day.

The sunset's enfolding the garden

And the peace is spread above".

Example 4 (Herman N., 9 years old).

"White snowflakes are spreading afar, covering colourful autumn leaves, making a carpet of resplendent hue, it is crunching pleasantly. I looked up and found that the snowflake which was the fairest of all. I called her Snowy. She was dancing gracefully. She was very delicate. She was the miracle created by Nature".

Example 5 (Savely O., 17 years old).

"I like snowstorm, because it is the only element that can dance. I like to dance with snow in pair, matching the speed and rhythm of music.

I like to learn new dance steps and to dance to the music of the snow and the wind with delight. When the storm dies down, and the dance is over, I have my red cheeks not due to the fact that the frost is hard, and the snowfall is heavy, but as a reminder of my excitement and pleasure, because the partner is perfect, and we have been dancing all the way to my school".

The obtained results allow us to say that a new, broadly applicable method of constructing a positive cognitive-emotional space for young children and adolescents is created. It may be called *the method of cognitive painting*.

During the last decade, it has been broadly realized that education in knowledge society (or smart society) is to pay a particular attention to supporting and developing in the learners the significant, domain independent skills called soft skills [34], [35] or transversal skills [36], [37], first of all, analytical and critical thinking, creativity, out of box thinking, thinking and acting in terms of public good.

The examples received from children and adolescents show the revealing of creative thinking, out of box thinking, analytical

thinking, and figurative reasoning. The application of the SSOL-model supports and improves emotional intelligence and imagination. That co-creative work underpinned with the SSOL-model helps to transfigure the reality (which is the property of the big "C" creativity).

3 CONCLUSION

1. Cognitive and emotional maturity has a strategic significance, because it leads to active creative work and helps to improve out of box thinking. Under the condition of pandemic situation, it helps to expand the limits of life space and helps to substitute obvious restrictions by the strong cognitive activity giving way to mental representation of one's spiritual life.

2. Student-self oriented learning model, used in our approach to solving the problem of unexpected location of non-trained children and adolescents on board of "digital space ship", is proved to be fruitful, because it leads to cognitive engagement and strong emotional output. We "outwit" the brain, and it doesn't suffer from the restrictions.

3. The necessity of having an emotional and creative prop in the situation when children and adolescents are bereft of off-line group activities, such as round table discussions, sport events and creative contests, parties, balls, museums gives birth to a new cognitive tool called cognitive painting, when a so called "cognitive-colour scheme" is given with the help of big "C" creativity (in our case - the poems of the world known poets such as Alexander Pushkin and Boris Pasternak). Several slots are constructed within the frame of the poems in order to make children fill the slots, occupy all the space in these cognitive slots with descriptions and metaphors based on their own way of viewing the given entity or subject under discussion.

4. 62 school children took part in that work (from 7 to 18 years old). As a result, we have a 90-page printed book as a result of that co-creative work.

5. It proves the existence of the ability to create a positive cognitive-emotional space for young children and adolescents (without using virtual reality), using thought-provoking cognitive activity leading to strong emotions and, as a result, leaving a semantic trace and evoking overwhelming fruitful spiritual and intellectual life for each personality and for community in general.

6. A very precious feature of our method is that it can be effectively applied in arbitrary countries, taking into account the peculiarities of national culture and nature. The initial version of the new year story and the slots may be used without any changes in the countries with snowy winters.

REFERENCES

[1] L. Arantes de Araújo, C. F. Veloso, M. de Campos Souza, J. M. Coelho de Azevedo, and G. Tarro, "The potential impact of the COVID-19 pandemic on child growth and development: a systematic review", Journal de Pediatria (Rio J). 2020 Sep 23, doi: 10.1016/j.jped.2020.08.008 [Epub ahead of print]

[2] D. Marques de Miranda, B. da Silva Athanasio, A. C. Sena Oliveira, A. C. Simoes-e-Silva, "How is COVID-19 pandemic impacting mental health of children and adolescents?", International Journal of Disaster Risk Reduction. 2020 Dec; 51: 101845. Published online 2020 Sep 10. doi: 10.1016/j.ijdrr.2020.101845

[3] U. Ravens-Sieberer, A. Kaman, M. Erhart, J. Devine, R. Schlack and C. Otto, "Impact of the COVID-19 pandemic on quality of life and mental health in children and adolescents in Germany". European Children and Adolescents Psychiatry. 2021 Jan 25:1-11. doi: 10.1007/s00787-021-01726-5. Online ahead of print.

[4] O. S. Fomichova and V. A. Fomichov, "The pillars of higher personality development of net generation in smart society", in Zbornik 22. mednarodne multikonference INFORMACIJSKA DRUZBA - IS 2019. Zvezek E. Proceedings of the 22th International Multiconference INFORMATION SOCIETY - IS 2019, Volume E. Kognitonika/Cognitonics. Uredila/Edited by Vladimir A. Fomichov, Olga S. Fomichova. 7.-8. oktober 2019/ 7-8 October 2019, Ljubljana, Slovenia. Ljubljana : Jozef Stefan Institute, 2019, pp. 15-18.

[5] H. Gardner. "Creating Minds: an Anatomy of Creativity Seen Through the Lives of Freud, Einstein, Picasso, Stravinsky, Eliot, Graham, and Gandhi". Basic Books, New York, 1993.

[6] V. T. Kudryavtsev. "The phenomenon of child creativity". *International Journal of Early Years Education.* 2011, vol. 19, No. 1, pp. 45-53, https://doi.org/10.1080/09669760.2011.570999.

[7] A. Craft. "Little c creativity". In A. Craft, B. Jeffrey and M. Leibling (Eds.), *Creativity in Education.* Continuum, London, 2001, pp. 45-61.

[8] A. Craft. 'Creativity in Schools: Tensions and Dilemmas'. Routledge, Abingdon, 2005. https://doi.org/10.4324/9780203357965.

[9] V. A. Fomichov and O. S. Fomichova, "The social responsibility of computer science specialists for the creative potential of the young generation". Intern. Journal of Artificial Intelligence in Education, 2000, vol. 11, pp. 208-219.

[10] O. S. Fomichova and V. A. Fomichov, "Computers and the thought-producing self of the young child", The British Journal of Educational Technology, 2000, vol. 31, pp. 213-220.

[11] V. A. Fomichov and O. S. Fomichova, "The Student-Self Oriented Learning Model as a Paradigm for Supporting and De veloping Emotional Intelligence and Creativity", in Informacijska druzba - IS 2017. Proceedings of the 20th International Multiconference - IS 2017, Edited by V. A. Fomichov, O. S. Fomichova. Vol. Kognitonika/Cognitonics. October 9th-10th, 2017, Ljubljana, Slovenia . Jozef Stefan Institute, Ljubljana, 2017, pp. 11-16.

[12] V. A. Fomichov and O. S. Fomichova, "The student-self oriented learning model as an effective paradigm for education in knowledge society". Informatica. An International Journal of Computing and Informatics, 2019, Vol. 43, No. 1, pp. 95-107.

[13] V. A. Fomichov and O. S. Fomichova, Cognitonics and Its Significance for Education in the Digital Age. Moscow, Publishing House MAKS Press, 2018. 344 p. (in Russian).

[14] O.S. Fomichova and V.A. Fomichov. "The Web-based Lectures as Leverage for Developing the Sense of Belonging in the All-Russian Creative School-Contests". In: 2020 43rd International Convention on Information, Communication and Electronic Technology (MIPRO), September 28 – October 2, 2020, Opatija, Croatia. Proceedings. Rijeka: Croatian Society for Information, Communication and Electronic Technology - MIPRO, 2020, pp. 855-860.

[15] O. S. Fomichova and V. A. Fomichov. "Education with the Focus on Education in Knowledge Society". Moscow: MAKS Press, 2020. 576 p. (in Russian).

[16] V. A. Fomichov and O. S. Fomichova, "Cognitonics as a new science and its significance for informatics and information society", Informatica. An International Journal of Computing and Informatics (Slovenia), 2006, vol. 30, 2006, pp. 387-398.

[17] O. S. Fomichova. and V. A. Fomichov. "Cognitonics as an Answer to the Challenge of Time". In Proceedings of the 12th International Multiconference Information Society - IS 2009, Slovenia, Ljubljana, 12 – 16 October 2009. The Conference Kognitonika/Cognitonics. Jozef Stefan Institute, Ljubljana, 2009, pp. 431-434.

[18] V. A. Fomichov and O. S. Fomichova, "A contribution of cognitonics to secure living in information society", Informatica. An International Journal of Computing and Informatics (Slovenia), 2012, vol. 36, pp. 121-130.

[19] V. A. Fomichov and O. S. Fomichova, “An imperative of a poorly recognized existential risk: early socialization of smart young generation in information society”, Informatica. An International Journal of Computing and Informatics, 2014, vol. 38, pp. 59-70.

[20] V. A. Fomichov, “Conscious control during childhood, development of”, in International Encyclopedia of the Social and Behavioral Sciences, Second Edition, vol. 4. Oxford: Elsevier, 2015, pp. 666-672.

[21] V. A. Fomichov and O. S. Fomichova, “Early Development of the Human Being Ideal Constituent and Art Cognitonics as the Answer to the Challenge of Knowledge Society”. In: Informacijska druzba - IS 2015. Proc. of the 18th International Multiconference - IS 2015, Edited by V. A. Fomichov, O. S. Fomichova. Vol. F: Kognitonika/Cognitonics. Oct. 12th-13th, 2015, Ljubljana. Jozef Stefan Institute, 2015, pp. 27-32.

[22] V. A. Fomichov and O. S. Fomichova, “Predgovor/Foreword”, in Informacijska druzba - IS 2019. Zvezek E. Proc. of the 22nd Intern. Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, 2019, pp. 3-4.

[23] V. A. Fomichov and O. S. Fomichova, “The theory of dynamic conceptual mappings and its significance for education, cognitive science, and artificial intelligence”, Informatica. An International Journal of Computing and Informatics, 1994, vol. 8, pp. 31-148.

[24] V. A. Fomichov and O. S. Fomichova, “The artificial intelligence theory and highly effective methods of teaching young children foreign languages”. Cybernetica, 1995, vol. XXXVIII, pp. 321-344.

[25] O. S. Fomichova and V. A. Fomichov, “Theoretical foundations of a new method of teaching children effective information processing”. Informatica. An International Journal of Computing and Informatics, 1996, vol. 20, pp. 381-399.

[26] V. A. Fomichov and O. S. Fomichova, “An informational conception of developing the consciousness of the child”, Informatica. An International Journal of Computing and Informatics (Slovenia), 1997, vol. 21, pp. 371-390.

[27] V. A. Fomichov and O. S. Fomichova, “A new theoretical and practical approach to early positive developing child's consciousness”, in R. Trappl (Editor), Cybernetics and Systems'98. Proceedings of the 14th European Meeting on Cybernetics and Systems Research. Vol. 1, Vienna: Austrian Society for Cybernetic Studies, 1998, pp. 276-281.

[28] V. A. Fomichov and O. S. Fomichova, “Early development of natural-language-processing abilities as a key to up-bringing of children without conflicts”, in G. Ritschard, A. Berchtold, F. Duc, D.A. Zighed, Eds. Apprentissage: des principes naturels aux methodes artificielles. Editions HERMES, Paris, 1998, pp. 67-81.

[29] I. Panev, I. Pogarcic and L. Gjergjeska, “Goals of cognitonics in formal ICT education”, in Informacijska druzba - IS 2017. Zvezek D. Proc. of the 20th Intern. Multiconference - IS 2017, Edited by V. A. Fomichov, O. S. Fomichova. Vol. D, Kognitonika/Cognitonics. October 9th-10th, 2017, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, 2017, pp. 61-65

.[30] I. Panev, “Creating multimedia systems according to principles of cognitonics”, in Informacijska druzba - IS 2019. Zvezek E. Proc. of the 22nd Intern. Multiconference - IS 2019, Edited by V. A. Fomichov, O. S. Fomichova. Vol. E, Kognitonika. International Conference on Cognitonics. October 7th-8th, 2019, Ljubljana, Slovenia. Jozef Stefan Institute, Ljubljana, 2019, pp. 50-53.

[31] T. B. Kane, “Using cognitive tunnels in a new approach to building social elevators in the information society”, Informatica. An International Journal of Computing and Informatics (Slovenia), 2014, vol. 38, p. 263-271.

[32] T. B. Kane, “A Cognitonics methodology for artificial persons”, in Zbornik 20. mednarodne multikonference INFORMACIJSKA DRUZBA - IS 2017. Zvezek D. Proceedings of the 20th International Multiconference INFORMATION SOCIETY - IS 2017, Volume D. Kognitonika/Cognitonics. Uredila / Edited by Vladimir A. Fomichov, Olga S. Fomichova. 9.-13. oktober 2017/ 9th - 13th October 2017, Ljubljana, Slovenia. Ljubljana, Jozef Stefan Institute, 2017, pp. 30-33.

[33] P. Craig, N. Roa-Seiler, M. Martínez., and F. Lara Rosano, “A cognitonics approach to computer supported learning in the Mexican state of Oaxaca”, Informatica. An International Journal of Computing and Informatics (Slovenia), 2014, vol. 38, pp. 241-248.

[34] Soft skills. TVETipedia Glossary, 2019. Available at https://unevoc.unesco.org/go.php?q=TVETipedia+Glossary+A-Z&filt=all&id=602 [accessed: 21.12.2019].

[35] V. Buselic, “Information literacy and critical thinking freshman course experience”, in the Proceedings of the 41st International Convention MIPRO 2018 (Opatija, May 20-24, 2019), Conference “Computers in Education”, P. Biljanovic et al., Eds, Opatija, Croatia: Mipro and IEEE, 2019, pp. 920-925.

[36] Transversal skills. TVETipedia Glossary, 2019. Available at https://unevoc.unesco.org/go.php?q=TVETipedia+Glossary+A-Z&id=577 [accessed: 21.12.2019].

[37] Bottino, Rosa Maria, Chioccariello, Augusto, Freina, Laura, and Travella, Mauro. 2019. “Digital Games in Primary Schools for the Development of Key Transversal Skills”. In Sustainable ICT, Education and Learning. IFIP WG 3.4 International Conference, SUZA 2019.

Chess as a Tool for Developing 21st Century Skills with a Deliberate Practice Approach

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ABSTRACT

How to study to achieve the highest quality of acquired knowledge? Modern pedagogical approaches have extended classical learning of specific content and propose to learn general skills applicable to specific needs through targeted practice. Chess is a good tool for this purpose. It allows the simultaneous development of many skills that can be transferred to different areas of life in the 21st century. Chess training includes several aspects and protocols of deliberate practice approach, which makes it a modern educational tool.

KEYWORDS

Chess, 21st century skills, deliberate practice

1 MODERN PEDAGOGICAL APPROACH

Christodoulou [7] points out that experts in all fields rely on extensive and detailed knowledge structures stored in their long-term memory. These structures, often referred to as schemas or mental models, enable the expert to encounter new problems and solve them with ease. How can one reach the highest level of this knowledge, which can be applied to various areas of life?

1.1 Deliberate practice approach

Modern pedagogical approaches favor the generic competencies and, in particular, deliberate practice over memorization, which focuses on specific knowledge and regular practice. The main problem with the generic skills approach is that the skills learned under this term are usually specific rather than generic. The goal is to teach the desired skill directly, with activities reflecting the desired end product. However, the educational process should develop general skills such as problem solving or critical thinking that can be applied in many different areas of life.

Deliberate practice is an appropriate approach for this purpose. It means practicing with a clear awareness of the specific components of a skill we want to improve and knowing exactly how to improve it. While regular practice involves mindless repetition, deliberate practice requires focused attention and is done with the specific goal of improving performance. Deliberate practice is a way to improve a skill through a series of planned activities, reflection, and collaboration. This includes setting personal goals, targeted practice and feedback, observing and discussing lessons, and monitoring one's progress [21].

1.2 21st Century Skills

What should be the content of modern learning? The experts' answer is: "21st century skills, sometimes called "executive skills" or "soft skills," are non-academic thinking skills that involve managing oneself and available resources to achieve a goal [9]. They are necessary to develop successful work habits, organization, time and materials management, project planning, and mental control with self-regulation. Examples include adaptability, time management, impulse control, collaboration, organizational skills, decision making, and project management [1]. Most definitions of 21st century skills include critical thinking with problem solving, creativity, and communication with collaboration.

The 21st Century Learning Model (see Figure 1) is a unified vision for learning to ensure student success in a world where change is constant and learning never stops. It defines and illustrates the skills, knowledge, expertise, and support systems students need to succeed in work, life, and society [2].

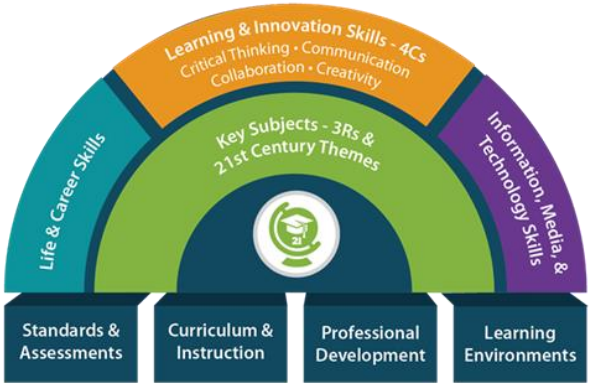

Figure 1: 21st century skills with learning model

1.3 Obstacles to instructing and assessing 21st Century skills

The challenges and considerations for assessing 21st century skills that the educational community must resolve are: poorly defined constructs, limited understanding of how students develop these skills over time (e.g., learning progressions), lack of understanding of the interactions and relationships among the various skills, the appropriateness of separating skills from content and context. The 4 C's are not adequately addressed in the core curriculum [11]. Can chess in education be the solution?

2 EDUCATIONAL VALUE OF THE 21ST CENTURY CHESS

Although the game of chess is over 1500 years old, it seems relevant to address the challenges of modern centuries. Chess, a

highly motivating and potentially competitive game, can be a valuable tool for developing many of the 21st century skills, as they are central factors in successful play. These skills are needed by future citizens who must be adaptive problem solvers. In the study by Chitiyo et.al. [6], 62 teachers assessed eight skills of 1,502 students in the chess group and 634 students in the non-chess group. Teachers rated higher improvement in problem-solving skills (3.9 versus 3.5 out of 5) at all grade levels among the chess players. Students in the chess group were rated as better problem solvers (78%), critical thinkers (73%), and strategic thinkers (75%). Students in a chess class reported working harder on their schoolwork (82%), enjoying learning more (76%), and now being able to solve the most difficult problems when they try (80%). Results from the Chess in Education program (CIE) [8] showed increased enthusiasm for learning, an increase in overall knowledge, an increase in student attendance, an increase in self-confidence, an increase in parent involvement, etc. According to the studies presented in McDonald [20], chess develops several generic skills such as concentration, patience and perseverance (with careful and concentrated observation), visualization (imagining the sequence of moves before they actually happen), planning (thinking a move in advance; in chess you must think first and then act. There should be no impulsiveness. You need to see the possible consequences of your actions), weighing options (you do not have to do the first thing that comes to mind. There are other options as well. We need to consider them), accurate analysis, systematic, scientific thinking, precision, logical reasoning, abstract thinking (a chess player needs to see the big picture), curiosity.

Sala and Gobet conducted a meta-study [24, 25] to verify the validity of several previous studies showing the beneficial effects of chess and its transfer to other domains. They concluded that chess practice enhances some general cognitive skills, such as short- and long-term memory, executive functions, metacognition, visuospatial skills, critical appraisal, and general intelligence, which in turn improves students' academic performance. The analysis also showed a direct correlation between the duration of the chess intervention and the magnitude of the effect. Costello [10] argued that the positive effects of chess also depend on the appropriateness of the approach and the developmental period of the training (the best period is early childhood). Further, we present studies showing that chess develops some of the core skills of the 21st century, as shown in Figure 1.

2.1 Critical thinking and problem solving

Ferguson's systematic study [14] shows that chess was more effective in developing critical and creative thinking than any other "enrichment" activity he tested. An innovative, groundbreaking initiative to promote child development through chess in schools, Alabama Chess in Schools [1], similarly showed that critical thinking skills (measured with Cornell Critical Thinking Test) improved more for students playing chess in the lower grades, but not as much in the upper grades.

Chess players are problem solvers. Every day they practice solving chess problems. In this way, they develop not only analytical and problem-solving skills, but also perseverance to find the right solution [3]. From a functional point of view, a chess player is a self-determined, persistent problem solver who is ready to face any challenge [19]. Mikhalchishin [22], a top chess grandmaster and one of the best coaches, describes the thinking and decision making of chess players on the three levels:

1. Based on precise acquired knowledge (e.g. openings)
2. Logical reflection (calculation of variants)
3. Intuitive decision (gut feeling/implicit decision based on a large knowledge base)

Jelen [17] defines the process of move selection with the following steps:

1. After each opponent's move, before each intended move, sometimes even during variant calculation, a chess player asks himself: Which move is a threat and over which important squares has the opponent gained control? What has the move overlooked or given up control of?
2. The evaluation of the position.
3. Based on the evaluation of the position, the chess player makes a plan for further play.
4. On the basis of the evaluation and the plan, the player selects all candidate moves that should be considered in choosing the best move.
5. He calculates all the candidate moves and makes an evaluation of each move based on the calculations.
6. He selects the best move, i.e. the move with the best evaluation. When he re-checks it, the move can be played.

A chess player must also learn to manage time (he plays against the clock or against a time limit set by the coach, with rapid chess being the most challenging). He not only knows mathematically the difference between five and ten minutes, but he also knows how these different periods of time feel. Chess players need to control impulses (holding back a move until both players' positions have been assessed, and considering cause and effect when making multiple moves) and organize materials (pieces on the board) [4]. These are crucial skills for standardized testing situations, in which experienced chess players generally feel more comfortable because they have a lot of practice in dealing with different amounts of time and stressful situations [8].

2.2 Creativity and flexibility

Creativity is a phenomenon in which something new and somehow valuable emerges, usually based on existing knowledge. In chess, almost every move is creative because no two games are the same, but a lot of chess knowledge is required. Former world chess champion Gary Kasparov said, "*Chess is not about being an inventor with occasional flash of creativity, but about being constantly innovative in your decision-making process*." In chess, you also have to be flexible because the position changes with each move and you have to adjust your calculations and evaluations. Creativity adds a motivational note to the game of chess. As former world champion Kramnik said "*a chess player feels beauty when he succeeds in creating situations that contradict expectations and the rules, and when he manages to master that situation*". According to Ferguson [15], chess players are better than non-chess players in various aspects of creativity: fluency, flexibility, and originality (Figure 2).

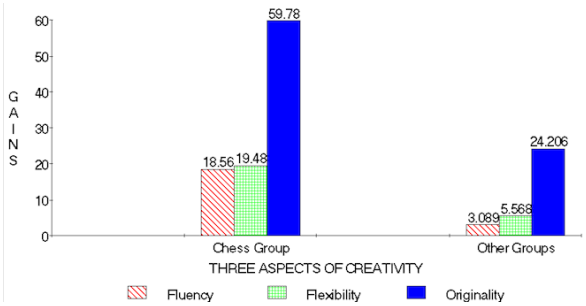

Figure 2: Comparison of the increase in creativity aspects with chess players and non-chess players [15]

2.3 Communication and collaboration

Chess emphasizes the importance of good sportsmanship and respect for others. The nature of chess as a "gentleman's game" contributes to the development of positive interpersonal relationships as well as the formation of lifelong friendships based on a common interest, despite participation in competitions. Chess also teaches players to listen well [23]. Many sales managers recommend the 80-20 rule of listening 80% of the time and talking 20% of the time. Educators from the Chess in Education (CIE) program [5] have found that chess creates a bond between students and teachers and improves the classroom and school environment. In a year when the pandemic and distance learning have caused many students to miss out on the social learning that occurs during a normal school year, CIE can help overcome this deficit. Chess is also good socialization training. A study by McDonald [20] showed that introducing chess to children with special needs reduced suspensions for misbehavior by 60%.

2.4 Chess as deliberate practice

Chess has been shown to be a powerful pedagogical tool by making deliberate connections for transferring skills to other domains. Educators attribute the depth and breadth of chess's effectiveness to many factors: Chess accommodates all learning modalities and requires the integrated use of multiple skills simultaneously. In chess, there is an almost infinite variety and quality of problems to solve. There is always a problem that has not been seen before. Some are simple, while others are difficult and complex. Chess provides immediate punishments and rewards for students' choices (during play) on the one hand, and requires the ability to delay the reward between practice time and play on the other. The game of chess causes players to develop a particular style of thinking in which they are always looking for more and different alternatives. Competition in chess increases motivation and mental alertness [18].

Chess training in many ways follows the protocol of deliberate practice:

- **Goal setting and focused practice:** no chess training can begin without setting goals. Among the inevitable questions in chess training are: Will the training focus be on the opening, the middle game, or the endgame? Which opening will we train, and what do we want to achieve with it? What is my short- and long-term goal? Both the training process and playing require a high level and long lasting focus. In chess, one bad move may nullify 40 good ones.
- **targeted feedback, observation and discussion of lessons**: evaluation of one's game is inevitable in chess. Moreover, each game of a chess player is carefully analyzed with the computer and the trainer from different aspects (chess, psychology, time management), so that a chess player can progress.
- **monitoring your progress:** chess progress can be easily measured not only by the result, but also by the ELO rating. This is an objective measure of the chess player's strength.
- **modelling**: if you want to advance, you need to learn from the best. During training, a chess player must analyze hundreds of games of better grandmasters to improve his performance. He must understand why they are so good - what do they do differently, how do they think, etc. The process of recreating excellence is called modelling. It starts with finding a suitable expert who best fits your learning objective (e.g., the best player of a particular chess opening). Then you should collect the relevant information (instructive chess games). As with deliberate practice the complex behaviors should first be broken down into smaller meaningful parts (called chunks), transparent components, following the rule "as simple as possible and as complex as necessary"(e.g., chess motif). Any task is manageable if it is broken down into sufficiently small parts and trained step by step from an early age (see Figure 3). These units are later recognized during play and recalled when deciding on the best move (see Figure 4). The player then organizes the patterns into logical, coherent structures (opening tree), tests the effectiveness of the model (plays a game), if possible, reduces the model to the simplest form that leads to the desired result (deletes irrelevant lines), identifies the model to transfer the knowledge to other (similar) situations (understand in which position a particular motif works and where it doesn't), evaluate the model (results) and understands its limitations (where the particular position and adequate move does not correspond to the learned line) [13].

Figure 3: Step by step learning [26]

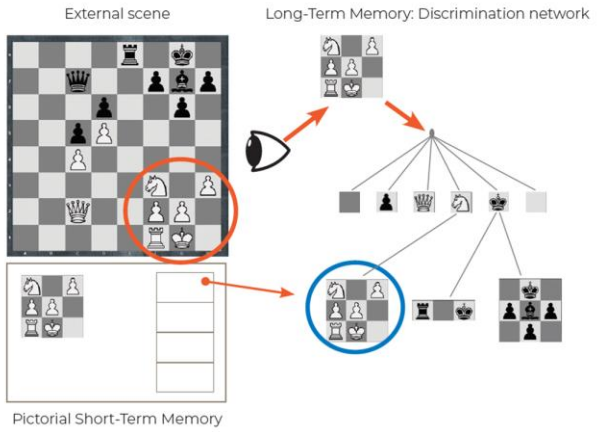

Figure 4: Example of a pattern in a chess position [16]

Chess is an active teaching tool that leads to comprehensive acquisition and development of higher skills, independent learning methods, comprehensive acquisition and higher motivation to work. However, it is extremely important to create a classroom environment where students feel safe and accepted, respect diversity and differences, allow for differing opinions and criticism, and where mistakes challenge learning and collaboration. The way in which knowledge is acquired should follow the circular experiential learning from critical games [12] in the following protocol:

1. Concrete experience: we first select a critical game, where we encounter problems or lack of understanding.
2. Reflective observation: analysis of thought processes and experiences during the game (written down immediately after the game) together with a time consumption analysis.
3. Theoretical analysis: chess-psychological analysis of critical games after the tournament based on data from chess books and other sources of knowledge.
4. Active experimentation: in unimportant games we can test new insights, ideas and skills gained in earlier stages of learning.

Last, but not least, the learning environment is a game, but the effects can be transferred to other areas. Studies and projects on chess as an educational tool are underway, one of which is the project CGS: Chess: a Game to be Spread in schools, funded by Erasmus+ and ECU.

REFERENCES

[1] Alabama State Department of Education - ASIE (2016). Gifted Standards and Student Outcomes. Retrieved on 12.9.2022 from: (https://chessplus.net/research/the-alabama-school-chess-initiative/)

[2] Battelle For Kids. Retrieved 13.9.2022 from https://www.battelleforkids.org/networks/p21

[3] Burgoyne, A. P., Sala, G., Gobet, F., Macnamara, B. N., Campitelli, G., & Hambrick, D. Z. (2016). The relationship between cognitive ability and chess skill: A comprehensive meta-analysis. Intelligence, 59, 72-83.

[4] Chess in education. Retrieved on 12.9.2022 from: https://chessineducation.org/21st-century-skills/

[5] Chess in education. Retrieved on 12.9.2022 from: https://chessineducation.org/life-skills

[6] Chitiyo., G:, Zagumny, L., Akenson, A.B., Littrell, M., Davis, K., Besnoy, K., 2019. Teaching with Chess: Exploring the Relationship between Chess and Student Learning Outcomes. ACIS Years 1-3 Report.

[7] Christodoulou, D. (2017). Making good progress? The future of assessment for learning. Oxford University Press-Children.

[8] Code to the Future. Retrieved on 13.9.2022 from: https://www.codetothefuture.com/parents/classes/chess)

[9] Cooper-Kahn, J., & Dietzel, L. C. (2008). *Late, lost and unprepared: A parents' guide to helping children with executive functioning.* Bethesda, MD: Woodbine House.

[10] Costello, P. J. (2013). The gymnasium of the mind: teaching chess in early childhood. *Early Child Development and Care*, 183(8), 1133-1146.

[11] Dawson, P. & Guare, D. (2010). *Executive skills in children and adolescents: A practical guide to assessment and intervention, 2nd Edition*. New York: The Guilford Press.

[12] Etkina, E., Brookes, D. T., & Planinsic, G. (2019). *Investigative science learning environment*. Morgan & Claypool Publishers.

[13] Excellenceassured (2019). NLP Retrieved on 12.9.2022 from: https://excellenceassured.com/nlp-training/nlp-certification/nlp-modelling

[14] Ferguson, R. (1986, April). Developing critical and creative thinking through chess. In report on ESEA Title IV-C project presented at the annual conference of the Pennsylvania Association for Gifted Education, Pittsburgh, Pennsylvania.

[15] Ferguson, R. (1998). Study I. The ESEA Title IV-C project: Developing critical and creative thinking through chess.

[16] Gobet, F., & Simon, H. A. (1996). Templates in chess memory: A mechanism for recalling several boards. Cognitive psychology, 31(1), 1-40.

[17] Jelen, I. (2006). *Delavnica: postopek izbiranja poteze.* Ljubljana: Zavod za šolstvo.

[18] Langen, R. (1992). Putting a Check to Poor Math Results. *The Reporter*.

[19] Liaskos, L. (2019). 7 reasons you should hire a chess player. Retrieved on 14.9.2022 from: https://en.chessbase.com/post/7-1-reasons-why-you-should-hire-a-chess-player

[20] McDonald, P. S. (2008). The benefits of chess in education. A collection of studies and papers on chess and education. Unpublished manuscript.

[21] Miami-Dade County Public Schools (M-DCPS): retrieved 14.9. 2022 https://mdcdhr.entest.org/pdf/PDE/Module%204-%20Deliberate%20Practice.pdf

[22] Mikhalchishin, A. (2018). Decision making process. Blitz chess and rapid chess video. https://www.youtube.com/watch?v=uDW74zZvw-s&t=12s&fbclid=IwAR3cmokqohOYFSPPqIjWkizpGwJAps8kMdE3YhDzKVJxRaBjRnVrtzyfW20

[23] Rabin, E. (2019). Making a difference in Africa. en.chessbase.com. https://en.chessbase.com/post/making-a-difference-in-africa

[24] Sala, G., Burgoyne, A. P., Macnamara, B. N., Hambrick, D. Z., Campitelli, G., & Gobet, F. (2017). Checking the "Academic Selection" argument. Chess players outperform non-chess players in cognitive skills related to intelligence: A meta-analysis. *Intelligence*, 61, 130–139.

[25] Sala, G., & Gobet , F. (2016). Do the benefits of chess instruction transfer to academic and cognitive skills? A meta-analysis. *Educational Research Review*, 18, 46-57.

[26] Zaretsky, V. (2019). Internal material.

Karma and Dharma : Two ways of human living

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ABSTRACT

Karma is causality beyond life and death. One may suffer the effects in this life due to the causes in the previous lives. Dharma is the principle of overcoming this karma. This article tries to make clear the structure and process of karma. And through understanding these two concepts of living a life, one may find a solution for self-development.

KEYWORDS

karma, dharma, reincarnation, causality, karmic structure, karmic process

1 INTRODUCTION: TWO CONTRASTING CONCEPTS IN THE RELIGIOUS AND SOCIAL CONTEXT

Indian philosophy is abundant in religious concepts and thoughts which can be applicable to contemporary human society. Above all, karma and dharma are essential and have many implications for human life. These concepts are used in broader religious, social, and cultural environments with the background, not only of Hinduism or Buddhism but also of Christianity or Islam.

The word karma has been understood as fate and has become a general and popular term in the West as well as in the East. Karma is understood as the law of cause and effect. But this law has continuity beyond life and death, which is reincarnation. Sufferings resulting from sin in previous lives, called karma, are almost synonymous with fate. But the term karma originally means action in Sanskrit. And at the same time, it signifies the result of the action. It hints that human activity intrinsically includes negative characteristics.

Dharma is an ethical concept, and it has been developed and formulated as a moral ordinance, especially in the Buddhist doctrine, which is not based upon the idea of God. The concept of dharma is related to the righteous value criteria, law, and religious symbols. Historically, it has been used as the name of Buddhist saints, idol, and in the Indian national flag. Socially and spiritually, dharma signifies the ideal law requiring men's ideational lives.

There are so many references with a profound analysis of each concept in the field of humanities, but I could not find one that considers them as a paired concept and set it as the central principle of life.

In this paper, I analyze the two concepts with a focus on the relation between the two, and categorize two individual or social logic of life concerning the overcoming of the ego.

2. KARMIC LOGIC

2.1 Reincarnation as the precondition of karma

If we try to understand the karmic logic, we must recognize the reality of reincarnation[1] of the human being as its precondition because karma develops its logic through rebirth. You should suffer, but you must not know the reason why. That which connects this gap between ontological Grenzsituation and epistemological agnosticism is rebirth; that's why no reincarnation, no karma.

In the 18th century, Swedenborg made a significant contribution to the understanding of the afterlife based on Christian mysticism. In the early 20th century, Evans-Wentz made a decisive interpretation of death and rebirth by introducing the Tibetan Bardo Thodol [2].

Bardo Thodol's process is precisely described as below, in modern terminology: “The first contest of the soul in each incarnation is other souls seeking rebirth. With the union of sperm and ovum to begin the formation of a new human body, a flash of light appears in the astral world, the heavenly home of souls between incarnations. That light transmits a pattern which attracts a soul according to that soul's karma- the self-created influences from actions of past lives. In each incarnation, karma works itself

[1] The process of reincarnation has been described in not a few mystical religious books. And recently, the reality of reincarnation has been reported by those who have extraordinary talents in this field. But it is still terra incognita, the scientific test of which is not completed. Science may criticize this issue as unscientific or superstitious because it does not know much about that. But that means that science is not so much advanced as to understand that.

Evans-Wentz mentioned a similar point: Thus while the Occidental may not question the validity of this law of cause and effect when applied to physics, he does question it when applied to psychics, he does question it when applied to universally to psychics. In assuming such an attitude, the Occidental, in the eyes of the Oriental, ceases to be scientific, inasmuch as he fails to see that in any complete science of man the physical cannot be separated from the psychic ([3], p. 47).

out partly through hereditary forces; the soul of a child is attracted into a family in which heredity is in conformance with the child's past karma. Many souls vie to enter this new cell of life; only one will be victorious (in the case of a multiple conception, more than one primal cell is present) ([4] p.7)."

This shows once more again that reincarnation is deeply related to karmic law.

2.2 The structure and process of karma

Many people in the East Asian social culture often say, when they suffer seriously from something beyond their capability: What sin had I committed in the previous life? They believe that there must be some reason for this hardship the reason why they don't know. Karma is usually paired with reincarnation. If there is no reincarnation, there is no karma. The hardship, the cause of which one can understand, is no karma. The essence of karma lies in the continuity of being beyond the lives by which one transforms oneself into another identity.

a^1 in the previous life is a^2 in this life (Figure 2). What connection does the identity of a^1 in the last life have with that of a^2 in this life? Why should a^2 pay the price of a^1?

Accept the premise that the suffering in this life is due to the sin in the previous life and suffer the pain: is this the right way of living? Should we make redemption for the debt we can't remember whether we borrowed it or not? It is a mental pressure that makes us compensate for the sin, which is not directly linked to I as it is now in this life. Original sin in Christianity is something similar to this religious, psychological pressure. Humankind suffers the burden that Adam and Eve had made. Human being must suffer in this life or be born again spiritually to compensate for this original sin.

Karma forms a unique worldview by merging several factors: causality+action +feedback+reincarnation.

The unique karmic worldview begins with two categories (Figure 1):

Elements: actor(a), object of the action(A), the result of action(B)

Function: action($a \rightarrow A$), causality relation($A \rightarrow B$), feedback of the result to the actor($B \rightarrow a$)

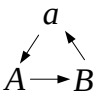

Figure 1: Simple causality triangle

a is an actor (ego) who acts A, which results in B, and this B returns its effect to a. Action is feedbacked to the actor through causality, that is, cause and effect. Here A is the cause and B the effect. So this triangle shows the action of a and its result to a, and the cause-effect relation between A and B.

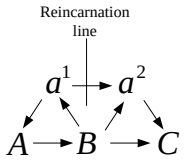

Figure 2: Causal reincarnation

When a^1 transited to a^2 in the next life, a more complicated causality appears. a^1 died and is reborn as a^2, because he adheres to the physical world of A, B, C ….

$a^1 \rightarrow a^2$ transition (=reincarnation) is performed with the ontological identity of $a^1 = a^2$. Across the reincarnation line, a^2 has the same identity as a^1, so that the result of $B \rightarrow a^1$ is succeeded as the $B \rightarrow a^2$. a^2 succeeded B as well as a^1. This reincarnative identity is karma.

B is applied to a^2, because a^2 is a^1. Stimulated by B, a^2 reacts, and produces C. This triangular relation $B \rightarrow a^2 \rightarrow C$ is simplified as $B \rightarrow C$. So the $A \rightarrow B \rightarrow C$ causality continues.

This process is based upon two structures: the causal triangle and the incarnative identity triangle. $a^1 - A - B$ forms the causal triangle and $B - a^1 - a^2$ forms the incarnative triangle. In the former, a^1 is influenced by $A \rightarrow B$ causality. In the latter, B is applied evenly to a^1 and a^2 on the ground that

$$a^1 = a^2 \;\; \therefore B \rightarrow a^1 = B \rightarrow a^2$$

Here by B, an existential transformation of $a^1 \rightarrow a^2$ is mediated, and the action $B \rightarrow a^2$ brings about the reaction $a^2 \rightarrow C$, which gives the casual process $B \rightarrow C$, which can be called karmic causality. And $B \rightarrow a^2 \rightarrow C$ forms the karmic causality triangle.

This resulted in two processes: ontological continuity of the actor (ego), $a^1 \rightarrow a^2 \rightarrow \cdots \rightarrow a^n \rightarrow \cdots$, and the causal continuity of the object of the action $A \rightarrow B \rightarrow \cdots \rightarrow Z \rightarrow \cdots$ (Figure 3).

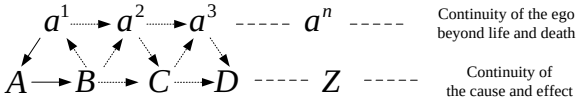

Figure 3: Truss structure of the karmic bridge

The truss has been traditionally thought to be the most robust bridge structure. The continuity of the ego line and that of the cause and effect line go side by side forever in Figure 3. This is the basic concept of karmic structure and process. In Figure 3. the truss of two triangles solidifies the karmic structure, from which only few can escape.

3 DECONSTRUCTION OF KARMA

How can we deconstruct this karmic truss? It lies in dismantling the process

and the structure of karma, in other words, in disassembling the triangles and, as a result, in removing the causality line and the ego line.

The first one, which is the removal of the causality, is basically the discontinuation of the reaction. The most effective response to nullify this cause-effect relation is to stop the reaction to the evil cause.

Jesus said that "You have heard that it was said, 'Eye for eye, and tooth for tooth.' But I tell you, do not resist an evil person. If anyone slaps you on the right cheek, turn to them the other cheek also (Matthew 5:38-39). This is not a masochistic behavior but a call for the cessation of the continuity of action and reaction based upon the egoistic causality, "by yourself."

He said again: "You have heard that it was said, 'Love your neighbor and hate your enemy.' But I tell you, love your enemies and pray for those who persecute you, (Matthew 5:43-45). The continuity of revenge brings about a vicious cycle in human society.

The second one regarding the removal of the ego line is the other aspect of the first one. a is bound to the causality of $A \rightarrow B$, because he expects B, which is the result of A. In the background of action and reaction exists ego. According to various religious scripts, such as Buddhist's or Hindu's, the feedback $B \rightarrow a$ is said to be due to a's adherence to B (Figure 1,2,3). B is feedbacked to A when a requires B as the result of A. Where there is ego, there is attachment to the result of an action. By expecting B, a accepts the causality of $A \rightarrow B$, that is, the feedback from B. If a doesn't desire B, then causality does not function. $a \rightarrow A$ is all. This is an orientational duty. There is no feedback $B \rightarrow a$.

Bhagavad Gita teaches the pursuit of pure action as its essential lesson, which can be expressed as below: Do your duty without expecting the reward for it. To attach to the result of the action is to damage the significance of the action in its pure form. If one attaches too much to the result of an action in the pursuit of ego-centric interest, he loses the significance of the action as a duty. Duty is not an investment for the ego's profit; it is a dedication to something beyond the ego. By performing duty beyond ego, you behave as the Absolute.

A dutiful action means a performance denying the spillover to the ego. Is there any action that ends in itself? One of the actions, which is not bound to the result of the action, is meditation practiced with the absolute orientation. Meditation means the orientation in general towards the Absolute, through which one is rerecognized. By this recognition, an orientational action that does not regress to oneself is possible in the consciousness as the act of Absolute, not ego. Therefore, meditation is said to be the best way of escaping from karmic life and the ultimate expression of dharma. Meditation brings about the collapse of the ego, and the equality of 'I = other' appears in the orientation towards the Absolute.

Thirdly, karmic destruction may be possible by fully experiencing karma, which can be called karmic justice.

As was said previously, karma begins with the action. Here the characteristics of karma include the process of the feedback of the result to the actor. One's action necessarily returned to oneself: this is the karmic causality. The problem is that this consequence of the action is applied to a person (ego) beyond life and death. If the consequence is happiness, that's good, but if it were hardship, then the ego suffers without knowing the reason why.

Let's suppose one (a^1) goes through $A \rightarrow B \rightarrow C$ with the identity of a^2 in the next life (Figure 3). He who did A is reborn with B, and suffers from the painful reality B. He, who cannot understand the causality $A \rightarrow B$, shouts' why?.' This 'why?' is karmic fate.

The name of the game through incarnation is karma, and the rule of the game is that the actor must accept his own action's result, which he doesn't know the meaning of why beyond life and death, therefore beyond his understanding. The action was free, but the result is binding.

Then should all the hardships in this world be justified?

What he did to others returns to himself. In effect, he did it to himself. Other's suffering cannot be felt unless he himself becomes that other. He himself, who became that other through reincarnation, experiences that feeling, not knowing the reason why. If the state in this world is the result of the action in the previous life, then this state is justified as it is, and there is no need to sympathize with the suffering, and one should accept one's suffering as it is.

Is this the realization of justice beyond life and death? Or a dextrous trick of God to make us feel the same feeling that we made others feel in our previous lives. Through the indifferent viewing of one's suffering, just like others', we can get out of that suffering. Then we may conclude that karma's significance lies in the realization of justice beyond life and death

In that sense, karma is dharma, dharma is karma, and the meaning of life lies in enjoying the game of karma through repeated reincarnation.

4 FROM KARMA TO DHARMA

There are two ways of living; karmic and dharmic (Table 1), in other words, causal or orientational. About karma, much has been said in the previous part. The dharmic way of living is the antithesis of the karmic way.

Table 1. Characteristics of karma and dharma

	Ontological characteristic	Motivation of action	Principle of behavior	Behavioral characteristic	Geometrical characteristic
Karma	ego-centric	ego-centric interest	causal	attachment	triangular causality
Dharma	Self-centric	duty	teleological	orientational	linear

The essence of dharma lies in orientation. The orientation means being apart from ego-centric existence. Karma is causal, dharma is teleological and orientational. Dharmic action is done by deciding the deed based upon the fundamental value criteria, which makes the actor free from the result of the

action. This can be interpreted that if one is free from oneself, then he is freed from the result of his action.

In $a \rightarrow A$, dharma has the mono-linear relationship between the actor a and its orientational purpose A (Figure 1). Here A is for A, whereas in karmic triangular structure, A is for B. A is relativized to B. a has the direct object A and indirect object B. B is the purpose of A and at the same time the result of A. This mixed and complicated relation between a and B by way of A makes a attached to B, and B rules a. The unfulfilled desire of a^1 is attached to a^2 in the next life.

You reap as you sow the seed. This is a universal truth. If you follow dharma in the original cause, receive the dharmic result. The dharmic orientation of sowing the seed brings about salvation from karma. Karma is the result of a dharmic response to the individual, egoistic claims which despise the universality.

$$A \rightarrow B$$

If A is dharmic, then B is happiness. If A is ego-centric, then B is unhappiness. Karma and dharma are closely related. Dharma functions as the cause setting of karma. We are asked every moment: Self-centered life or ego-centered life? An orientational act of a causal act?

We can do the cause but cannot control the result. The result is decided following the cause, and we cannot but accept it. That's why the righteousness of the cause is salvation. The idea that the best way to get out of hardship is to get out of the ego, to where the hardship returns, is logical and fundamental and rational or even utilitarian.

The universal expression of karma is dharma. The individual application of dharma is karma. So that the universal orientation beyond individuality is the dharma of overcoming karma. It's a matter of the whole or the individual.

Karmic law is applied mathematically beyond life and death, which is a mystical ontology. Reincarnation is the ultimate expression of ontology. When the causality continues with reincarnation, it is transformed into ontological issues from logical, epistemological issues. Therefore, the karmic idea resulted in the question 'who am I ?'. Karmic shout 'why am I suffering?' is, in turn, transformed into 'who am I that is suffering?' and beyond a^1 and a^2, an approach towards the real Self begins. This transformation of question from 'why?' to 'who?' is the dramatic turning point in the long journey of karma because the wanderer in the darkness asked the right question to be answered, that is, the right step towards the light. At last, reincarnation begins to lose its significance[2].

5 CONCLUSION: THE SUN AND THE SHADOW

Overcoming ego by turning to the right direction is the essence of dharmic life.

When you have the sun at your back, you see the shadow of yourself. And you find it impossible to erase your shadow on the ground. The body is ego, and the sun is dharma. The shadow is the reflection of the ego appearing when you defy the sun. Shadow is pain and hardship. Shadow is karma. To see the dark side of ego is suffering.

Being against the sun visualizes the dark side of ego, and however hard we try to erase it, it does not disappear. The only way to erase it is to orientate the sun again. The sun is dharma, the righteous direction. The shadow disappears of itself. The ontological orientation deletes the epistemological shadow. Orientation to dharma makes karma disappear naturally. The shadow itself ceases to exist. Therefore the direction is the ultimate solution. When one resolves to stand up from the shadow and proceed to the sun, darkness dissolves.

We can make some analogical interpretations of karmic or dharmic action in relation to the international order and human society. Therefore, overcoming a small ego for the universal Self can be adapted to international society. We are witnessing continuous action, revenge, and reaction, due to the historical and political causality. We must get out of this international karma attributed to the national ego towards the global dharma. Right direction from ego to Self, this will put an end to the karma of humankind, individually, socially, and globally.

And it goes without saying that dharmic orientation is the essence of education, which can be applied to children as well as adults.

Until the 16th century, Ptolemaic theory prevailed. According to that, the sun moves around the earth. This planetary ego was justified by religious belief. And then heliocentrism proved to be true. Not that the sun (Self) turns around the earth (ego), but that the earth (ego) turns around the sun (Dharma); this Copernican turn must be introduced to our lives to overcome the karmic bondage.

REFERENCES

[1] Brunton, Paul and Munagala Venkataramaiah (1996) *Conscious immortality: Conversations with Ramana Maharshi*, Sri Ramana Asramam.

[2] Evans-Wentz, W. Y. (1927) *The Tibetan Book of Death*, Oxford University Press.

[3] Evans-Wentz, W. Y. (1958) *Tibetan yoga and secret doctrines*, Oxford University Press.

[4] Yogananda, Paramahansa (1996) *God Talks With Arjuna: The Bhagavad Gita*, Self Realization Fellowship

[2] Ramana Maharshi says: the body is born again and again. We wrongly identify ourselves with the body, and hence imagine we are reincarnated constantly. No. We must identify ourselves with the true Self. The Realised One enjoys unbroken consciousness, never broken by death — how can he die? — or by birth. Only those who think 'I am the body' talk of reincarnation. To those who know "I am the Self" there is no rebirth. Reincarnations exist only so long as there is ignorance. There is no incarnation, either now, before or hereafter. This is the truth (Talk 363) [1].

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Zvezek E

Proceedings of the 25th International Multiconference

INFORMATION SOCIETY – IS 2022

Volume E

15. mednarodna konferenca o prenosu tehnologij
15th International Technology Transfer Conference

Urednika / Editors

Špela Stres, Robert Blatnik

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10.–14. oktober 2022 / 10–14 October 2022
Ljubljana, Slovenia

PREDGOVOR / FOREWORD

Spoštovani generalni direktor direktorata za znanost dr. Tomaž Boh, spoštovani direktor Instituta »Jožef Stefan«, prof. Boštjan Zalar, spoštovani udeleženci, lepo pozdravljeni in dobrodošli na 15. Mednarodni konferenci za prenos tehnologij.

Today we are gathered technology transfer experts, researchers, students and post-graduate students with entrepreneurial ambitions, established and future entrepreneurs, investment managers, innovators and also representatives from governmental institutions and policy-making organizations.

Najlepše se zahvaljujemo soorganizatorjem ter drugim partnerjem, ki so podprli konferenco.

Začetni del konference s pozdravnimi nagovori bo v slovenščini, nadaljevali pa bomo v angleščini.
Part of the participants is here in the hall at the Jožef Stefan Institute, the other part is with us on Zoom.

The event, except the pitch section, is being recorded. Its parts will be made public in the next days. The welcome addresses will be held in Slovenian, later sections will be in English.
Po pozdravnih nagovorih bo spoštovani gost Michele Neu predstavil kako sodeluje s podjetji The French Alternative Energies and Atomic Energy Commission. Sledilo bo tekmovanje raziskovalno-podjetniških ekip, ki se potegujejo za naziv najboljše inovacije iz javnih raziskovanih organizacij, nato bo razglasitev nagrade Svetovne organizacije za intelektualno lastnino WIPO IP Enterprise Trophy.

Sledili bodo predstavitve odličnih projektov slovenskih znanstvenikov, razglasitev WIPO nagrade Medal for Inventors ter raziskovalni prispevki o prenosu tehnologij in intelektualni lastnini. Vzporedno bo izvedena še sekcija o povezovanju Instituta s šolstvom.

Program je, kot vidite, res bogat, saj se dotika množice aktivnosti, pri katerih smo v pisarnah za prenos tehnologij osrednjega pomena.

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Technology transfer offices as a facilitator of knowledge triangle integration in the knowledge valorisation era: focus group discourse analysis *

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ABSTRACT / POVZETEK

Knowledge triangle integration, together with knowledge valorisation era, positions technology transfer offices (TTOs) as a central point in transforming research results into the products and solutions for the benefit of economy and society. The present study was qualitative focus group analysis to explore issues and obstacles in communication, how they network and keep relationships with different stakeholders. Analysis showed that the majority of TTOs faced similar problems when it comes to the communication and networking such as lack of resources and low interest or skipping TTOs in the innovation lifecycle. Showcasing success stories and storytelling are suggested as best tools to attract new beneficiaries in the knowledge triangle while cultural change and top-down approach are key to gaining more impact and success.

KEYWORDS / KLJUČNE BESEDE

Technology transfer office, knowledge triangle, knowledge valorization, focus group

1 INTRODUCTION

The knowledge triangle involves different stakeholders with various interests trying to cover three main missions of higher education institutions: education, research and innovation. Knowledge triangle as a concept also tackles different interconnections and relations within the knowledge triangle [1]. Finding synergies and creating new opportunities is of immense importance for the successful knowledge triangle integration [2].

Technology transfer offices (TTOs) are in the center of the knowledge triangle and therefore are in the best position to stimulate its integration. Furthermore, TTOs are in the best position when it comes to the new European commission knowledge valorisation policy aiming to transform the excellent research results and data produced in Europe into sustainable products and solutions for the benefit of society and economy. TTOs, as intermediary organizations, are in a position of creating a channel for knowledge valorisation by improving the conditions for knowledge and technology transfer and serving as the first contact point for industry and researchers in the commercialization process. Through the networking, mentoring, coaching and best practices exchange TTOs can also boost research innovation potential [3].

Information flow and good communication are one of the key enabling factors for building sustainable and long-term cooperation and achieving social and economic benefits of knowledge triangle integration [2]. However, successful and effective communication largely depends on mechanisms of information, promotion and dissemination in addition to the commercialization activities and setting ground for new collaborations [4]. Traditional activities to foster collaboration between universities and businesses are usually focused on networking and matchmaking events. Recently, an ecosystem approach including co-creation and open innovation platforms was introduced, to achieve more concrete outputs [5]. However, TTOs face the challenge of having to communicate with various audiences, which includes businesses, other research organizations, governmental bodies, external partners, NGOs and other decision makers that require distinct key messages and a different approach. TTOs should be the main contact point and the facilitators of these partnerships, however, this is not yet as relevant to the external partners. The contribution of a TTO is crucial and brings value [3].

The aim of the present study was to better explore different aspects and situations of TTO functioning, how they network and how they form and keep relationships with different stakeholders. Furthermore, the aim of the study was to detect main obstacles and opportunities for better communication within the knowledge triangle.

*Article Title Footnote needs to be captured as Title Note
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2 METHODOLOGY

The present study was qualitative focus groups discourse analysis and was done as a part of the EIT funded project called CHIC - Creating holistic innovation capacity. Specifically, focus groups were part of the E3 initiative intending to explore issues and obstacles in communication within the knowledge triangle and empowering participating TTOs with the right communication strategies, tools, content and plan that could enhance their outreach. The three Es stand for three essential values: ENGAGE – networking and matchmaking people within the knowledge triangle by equipping TTOs with communication strategies that will; ENABLE – to raise their outreach and strength ties with stakeholders by giving them the right information and the necessary knowledge and actively participating in the knowledge triangle to EVOLVE – by facilitating interactions within the ecosystem and achieving higher engagement. The E3 initiative represents a set of activities and best practices with the main aim of driving the change for a more creative, constructive, collaborative and competitive innovation ecosystem.

Focus groups were held during the international ASTP conference in Lisbon, from 18th till 20th of May 2022. Participants were recruited through a convenient sampling, after submission of an online registration form published on the official ASTP webpage. Prior to the focus group discussion, participants were introduced to the CHIC project and the E3 initiative and were asked to anonymously answer several baseline questions using Mentimeter.com online tool.

Participants were randomly distributed in 4 groups with an even number of participants discussing one of the following topics: i) Networking and KTT ecosystem, ii) TT added value activities, iii) Communication activities, iiii) Stakeholders relationship. Each group participated in two discussions on different topics, to have the overall better input for each discussed topic. Each topic had one moderator, experienced in the tech transfer field and one volunteer reporter taking notes during the discussion. Discussions lasted about 30 minutes after which the moderator changed the table and started the same set of questions with another group.

Discussions were audio recorded and all participants were asked to sign informed consent including recording the discussions. Efforts were made to elicit responses from all participants. Recordings were transcribed for coding and all participant information were anonymized to protect confidentiality. Text analysis was done using Atlas.ti Web (version 4.0.0-2022-07-26) [6] while results were reported using COREQ 32-items checklist for qualitative studies [7].

3 RESULTS

Overall 40 participants were included in the focus groups, 27 female and 13 males, while each group had from 9 to 12 participants. Participants were from all over the world, mostly Europe, but also USA and South Africa (Table 1). Majority of participants, approximately 30% were from TTOs having between 6-10 employees, 22,5% were form TTOs having either from 3-5 or 11-15 employees, while rest were from very small TTOs (1-2 employees), or very big with more than 15 employees (Table 1).

Table 1: Baseline characteristics of included participants

Characteristic	N(%)
Gender	
Male	13 (32,5%)
Female	27 (67,5%)
Size of the TTO	
1-2 employees	5 (12,5%)
3-5 employees	9 (22,5%)
6-10 employees	12 (30%)
11-15 employees	10 (25%)
More than 15 employees	4 (10%)
Countries	**N of participants from each country**
Poland, Ireland	4
UK, Luxembourg, Estonia, Portugal, Hungary	3
USA, Czech Republic, Iceland, Austria, Romania, Netherlands	2
Chile, Sweden, Croatia, South Africa, Germany, Belgium	1

Text analysis was done separately for each of the discussed topics. Regarding the networking and KTT system participants stressed out the importance of organization of different events serving as an opportunity to include different stakeholder groups. Furthermore, showcasing the success stories and storytelling was mentioned a number of times (Table 2).

For the TTO added value services the majority of participants, no matter how big or small TTO provides networking and matchmaking activities, access to finance and having teaching activities on different topics, mostly innovation and entrepreneurship, following managing of innovation funds and organizing specialized events such as hackathons (Table 2).

When it comes to the communication activities participants were very active in terms of defining main barriers in effective communication and suggesting the best tools to overcome those barriers. Lack of resources in terms of time and people and skipping the TTOs completely in the innovation ecosystem were suggested as common barriers. Direct one on one communication, storytelling and having a system of awards or recognized individuals at the university can help in communicating TTO values (Table 2).

For the stakeholder relationship participants came up with the conclusion that TTOs usually have very little impact on the policy making and funding mechanisms unless there are joint efforts on the i.e country level. Majority of the smaller TTOs are driven bottom-up while top-down approach is needed for cultural change and success (Table 2).

Table 2: Summary of topics with examples

Topic	Sub-topics and description	Example
Networking and KTT ecosystem	type of collaborations, how collaborations are establsihed, how active is networking	*"And for the cultural change, it can help if there will be some more pressure in the programs to think about this and to accept technology transfer successes as an equivalent to academic publishing currency."*
TT added value activities	type of services provided and for whom	*"Once a year we are having showcase event where different successful technologies which are patent protected, can be offered, can also be introduced by the research itself, not only by a PD. We also offer entrepreneurial club meetings, where we are supporting and offering some discussions with investors and smaller companies, and so on..."*
Communication activities	main communication barriers, what works best in communication	*"We've created a new title to give - innovation ambassador, something like that. So, each student federation, of each academic unit, or career has a innovation manager and he's a student that goes around and helps us with all our activities, contests, whatever we do. So this ambassador system has worked really good."*
Stakeholders relationship	the position of TT, impact on policy and decision making	*"If you have if you've got an ecosystem that's not developed, you need to be going up to God, you need to all of the universities together. And that becomes a very strong lobby for government to ignore."*

4 CONCLUSION

TTOs can serve as valuable intermediaries in the knowledge valorisation era and can be a first contact in establishing networks and creating ecosystems. Showcasing success stories and storytelling are suggested as best tools to attract new beneficiaries in the knowledge triangle. However, cultural change and a top-down approach are crucial for the healthy ecosystem and success that will be to the benefit of the entire society.

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REFERENCES

[1] Lassnigg, L. et al. (2017) Higher Education Institutions and Knowledge Triangle: Improving the interaction between education, research and innovation. Institut für Höhere Studien - Institute for Advanced Studies (IHS) (IHS Sociological Series, 118).

[2] Meerman, A. and Kliewe, T. (2014) UIIN Good Practice Series 2014: Fostering university-industry relationships, entrepreneurial univeristies and collaborative innovation.

[3] European Commission (2020) Research & innovation valorisation channels and tools: boosting the transformation of knowledge into new sustainable solutions. Available at: https://op.europa.eu/publication/manifestation_identifier/PUB_KI0120038ENN (Accessed: 29 July 2022).

[4] Smol, M. and Kulczycka, J. (2019) 'Towards innovations development in the European raw material sector by evolution of the knowledge triangle', Resources Policy, 62, pp. 453–462. Available at: https://doi.org/10.1016/j.resourpol.2019.04.006.

[5] Katzy, B. et al. (2013) 'Innovation intermediaries: a process view on open innovation coordination', Technology Analysis & Strategic Management, 25(3), pp. 295–309. Available at: https://doi.org/10.1080/09537325.2013.764982.

[6] 'ATLAS.ti Scientific Software Development GmbH' (2022). Available at: retrieved from https://atlasti.com (Accessed: 29 July 2022).

[7] Tong, A., Sainsbury, P. and Craig, J. (2007) 'Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups', International Journal for Quality in Health Care, 19(6), pp. 349–357. Available at: https://doi.org/10.1093/intqhc/mzm042.

Proof of Concept typology: a method for classification of PoC activities according to a technology cycle timeframe

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ABSTRACT

The paper presents the results of an experimental study aimed at creating a typology for the Proof of Concept (PoC) activities that could be more domain-specific and help practitioners to develop more effective PoC schemes. The typology has been developed by using real cases from the sample of the European Research Council (ERC) funded PoC projects. The automated subject indexing helped to generate keywords that were matched with technology descriptors from the Gartner Hype Cycles for Emerging Technologies to identify the timeframes for the funding gap according to a Hype Cycle. Accordingly, the PoC activities have been categorized into Pathbreaking PoCs, Mature PoCs and Catching-Up PoCs. The main characteristics have been identified, and further steps for the typology validation presented.

KEYWORDS

Technology, innovations, finance, technological development, transfer of technology, typologies, research and development.

1 INTRODUCTION

The quickening pace of technology developments has created an additional impetus to make the knowledge generation and commercialization processes that lead to the creation of innovations faster, more agile and aligned with technological cycles. McKinsey predicts that more technological progress will come in the decade ahead than in a century [1], hence the urgency for assessing funding for upcoming technologies ahead of time.

It is a broad consensus among academics and practitioners [2,3,4] that the main hurdle for increasing the generation and transfer of scientific knowledge resulting in intellectual property with a potentially high value to be realized in the emerging and existing markets is a funding gap. A gap stands between the need for funding to validate inventions on one side and the lack of market demand for high-risk undertakings on the other. Both popular and academic literature often associate this gap with the term (a metaphorical expression) "Valley of Death", which designates an initial stage in the technology life cycle where a gap between the development of new scientific knowledge and the commercial development of new products can become fatal to new ideas [5].

1.1 Study aims and research objectives

The presented study has aimed to analyse one of the funding instruments that public funding institutions and, increasingly, also research and technology organizations plan, design, and employ to help scientific research-based inventions overcome the funding gap and move closer to market. The funding scheme in question is called the PoC programme or instrument, which provides on a competitive basis a certain fixed amount of money in the form of a grant, a subsidy, or an investment for the projects that need funds to validate and commercialize new technology. The amounts can vary from ca. 20 to 60 thousand euros for initial PoC grants to more than 100 thousand for more advanced ones.

Two research objectives have been established for this study. First, to create a method that could help categorize the PoC activities according to the logic of the technological life cycles. Second, to test the approach on selected cases of the ERC PoC projects using publicly available data and create a typology of PoCs providing the basic descriptors for individual PoC types.

2 METHODOLOGY AND DATA

2.1 Research design

Any analysis of the PoC projects has a priori limitations due to the confidentiality of the source material (let alone its availability on a scale to allow a representative sample) and the complexity of the scientific, most often interdisciplinary, fields addressed. Hence, the approach adopted for this pilot study on the typology of the PoCs has been based on using the following mechanistic causal inference. If one can assume that the PoC activities can be related to a specific technology life cycle timeframe, then one could categorize PoCs against the time expectancy of that cycle.

Three subsequent tasks have been formulated to meet these objectives. The first task was to explore, using the existing literature, the relationship between time and expectations that define a funding gap and find a way of measuring a timeframe for the current or perceived gap. The second task was to analyse the actual cases of the ERC PoC projects (using the publicly available limited information about the project duration and

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scope) and categorize them according to different timeframes of the expected funding gaps in each case. The third task was to describe the categories and discuss avenues for further research in validating the proposed typology and its uses for practitioners.

2.2 Data sets

Three datasets have been compiled to complete the tasks. Below is a brief description of each. Due to the space limitation for this paper, the data has not been included in an appendix. They could be provided upon request or shared through a public repository.

Dataset 1 in an Excel file contains details about 1225 PoC projects covering the period from 2014 to 2023 [6]. The following variables in the dataset have been used for analysis: project title, a project abstract, fields of science, and project start and end dates. Dataset 2 in an Excel file contains the information about the upcoming technology areas taken from the Gartner Hype Cycles for Emerging Technologies for the period from 2011 to 2022 (altogether 425 entries, of which 134 are unique ones); all accessed through Google search. The following variables in this dataset have been used for analysis: technology descriptor, year of appearance on a Gartner hype cycle, the minimum and the maximum years remaining to reach "the Plateau" (to be referred to as a market maturity) on a hype curve.

Dataset 3 is a subset of Dataset 1 in an Excel file containing information about 10 PoCs projects covering the period from 2016 to 2022. The cases for analysis were selected from the first 300 search results filtered down by the scientific fields of "engineering and technology/electrical engineering, electronic engineering, information engineering/electronic engineering". The following variables in the dataset have been used further: project title, URL (a reference to the project description on the Cordis website), five most relevant keywords generated from the abstract using a web-based automated subject indexing service Finto AI (see below), project start date, the matching emerging technology descriptor, the earliest and the latest year for reaching a market maturity (the latter two taken from Database 2).

3 CURRENT STATE OF RESEARCH AND DESIGN OF PoCs

The existing PoC schemes, their design and their basic characterisation, have been recently quite extensively analysed [7-11]. Bataglia et al. (2021a) analysed the operationalisation of PoC instruments in a selected higher education institution and looked at different enablers that contribute to implementing PoCs. Further, Bataglia et al. (2021b) compared different PoCs and analysed the determinants influencing commercialisation outputs in these cases. Munari and Toschi (2021) compared the valorisation outcomes of those obtained with a PoC grant to a group of projects that applied to the PoC scheme but were not funded. The authors confirmed that the instrument was effective in the early valorisation of scientific discoveries. Munari and Wessner (2017) conducted an in-depth analysis of the ERC PoC programme to understand better how well the PoC scheme contributes to maximising the value of ERC-funded research by facilitating its commercial and social potential development. These and other academic contributions helped to map out the rationale behind the PoC schemes and their current uses by institutions from the perspective of a generic approach to the R&D life cycle and innovation. The research completed to date helped to assess individual PoC instruments according to the scope and size of funding, yet did not attempt to categorize PoCs.

The academic interest in PoC schemes has mirrored the institutionalization of this public funding instrument, which has also been adopted by leading RTOs and universities. France has been the first to introduce PoC funding in its "Investing in the Future Programme" (2009-2011). The idea has been picked up by other EU Member States (e.g., EXIST programme in Germany) before being adopted EU-wide. Since 2011 the European Research Council has been running a PoC scheme as a top-up funding opportunity for the ERC grantees aiming to bring their research results closer to market. From 2011 until June 2022 ERC funded 1469 PoCs (the success rate stood at almost 30%).

At the same time, the research and technology organizations (RTO), both public and private, have started experimenting with different approaches to foster academic entrepreneurship and commercialization by adopting a mixture of traditional product development methods such as stage-gate processes and agile processes taken from lean management and startup development. CEA, TNO, SINTEF, Tecnalia and other major RTOs have set up internal PoC schemes to provide extra funding and additional support (including mentorship and guidance with industry expertise) to the selected teams of their researchers with credible ambition to create a viable commercial product or a spin-off [12].

4 ANALYSIS

4.1 Timeframes in the technology life cycles

The literature shows that a funding gap for PoC activities can be expressed and measured in terms of technology or investment readiness levels, time-to-market, person-months, and other performance indicators [7, 8]. However, for simplicity, this study uses a single indicator: a PoC timeframe. A PoC timeframe is a period from the start of the PoC activity until the market maturity of the relevant emerging technology field. A mature market is considered a stage where the growth rate slows to almost zero.

According to the generally accepted definition, a funding gap is the amount of money needed to fund the ongoing operations or future development of a business or project that is not currently funded with cash, equity, or debt [13]. Funding gaps can be covered by investment from venture capital or angel investors, equity sales, debt offerings, bank loans, and public funding programmes. Public and private investments attracted to address a particular funding gap are driven by various factors, of which the expectations about the potential of realising a substantial value out of the results of the R&D activities are of prime importance. Hence, one can argue that a funding gap is a function of the perceived and experienced trajectory of the technological cycle associated with technological breakthroughs and markets.

A hype cycle model introduced by Gartner Inc. in 1995 has become a standard approach to outline how the development of technologies is perceived [14, 15]. It plots a generally applicable path a technology takes in terms of expectations or visibility of the value of the technology (y-axis) as related to time (x-axis). The model incorporated two distinct equations/curves adopted from behavioural psychology and technology management studies, that is a hype curve shape for human expectations about any new technology and a classical technology diffusion S-curve showing the proliferation of the technology on the market [16].

Most recently, a new approach based on the insights from neuroscience has been taken into consideration when analysing the Gartner Hype Cycle [17]. The latest research has focused on exploring expectation dynamics in early-stage innovations to explain the hype cycle phenomenon that precedes innovation adoption. Different types of expectations (emotional and logical) and speed of acceptance or abandonment of new technology have been observed as being dependent upon time [17]. The faster the time-to-market, the more emotional and rapid the acceptance of technology, which creates logical expectations and drives the hype cycle of emerging technology. Hence, the duration of any technology validation is hype cycle time and domain-dependent.

Any technology development is always a design process. The philosophers of science agree that new technology becomes accepted through five types of experiments, efforts aimed at empirically demonstrating the proper development and working of technology, including feasibility experiments, trial experiments, field experiments, comparative experiments, and controlled experiments [18]. The results of individual experimentations thus lead to obtaining proof of concept, understood as an artifact that acts in this role to demonstrate the technology at a required level of complexity. The PoC activities include verification tasks and actions (evaluation of risk assessment, product and process capabilities, compliance with requirements, proof of concept through analysis, modelling and simulation, demonstrations and tests) and validation methods (prototyping, demonstration, market tests, field trials) [19].

4.2 Subject indexing and categorization of PoCs

The categorization of PoCs is an open-ended and ad hoc process. It relies on applicants' self-reporting and keyword assignment by funding agencies' staff and expert bodies. The interdisciplinary and inter-sectorial nature of the PoC projects creates difficulties in categorizing the PoCs due to their multidisciplinary, cross-sectorial and both scientific research and market-oriented nature.

Thus, for this study, the use of an automated AI-driven subject indexing tool has been sought. The used system (Finto AI) is based on the open-source AI-driven tool Annif for indexing and classification developed by a national library consortium to categorise text in several languages, including English [20]. The tool uses text classification algorithms and a neural network model based on TensorFlow trained on the General Finnish Ontology (linked to the US Library of Congress Classification).

The subject indexing was done as follows. The text of each full abstract of the project in Dataset 3 was entered into Finto AI online tool, and the obtained five most relevant keywords were added to the project entry in Dataset 3. Then the keywords were searched in Dataset 2 containing the Gartner Hype Cycle emerging technologies. The descriptor of the corresponding technology was included in Dataset 3 to identify the match. The keywords have been manually cross-checked with the emerging technology descriptors in Dataset 2, searching for matches. The matches have been identified if the wording was synonymous or related. The EuroSciVoc taxonomy has been consulted, where there was an additional need to clarify individual keywords.

The PoCs have been categorized according to the following procedure. First, the start dates of the analysed PoC projects have been correlated with the remaining years of the corresponding matching emerging technologies using the latest reported data from the annual Gartner Hype Cycles of Emerging Technologies. The PoCs have been classified according to the following principle. If the start of the year of the PoC activity was behind the estimated year for reaching the market maturity of the corresponding emerging technology, then the PoC was assigned to the category of "Catching Up PoC" (Type 3). If the start of the PoC activity was ahead of the emerging technology reaching market maturity by the earliest estimated date, then the PoC activity was assigned to the category of "Mature PoC" (Type 2). If the start of the PoC activity was ahead of the emerging technology reaching market maturity by the latest estimated date by more than ten years, then the PoC activity was assigned to the category of "Pathbreaking PoC" (Type 1).

Finally, to validate the approach, each categorized PoC activity from Dataset 3 has been additionally researched using publicly available sources, trying to find details about the follow-up activities confirming one of the patterns associated with these categories. Namely, in the cases of Pathbreaking PoCs, numerous scientific activities had to be observed, which are associated with the early stages of technology development. In the cases of Mature PoCs, more applied research activities could be expected, while in the case of Catching-up PoCs, the follow-up in terms of research activities expected to be relatively minimal. Thus, a typology of PoC has been created consisting of three categories. Table 2 summarizes their main characteristics.

Table 1: A preliminary typology of PoCs

PoC Type	Hype Cycle stage	Time to market maturity
Type 1: Pathbreaking	Innovation/Technology Trigger Peak of Inflated Expectations	7-13 years
Type 2: Mature	Peak of Inflated Expectations Trough of Disillusionment	2-8 years
Type 3: Catching Up	Trough of Disillusionment Plateau of Productivity	0-4 years

Table 2: Main details of the analysed PoCs

PoC No.	Keywords generated by Finto AI	Gartner descriptor	PoC Type
196345	EEG, brain, signal processing, diagnostics, measurement	Brain-computer interface	Type 1
200027	mobile communication networks, data communications networks, technology, product development, telecommunications technology	Machine-to-machine communication (M2M)	Type 2
202878	antibiotics, bacteria, antibiotic resistance, enterprises, pathogens	Biochips	Type 1
207634	video, content production, social media, content, YouTube	Social TV	Type 3
211122	energy consumption, high-speed technology, electronics, technology, consumption	Quantum computing	Type 1
211988	signal processing, lasers, optics, data transfer, polaritons	M2M	Type 2
216265	patients, metabolic disorders, public health service, wireless data transmission, monitoring	Home Health Monitoring	Type 3
220480	machine learning, energy efficiency, enterprises, simulation, simulators	Low-cost single-board computers on the edge	Type 1
220708	robots, robotics, automation, recycling, industrial automation	Mobile Robots	Type 2
227183	nanostructures, sensors, diodes, beamforming, light-emitting diodes	Not covered	Type 1

5 CONCLUSIONS AND LIMITATIONS

The study has helped to create a method to quickly categorize the PoC activities using the Gardner Technology Hype Cycles for Emerging Technologies. It helped to establish a typology with three possible types for classifying PoCs into Pathbreaking PoCs, Mature PoCs and Catching-Up PoCs. Those categories can provide an additional indication of the expected timeframes of PoCs and a potential funding gap ahead. Yet, they do not offer clues for assessing the potential value of the categorized PoCs. The typology could help to do a quick check on any technology-based product idea where the time prospects of the market are uncertain at a given moment of the technology development. The applicability of this typology requires validation using full details of a representative sample of PoCs. However, one can only achieve that on a limited scope due to confidentiality limitations.

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REFERENCES

[1] McKinsey & Company. 2022. McKinsey Technology Trends Outlook 2022 Report. August 2022. Accessed on 30 August, 2022 from https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/the-top-trends-in-tech

[2] Colin Mason and Jennifer Kwok. 2010. Investment Readiness Programmes and Access to Finance: A critical review of design issues. *Local Economy* 25, 4 (2010), 269-292. DOI: 10.1080/02690942.2010.504570

[3] Andrea Bellucci, Gianlucca Gucciardi, and Daniel Nepelski. 2021. Venture Capital in Europe. Evidence-based insights about Venture Capitalists and venture capital-backed firms. Publications Office of the European Union, Luxembourg. DOI: 10.2760/076298, JRC122885.

[4] Federico Munari, Maurizio Sobrero, Laura Toschi. 2018. The university as a venture capitalist? Gap funding instruments for technology transfer. *Technology Forecasting & Social Change* 127 (Feb. 2018), 70-84. DOI: 10.1016/j.techfore.2017.07.024

[5] Tereza Dean, Haisu Zhang, Yashen Xiao. 2022. The role of complexity in the Valley of Death and radical innovation performance. *Technovation* 109 (Jan. 2022), 102160. DOI: 10.1016/j.technovation.2020.102160

[6] Qlick.com. R&I Projects. Accessed on 30 August, 2020 from https://webgate.ec.europa.eu/dashboard/sense/app/98dcd94d-ca66-4ce0-865b-48ffe7f19f35/sheet/erUXRa/state/analysis

[7] Daniele Battaglia, Emilio Paoluccia, and Elisa Ughetto. 2021a. The role of Proof-of-Concept programs in facilitating the commercialization of research-based inventions. *Research Policy* 50 (2021). DOI: 10.1016/j.respol.2021.104268

[8] Daniele Battaglia, Emilio Paoluccia, and Elisa Ughetto. 2021b. Opening the black box of university Proof-of-Concept programs: Project and team-based determinants of research commercialization outcomes. *Technovation* 108 (Dec. 2021). DOI: 10.1016/j.technovation.2021.102334

[9] Munari, Federico and Laura Toschi. 2021 "The impact of public funding on science valorisation: an analysis of the ERC Proof-of-Concept Programme", Research Policy, vol. 50, 2021, 104211. DOI: 10.1016/j.respol.2021.104211

[10] Federico Munari, Maurizio Sobrero, and Laura Toschi. 2017. Financing technology transfer: assessment of university-oriented proof-of-concept programmes. *Technol. Anal. Strat. Manag.* 29 (2017), 233–246. DOI: 10.1080/09537325.2016.1241874

[11] Charles Wessner and Federico Munari. 2017. An Empirical Assessment of the ERC Proof-of-Concept Programme: a final report (Dec. 2017). Retrieved 30 August, 2022 from https://erc.europa.eu/sites/default/files/document/file/erc_scc_reaction_poc_review.pdf

[12] Michaël A Bikard et al. 2019. Early-stage financing of RTO spin-off companies. JRC Technical Reports. Luxembourg: Publications Office of the European Union, 2019. Accessed 30 August, 2022 from https://ec.europa.eu/jrc/communities/sites/default/files/early_stage_financing_rtos_spinoff_companies_technical_report.pdf

[13] Jake Frankenfield. 2019. Funding Gap Definition. *Investopedia.com.* Updated 26 June, 2019. Accessed 30 August, 2022 from https://www.investopedia.com/terms/f/funding-gap.asp

[14] Jackie Fenn and Mark Raskino. 2008. Mastering the Hype Cycle: How to Choose the Right Innovation at the Right Time, Harvard Business School Press.

[15] Martin Steinert and Larry Leifer. 2010. Scrutinizing Gartner's hype cycle approach. In Proceedings of PICMET 2010, 1-13. Retrieved 30 August, 2020 from https://ieeexplore.ieee.org/document/5603442

[16] Ozgur Dedehayir and Martin Steiner. 2016. The hype cycle model: A review and future directions. *Technological Forecasting & Social Change* 108 (2016), 28–41. DOI: 10.1016/j.techfore.2016.04.005.

[17] Shiam Yuwei and John Herniman. 2022. The role of expectation in innovation evolution: Exploring hype cycles. *Technovation* 29 (Jan 2022). DOI: https://doi.org/10.1016/j.technovation.2022.102459

[18] Viola Schiaffonati. Experimentation. 2022. In *The Routledge Handbook of the Philosophy of Engineering* (1st ed.), eds. Diane P. Michelfelder and Neelke Doorn. Routledge, 421-434.

[19] Francien Dechesne and Tijn Borghuis. On Verification and Validation in Engineering. *Routledge Handbook of the Philosophy of Engineering*, 435-446.

[20] Osma Suominen, Juho Inkinen, and Mona Lehtinen. 2022. Annif and Finto AI: Developing and Implementing Automated Subject Indexing. *JLIS.It* 13 (1), 265-82. DOI: 10.4403/jlis.it-12740.

The "Incubator of Innovativeness" program driving technical readiness levels of the Cracow University of Technology Innovations

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ABSTRACT

This paper presents the implementation of the Polish governmental "Incubator of innovativeness" program at the Cracow University of Technology. It deals with the methodology of projects' selection, management of Proof-of-Concept research, intellectual property protection, and commercialization process. It presents the barriers and challenges encountered in the process and recommends the improvements for the next editions of the program.

KEYWORDS

innovation, technology, transfer, TRL, technical readiness level, Proof-of-Concept, research funding

1 BACKGROUND AND RATIONALE

One of the objectives of the Center for Technology Transfer (CTT) of the Cracow University of Technology (CUT) in Kraków, Poland, is maximizing impact of scientific research through its successful commercialization. The capability of technology to be practically implemented is highly dependent on its development stage and is measured by the TRL level (Technical Readiness Level).

The critical advancement on the way of solution development is moving from the basic technology readiness level TRL 1-2 (basic principles observed, technology concept formulated) to a higher level, preferably 5-6 (technology validated and demonstrated in relevant environment). While the former is typically financed by universities and governmental scientific and R&D funds, the latter is just the beginning of VC and industry interest in technology. This gap in funding of technology development is often referred to as a "death valley", since public institutions' funding focuses on scientific results, while business investment is justifiable only in case of technologies ripe for implementation. This is well known from the literature [1] and the tech transfer practice in various TTO environments.

The road from idea to innovation leads through Proof-of-Concept, which is TRL level 3.

As commonly defined by EU institutions [2] Proof-of-Concept (PoC) is "1. the realization of a method or idea in order to demonstrate its feasibility, or to verify that a concept or theory has practical potential; 2. evidence, typically deriving from an experiment or pilot project, which demonstrates that a design concept, business proposal, etc. is feasible; 3. a small exercise to test a design idea or assumption.

A desirable effect of PoC research is transition from prototype to a Minimum Viable Product (MVP) on the way to a fully blown commercial product.

2 InIn PROGRAM OF THE POLISH MINISTRY OF EDUCATION AND SCIENCE

Ministry of Education and Science in Poland has addressed this issue by creating and maintaining the program called "Incubator of Innovativeness" (InIn), which started in 2014 and is currently continued in the 4th edition.

The objective of the program is to support entities active in the field of commercialization of the results of scientific research and R&D, in initiating cooperation of academia with the business environment and application in the specific market solutions. The "Incubator of Innovation 4.0" program initiated in 2020 provides support to "Innovation Incubators", i.e., universities and their special purpose vehicles (SPVs) – wholly owned university companies - or consortia established by universities, SPVs, scientific institutes of the Polish Academy of Sciences, research institutes or international scientific institutions. The support is provided for the following activities:

- conducting pre-implementation (PoC) research, including additional laboratory tests or adapting the invention to the needs of the interested buyer, the cost of which may not exceed PLN 100 k;
- the analysis of the market potential of inventions and the analysis of their readiness for implementation, as well as the valuation of intellectual property rights (IPR management);
- identifying entities interested in implementing the research results and development works;

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- technology portfolio management.

In 2014 Center for Technology Transfer of CUT created a consortium with the SPV of CUT Intech PK (Intech) and since then has successfully applied for the governmental funding in all 4 editions of the InIn program.
In 4 editions of the InIn program CTT has received 85 applications from the CUT research teams, out of which 43 have been granted research funding up to 100 k PLN (Eur 25k). Total program budget per edition at CUT was 2 MM PLN (Eur 500k) on average.

3 IMPLEMENTATION OF THE InIn 4.0 PROGRAM AT THE CRACOW UNIVERSITY OF TECHNOLOGY

3.1 PoC projects selection

The PoC projects applications have been received and selected by the Selection Committee, which comprised of the 4 external (non-CUT) members of the University Council (the controlling body approving the university budget and discharging the Rector for his term), Vice-Rector for Science, CTT Director, SPV President, Head of Commercialization and Head of the Academic Innovation Incubator. As one of the important InIn project indicators was successful direct and indirect commercialization of the technologies, the selection criteria were not only the uniqueness, novelty and feasibility of the proposed research idea, but also its commercialization potential. Out of 35 applications in the 4th edition 14 PoC research proposal have granted funding in the range of PLN 65-90 k (Eur 15-20 k). As a rule, the Committee did not grant the full amount applied for, but typically 90% of it, which allowed to accommodate more PoC projects.

3.2 Research management

Within the course of the project, it was critical that research work has been carried out according to the planned schedule and at the steady pace. This allowed for the uniform money spending throughout the project term, which in turn guaranteed timely payments of installments by the Ministry, which were only made upon reaching the research spending milestones. Thus the CTT job was not only responsiveness to the researchers needs and requirements, but also exercising some discipline in money spending by the scientists. This was of special importance due to the fact that not only research cost, but also project management remuneration was financed from the fund. Consequently, timely salary payments of CTT employees were dependent on regular researchers' spending.

3.3 Intellectual property rights

One of the critical issues was assuring timely protection of the intellectual property of the university, According to Polish law all IP resulting from employees' work belong to the university (no "professor's privilege"). Here the conundrum was applying for protection at the Polish Patent Office at the right time, i.e., when all the important attributes of the technology have been already discovered, but early enough to be able to start commercialization work before the deadline. CTT has been working closely with the Patent Attorneys Office at CUT to assure timely and effective IP protection. Potential international patent extensions (PCT and protection in particular countries) will be considered at the later stage depending on commercialization results.

3.4 Brokers and commercialization

Apart from increasing the TRL level of the university technologies, the InIn program's objective was improving the effectiveness of the activities of TTOs and SPVs in research organizations in the field of cooperation with business, including commercialization of the results of R&D works. This involved also investing in Technology Brokers by their high-quality training and by hiring the new ones.

Broker's major task in the InIn project successful direct and indirect commercialization of the technologies Already at the stage of PoC proposals selection by the Committee has been looking for the potential spin-off (start-ups with university/SPV co-ownership) and spin-out (start-ups with university/SPV co-ownership) founders. Among 14 technologies we have identified 2, which were showing the industrial potential of the solution and interest of scientists in running the business. The Ministry accepted our proposal and our project indicators became 12 direct and 2 indirect commercializations.
Currently the technology transfer process is underway and we are considering applying all forms of commercialization, including licensing, sale of patents and know-how as well as creating start-ups. The tangible results of the InIn project at CUT have been so far 4 spin-offs founded and 2 licenses granted. It is a lengthy and unpredictable process and it may (and certainly will) extend beyond the projects' end.

3.5 Barriers and challenges

3.5.1. Barriers

In the course of the project, we have encountered the following barriers, that we were not able to break:

- Researchers' conflict between fundamental science and applied research – publish or patent
- Scientists' lack of understanding of technology transfer – its objectives and methods; much training needed
- Purchasing procedures in public institutions – slow, restrictive and complicated
- Reporting – too detailed, too bureaucratic, too time consuming
- Funding - the limit of Eur 20-25 k was in many cases too low. While in some disciplines this may be enough (SSHA – Social Sciences, Humanities and Arts) in some technical disciplines it does not allow for the fulfillment of the research plan. More flexible spending limits should be considered.

3.5.2. Challenges

In the course of the project, we have encountered the following challenges, which have been mitigated partially or in full:

- Different or opposed interests of the consortium members – internal competition
- Focus on customers and their needs - the concept not liked by scientists, who value freedom of research.
- Know-how vs. patent - the nuances often disregarded by scientists
- International IP protection – PCT procedures are rigid and costly.

The legal regulations at the different levels are generating most of the barriers and we are not able to change them without legislative initiatives. As far as challenges, we have mitigated or even liquidated some of them thanks to tech transfer education and training of scientists.

4 RECOMMENDATIONS FOR THE NEXT EDITIONS OF THE PROGRAM

Based on the experience and results of the 4 editions of the InIn program Polish Ministry of Science and Education came up with the proposal of the new program called "Development Incubator" (DI), which is an extension and expansion of the existing InIn program [4].

Its objective is support for the management of commercialization of R&D results in research organizations. The project will consist of 2 modules:

1. CTT and SPV direct support module - program implemented in partnership – "Development Incubator" (DI);
2. Training module - E-learning platform prepared by the Ministry, customized training program.

The main tasks under the project have been formulated as follows:

1. Initiating and strengthening cooperation between the scientific community and the economic environment, including searching for entities interested in joint implementation of research projects and implementation of the results of scientific research and development works,
2. Mapping the potential of research organizations to conduct joint research projects in industrial and scientific consortia.
3. Promotion of research organization services aimed at the economic sector
4. Preparation of commercialization projects for the results of scientific research and development works, including in particular the valuation of industrial property rights, analysis of the market potential of inventions and analysis of their readiness for implementation.
5. Substantive preparation to conduct independent activity for research teams whose optimal commercialization path is the establishment of a spin-off company
6. Managing the R&D portfolio of a given research organization, including in particular:

• maintaining a database on ongoing research projects, including monitoring and analysis of the results of scientific research or development works in terms of their practical usefulness,

• analyzes of market needs to select topics of research or development work and research on the state of the art before starting research or work,

• analysis of the possibility of obtaining patent protection and the possibility of commercializing the results of scientific research and development works before their publication

• targeted analyzes and business plans for a potential investor (up to 50% of costs)

7. Conducting PoC works, including additional laboratory tests or adapting the invention to the needs of the interested buyer, the cost of which may not exceed PLN 100 k.

This proposal has been a subject of discussion within the Polish technology transfer organization PACTT, whose member is CTT of CUT.

PACTT is an association of 82 major universities in Poland, including technology and medical universities. It gathers together representatives of tech transfer offices (TTOs) responsible for protection, management and commercialization of universities intellectual protection. PACTT is the voice of technology transfer community in Poland.

As a result of internal discussion, the comments and recommendations to the Ministry of Science and Education have been formulated by PACTT, which are currently being considered.

Our major stipulations pertained to:

- Unit finding in excess of PLN 100k (Eur 25 k) per technology
- Spending allowed at any given moment of the project
- Simplified reporting
- Increased funding for training of brokers
- PCT patents financing allowed from grant money.

The current InIn 4.0 project ends April 30, 2023 and we expect the new edition, called "Development Incubator", to start May 1, 2023.

This governmental program has proven to be very effective in supporting the Proof-of-Concept research at the Polish universities and became a major instrument in financing commercialization of the university technologies.

ACKNOWLEDGMENTS

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REFERENCES

[1] Leban Marijan, Stres Špela "Technology Transfer Fund - Central Eastern European Technology Transfer (CEETT) platform", 14th International Technology Transfer Conference, Institut "Jožef Stefan", Ljubljana, Slovenia

[2] Introduction to Proof of Concept, EU JRC project EU4TechPoC, 2020, https://eu4tech.eu/wp-content/uploads/2020/05/EU4TECH-Podcast-1-Introduction-to-PoC.pdf

[3] Ministry of Education and Science (Poland), "Inkubator Innowacyjności 4.0" (in Polish), https://www.gov.pl/web/edukacja-i-nauka/inkubator-innowacyjnosci-40

[4] "Koncepcja MEiN Inkubatora Innowacyjności", PACTT document, 28.07.2022

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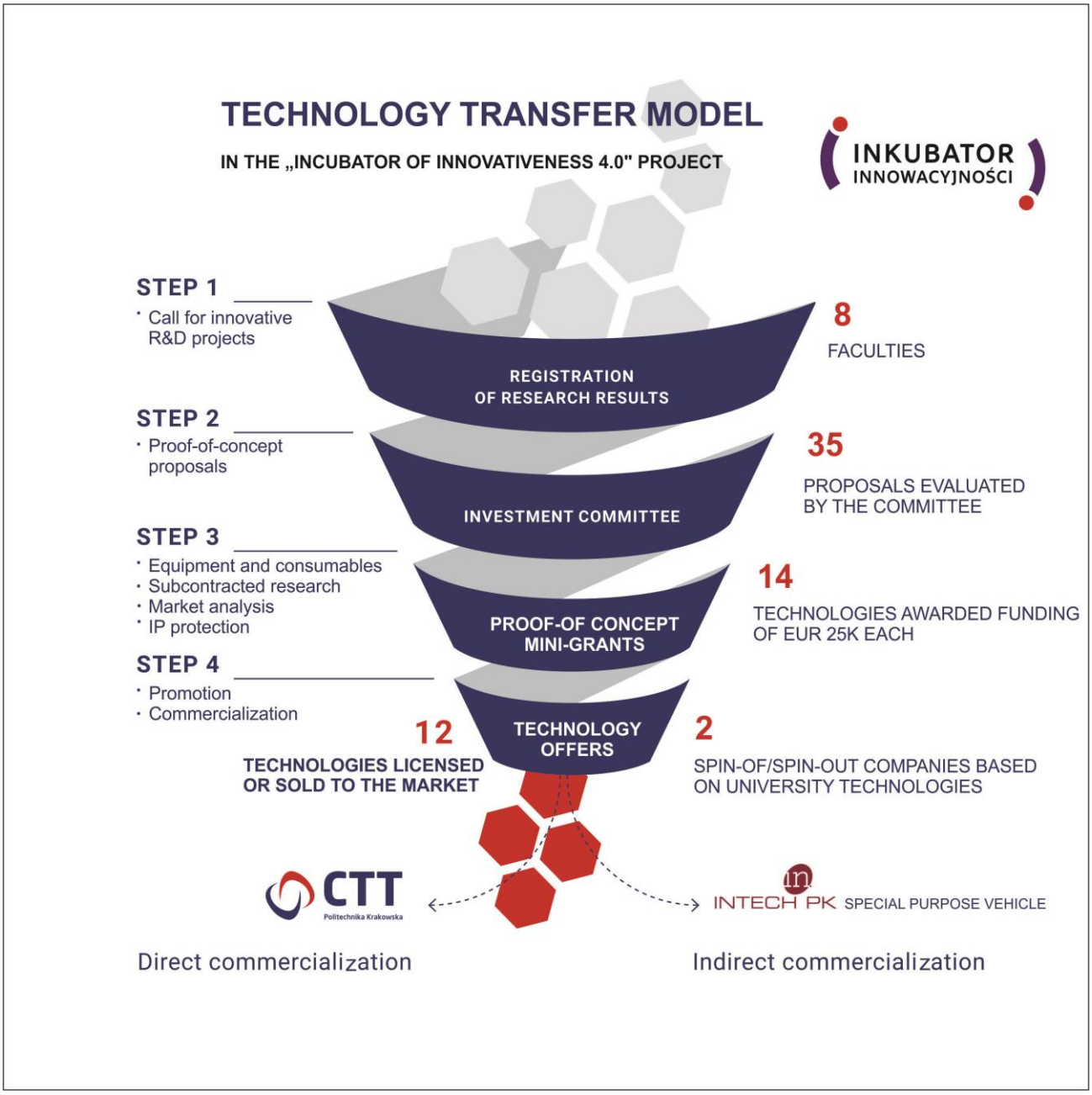
Figure 1: Technology Transfer Model in the "Incubator of Innovativeness 4.0" project at the Cracow University of Technology


TECHNOLOGY TRANSFER MODEL
IN THE „INCUBATOR OF INNOVATIVENESS 4.0" PROJECT
INKUBATOR INNOWACYJNOŚCI
STEP 1
· Call for innovative R&D projects
REGISTRATION OF RESEARCH RESULTS
8
FACULTIES
STEP 2
· Proof-of-concept proposals
INVESTMENT COMMITTEE
35
PROPOSALS EVALUATED BY THE COMMITTEE
STEP 3
· Equipment and consumables
· Subcontracted research
· Market analysis
· IP protection
PROOF-OF CONCEPT MINI-GRANTS
14
TECHNOLOGIES AWARDED FUNDING OF EUR 25K EACH
STEP 4
· Promotion
· Commercialization
TECHNOLOGY OFFERS
12
TECHNOLOGIES LICENSED OR SOLD TO THE MARKET
2
SPIN-OF/SPIN-OUT COMPANIES BASED ON UNIVERSITY TECHNOLOGIES
CTT Politechnika Krakowska
INTECH PK SPECIAL PURPOSE VEHICLE
Direct commercialization
Indirect commercialization

Science meeting the needs of entrepreneurs

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ABSTRACT

The rapid development of new technologies and innovations that we are seeing today means that it is most important that inventions meet the long-term needs of industry. Without this, there is a little chance for the successful commercialisation and appearance of the innovation on the market. Research to Business meetings and interviews are good practice for allowing the representatives of companies and universities to fully discuss inventions and commercially interesting technologies. The innovations dedicated to industrial partners, together with interesting financial tools that enable higher TRLs for inventions and technologies to be achieved, ensure an excellent basis for the development of future research cooperation and business synergy.

The aim of this paper is to discuss the relationship between science and enterprise in respect of science's response to the needs of industry, and is presented in the form of a case study of a project by scientists from Gdynia Maritime University (Poland). All the innovations within the framework of this project concern equipment for a mobile diving base, in particular, the flexible diving bell Batychron and the mobile electromagnetic mooring system.

KEYWORDS

needs of industry, research to business, relationship between science and enterprise, knowledge & technology transfer activities

1 INTRODUCTION

It is often claimed that it is the idea behind an invention that is the most important, however, there is a long road from the initial conception of an idea to its implementation. Creating new, innovative inventions almost always involves investment and inextricably requires the involvement of an inventor. To obtain funds for the implementation of any project, scientists often use various grant competitions. The idea itself is not enough to obtain such a grant, but a thoroughly prepared action plan and, more often than not, an industry partner are crucial. In other cases, some entrepreneurs have the required financial means but lack ideas to bring their business to the next level. Companies are often in the market for new ideas or for the scientists who will develop a given concept. This is where the relationship between science and enterprise comes in, like a system of connected vessels, supported by Technology Transfer Offices together with innovation brokers. It is crucial to ensure that the core values of both organizations promote the types of behaviour that strengthen and not hinder the development of trust-based relationships. It is worth highlighting that all research, technology, and product development as well as professional staff are becoming an element of competitiveness and competence building enterprises oriented for innovation [1, 2].

The European Innovation Council (EIC) Advisory Board said that researchers must work closely with entrepreneurs to make breakthrough research in Europe successful business opportunities [3]. If so, the innovations coming from science will not only meet the needs here and now, but also those in the future, which are more important for business from the economic point of view.

Great innovation should respond to the entrepreneurial need so that it can be successfully commercialised. Furthermore, Aliasghar et al. highlighted that the entrepreneurs are really looking for both knowledge and innovation in science [4]. Therefore, scientific research must respond to the needs of enterprises. The development of mutual benefits which facilitates scientific knowledge commercialisation is absolutely crucial [5] (Figure 1).

A World of Knowledge Transfer is an international knowledge transfer community gathering organization. In July 2022, the latest ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe was published [6]. The data source for the report was 519 Knowledge Transfer Offices (KTOs) from 26 countries for the financial year 2019. The ASTP 2020 Survey Report on Knowledge Transfer Activities in Europe from 512 KTOs (from 27 countries) for the financial year 2018 was presented [7]. The main conclusions are presented in Figure 2

†Author Footnote to be captured as Author Note

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[6, 7]. The headline numbers from the ASTP 2021 Report are promising [6].

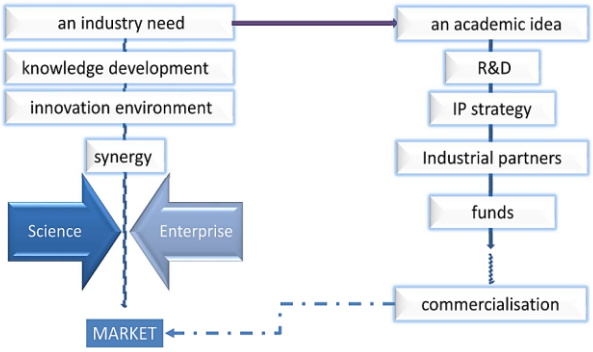

Figure 1: The diagram presents the innovation occurs directly as an industry need

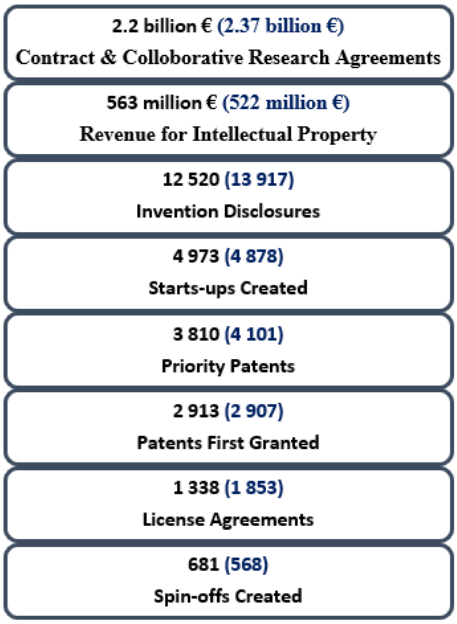

Figure 2: Overview of Survey Main Outputs and Findings for the financial year 2019 [6] – the black font (in compared to the financial year 2018 [7] – the navy font)

In general, a cooperation between companies and universities should generate economic activities such as purchasing or licensing research results, patents, etc. [1].

The KTOs' staff in the financial year 2019 performed mainly functions such as research support (31%), commercialisation (24%), others (24%), entrepreneurship support (11%), and business development (10%) [6]. This sees a change from the financial year 2018 when KTO's staff was more focused on commercialisation (31%) than research support (24%) [5]. This reverse relationship could be the result of the COVID-19 crisis. Additionally, the observation also confirmed the importance of Technology Transfer Offices in creating and maintaining relationships between science and entrepreneurs.

The total number of contract & collaborative research agreements and the total number of revenues for intellectual property has grown with time [6, 7]. The result is inspiring for the future.

European KTOs indicated a total of 177, 784 agreements with the industry of which 69% were Consultancy Agreements, 21% Contract Research Agreements, and 10% Collaborative Research Agreements [6]. The total number of agreements in the financial year 2019 was slightly higher than in 2018 at about 7 020 agreements [6, 7]. In the financial year 2018, the distribution of the number of agreements was similar: 70% Consultancy Agreements, 21% Contract Research Agreements, and 9% Collaborative Research Agreements [7].

Among commercial contracts, KTOs reported more licenses, options, and assignments in the financial year 2018 [6, 7]. The biggest difference was in the case licenses (1, 853 in 2018 [7] and 1, 338 in 2019 [6]). This fact could be the result of global economic uncertainty.

These observations confirmed the effective cooperation between industry and academic centers in commercialisation.

However, in relation to the intellectual property aspect in the financial year 2019, the results were a bit worse. The total number of invention disclosures and the total number of priority patent applications had decreased [6, 7]. This trend may be due to the coronavirus pandemic, but innovation brokers from technology transfer offices are taking an increasing number of different steps to promote science in the economy and to encourage entrepreneurs to cooperate with universities [1].

Last year, the same innovation brokers from the Technology Transfer Office of Gdynia Maritime University as part of creating a network of relations between science and enterprises were actively involved in activities aimed at recognizing the needs of the industry environment. This action was carried out on various issues as part of:

1. Invitation to a meeting of companies from the database of companies run by Technology Transfer Office of Gdynia Maritime University.
2. Cooperation with the "Instytut Autostrada Technologii i Innowacji" consortium, which brings together scientific entities and entrepreneurs.
3. Launch of a new initiative of Pomeranian academic centers under the name "Discovering needs for innovation" carried out in cooperation with different companies.

As part of the third initiative, eight science and enterprise meetings were held with micro, small and medium-sized companies, in particular from the Pomeranian region.

The undertaken new action was to serve the development of cooperation in the local innovation ecosystem. The main proposal of the action was to understand the needs of the Pomeranian enterprises, identify their innovation potential, and assess the barriers that prevent the growth of this potential. Additionally, the opening of companies to the Pomeranian academic centers is a new kind of communication between business and science.

In the next section of this paper, an example of increased cooperation science-enterprise will be described in more detail.

2 A CASE STUDY

This section presents a case study of a project by scientists from Gdynia Maritime University (GMU) (Poland). Innovations within the framework of this project concern the equipment of a mobile diving base, in particular, the flexible diving bell Batychron and the Mobile Electromagnetic Mooring System (MEMS).

In December 2020, a micro company from Gdansk (Poland) was looking for a scientific unit to prepare an R&D report on technological innovation for the contracting authority on its Mobile Base of the Marine Emergency Diving Service (MoB MEDS) project. Under the assumption, the MoB MEDS have to enable diving teams to quickly reach the vessel in danger, as a result of various random maritime accidents (e.g., collision, contact, grounding). Without performing effective repairs related to the need to carry out control inspections of the underwater part of the hull, and quick protection of the water area against potential oil and/or chemical spillage, a high-speed boat could seriously endanger the safety of human life, the environment, or marine navigation [8]. The research group from the Navigational Department of the GMU, along with members of the Student Special Interest Group of Underwater Research "Sea Quest" undertook the task of creating the report.

The research group proposed two solutions as innovative equipment for MoB MEDS. The company expressed its interest in implementing these systems in its newly built watercraft, which resulted in the signing of a letter of intent.

As a consequence of acquiring a business partner, in April 2021, the GMU Research Group applied and was accepted into a grant programme called "Innovation Incubator 4.0″, implemented under the programme of the Ministry of National Education of the Republic of Poland (earlier the Ministry of Science and Higher Education of the Republic of Poland) as part of the non-competition project entitled „Support for scientific research management and commercialisation of the R&D work results in scientific units and enterprises" under the Intelligent Development Operational Programme 2014-2020 (measure 4.4). The project reference number for the pre-implementation work is UMG-03. The project name is The Innovative Equipment of the Mobile Intervention Unit and contains two inventions the Batychron flexible diving bell and the Mobile Electromagnetic Mooring System.

Batychron is a flexible underwater bell patented by Gdynia Maritime University as a device applicable in hydro-technics for underwater transport and diving while maintaining the safety of human life [9]. There are several solutions for diving bells in hydroengineering [10], however, the disadvantage of the known solutions is the large construction of the bell and the weight. These devices were very heavy and needed to be moved together with the vessel, which required several people to be serviced. Under this assumption, the Batychron should be light, handy, and portable. One of the goals of the above-mentioned project was to build a new device called the Batychron in a modular form with the new materials (Figure 3). The utility model for this device was submitted to the Polish Patent Office (No. W.130766) on 05/05/2022. As a result of the research, it was confirmed that the Batychron device can be used not only as the equipment for intervention units but also to secure and make all kindsof training, tourist, internship, recreational, and sports dives more attractive.

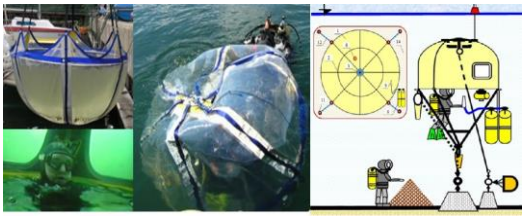

Figure 3: a Batychron

The second invention proposed in the mentioned project is the MEMS. The MEMS is an innovative mooring system designed to fit a small intervention/service vessel that moors to the sides of larger vessels requiring intervention for repair, servicing, or the transfer of cargo or people, without the need to involve a large number of crew members during mooring operations (Figure 4).

The main disadvantages of the known electromagnetic or vacuum mooring systems are, on the one hand, their extensive dimensions, which prevent them from being used on smaller vessels and, on the other hand, the inability to move the moored vessel horizontally along the other vessel. The MEMS solution, using a system of electromagnetic grippers with a unique set of mooring lifts ensuring constant rope tension, tackles the problems and requirements of small intervention/service watercraft, including working dive boats, during mooring to a larger serviced unit. The key elements in this solution are not only mobility, time, and lower energy consumption but, above all, safety - the risk of an accident with ropes on a serviced vessel is reduced.

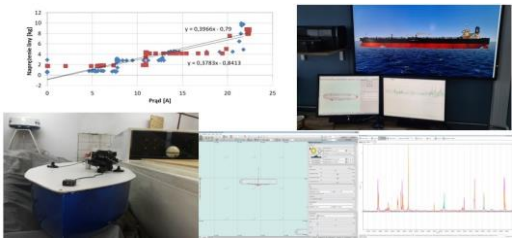

Figure 4: a MEMS

The application to the Polish Patent Office was filed by GMU (No. P.437572) on 13/04/2021. In April 2022, the European application number EP22000102 was filed. Currently, as part of the project, the simulation and laboratory/model tests are carried out to develop a plan for the construction of a demonstration model.

Both inventions have been promoted externally at several trade exhibitions and industry shows (e.g., at the 14th International Conference on Marine Navigation and Safety of Sea Transportation Gdynia 16-18/06/2021, XXI International Maritime Exhibition and Conference BALTEXPO 2021, Gdansk 6-8/09/2021). At the 15th Edition of International Invention and Innovation Show INTARG® 2022 Katowice 11-12/05/2022, the GMU Research Group presented 'Innovative Floating Intervention Unit Equipment: A Mobile Electromagnetic Mooring System and a Batychron for which they were awarded a silver medal in the category Transport and Logistics.

At the same time, one of the small local companies from Gdynia offered to cooperate with GMU by offering apprenticeships. The company was also looking for a wider cooperation related to R&D projects in their field. The company's marine automation department is involved in wide-ranging cooperation with shipyards and directly with shipowners around the world. They design and manufacture their systems in the field of power engineering and ship automation, as well as in servicing existing systems. Once acquainted with the Mobile Electromagnetic Mooring System, the company had no doubt that this was a project closely related to their industry, and one in which they wanted to be involved. The cooperation agreement was signed as part of the R&D activities. Currently, the level of technological maturity was determined as 5 – validation of the technology was performed in a near real-world environment (prototype) thanks to support from the "Innovation Incubator 4.0" grant programme. The small local company specializing in marine automation in order to scale the solution and demonstrate the willingness to conduct joint implementation works as part of applying for external funds. GMU extensively work together with Gdynia company to obtain funding to carry out an R&D project, as a consequence of which a fully certified MEMS device is to be created.

As shown in this case study, ideas for technological solutions can be developed and realized by effective cooperation between science and enterprises. Such a relationship is a win-win situation - the scientists from the University can conduct scientific research and realize their ideas, the entrepreneurs can generate income and develop their brand, and in this case, a Gdynia-based construction company can be the first to build the invention, and the previously mentioned company can use it. Working together they can offer a new technology to the market. The enterprises have noticed that those ground-breaking solutions have a global reach. Both devices can be used in sectors such as marine services, repair interventions of other marine vessels, diving services – recreational, training, repair or excavation work, underwater transport, cargo, and people transfer in the offshore area.

The GMU Research Group is still working, gaining momentum, and creating new ideas based on the needs of entrepreneurs. In April 2022, the members of the Student Special Interest Group of Underwater Research "Sea Quest" operating at the GMU would like to continue their research at the Batychron installation. For this purpose, they applied to the Ministry of Science and Higher Education for funding for a new project called the MUDS Base, the Mobile Underwater Diving Support Base. This project was submitted as part of a scientific competition organized by the Ministry of Science and Higher Education in October 2021 as a new initiative: "Student Circles Create Innovations". The project has been accepted and is under realisation. All the activities of the GMU Research Group are supported by innovation brokers from the GMU Technology Transfer Office. In line with the new trends, innovation brokers involve students in designing innovative solutions. This corresponds to increasing the awareness of both scientists and entrepreneurs that the new programs also offer the possibility of carrying out research in young research teams.

3 CONCLUSIONS

Creating new and innovative solutions is always associated with financial investment and building interdisciplinary research teams ready to take on the difficult challenges of the current economy. In this respect, the relationship between science and enterprise is of prime importance. Science is important to meet the needs of entrepreneurs because it is precisely this that stimulates their interest in the development of new technologies. These dependencies are crucial to conducting R&D focused on the needs of entrepreneurs.

A good example of cooperation between science and enterprises. is the project referred to in this paper involving GMU scientists. Innovations within the framework of this project concern the equipment of the mobile diving base, in particular, the flexible diving bell Batychron and MEMS. The cooperation between science and enterprise contributed to the creation of new innovations, their protection by patents, and further plans for their commercialisation. This case study highlights the importance of scientific work that corresponds to the needs of industry.

ACKNOWLEDGMENTS

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REFERENCES

[1] Dariusz Trzmielak, 2012. Współpraca ośrodków naukowych i przedsiębiorstw we wdrażaniu wyników badań. *Prace Instytutu Lotnictwa/Sieć Badawcza Łukasiewicz*, 225(4), 19-36. DOI: https://doi.org/10.5604/05096669.1077678.

[2] Michał Majczak, 2016. Centra Transferu Technologii w Polsce. Analiza, bariery i perspektywy rozwoju. *Studia Ekonomiczne/Uniwersytet Ekonomiczny w Katowicach*, 8(306), 81-96.

[3] Article of European Commission. 2019. Turning science into business is about recognising opportunity. https://ec.europa.eu/research-and-innovation/en/horizon-magazine/turning-science-business-about-recognising-opportunity (accessed on 10/10/2022).

[4] Omid Aliasghar, Elizabeth L. Rose, Sylvie Chetty, 2019, Where to search for process innovations? The mediating role of absorptive capacity and its impact on process innovation, *Ind. Mark. Manag.*, 82, 199-212, DOI: 10.1016/j.indmarman.2019.01.014.

[5] Diana Nadine Boehm and Teresa Hogan, 2013, Science-to-Business collaborations: A science-to-business marketing perspective on scientific knowledge commercialization, *Ind. Mark. Manag.*, 42(4), 564-579, DOI: 10.1016/j.indmarman.2012.12.001.

[6] ASTP A World of Knowledge Transfer. 2021. ASTP Survey Report on Knowledge Transfer Activities in Europe. https://www.astp4kt.eu/assets/documents/Report%20-%20ASTP%20Survey%20on%20KT%20Activities%20FY2019.pdf (accessed on 11/08/2022).

[7] ASTP, A World of Knowledge Transfer. 2020. ASTP Survey Report on Knowledge Transfer Activities in Europe. https://www.astp4kt.eu/assets/resources/impact/ASTP%202020%20Survey%20Report%20on%20KT%20Activities%20in%20Europe.pdf (accessed on 11/08/2022).

[8] Michał Jurczyński and Grzegorz Rutkowski, 2021. Analysis of Maritime Accidents in the Context of Demand for MoB MEDS the Mobile Base of the Marine Emergency Diving Service. *TransNav, Int. J. Mar. Navig. Saf. Sea Transp.*, 15(1), 209–214. DOI: https://doi.org/10.12716/1001.15.01.22.

[9] Julia Kosiek, Jan Nasur and Grzegorz Rutkowski, 2022. Analysis of the Batychron Research Project. *Sci. J. Gdynia Marit. Univ.*, 121(22), 20–27. DOI: https://doi.org/10.26408/121.02.

[10] Robert F. Marx. 1990. *The History of Underwater Exploration*. Dover Publications, Inc., New York.

Commercialization of R&D results created with public funds in the National Academy of Sciences of Belarus

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ABSTRACT

The paper informs on organizational structure, the current state of commercialization of R&D results created with public funds in the National Academy of Sciences of Belarus (NASB), difficulties to involve private capital in the process of commercialization and proposes ways to address these problems.

KEYWORDS

Technology transfer (TT), legislation, intellectual property rights (IPR), spin-off, start-ups, R&D contracts

1 INTRODUCTION

Founded in 1922, the NASB is the primary state scientific institution and the leading R&D center of Belarus. It incorporates over 110 organizations (incl. production, design, and 80 R&D institutions), and employs about 14 000 persons (incl. 5 000 researchers, 100 academicians, 120 corresponding members, 400 doctors of sciences and 1 600 candidates of sciences) [1, 2].

Between 1993–2020 the NASB registered nationally and internationally over 8 800 objects of industrial property rights: inventions (66,3%), utility models (25,2%), plant varieties (4,6%), trademarks (3%), industrial designs (0,7%). At the end of 2020, only 558 objects remained in force [3].

NASB ranks first by the number of national patents (table 1) and the number of registered license agreements (table 2) [3].

NASB licensing income for 12 years (2009–2020) amounted to 6 mln USD or about 500 000 USD per year, and as shown in table 3, the plant variety is licensed the most – 59%. In recent years, NASB exported annually ca. 50 mln USD of goods and services, which means that licensing revenue amounts to 1% of total export [3].

Table 1 – Obtained national patents in 1993–2020

Establishment	No. of patents	Pct., %
NASB	5 132	34,0
Ministry of Education	4 600	30,5
Ministry of Health	2 763	18,3
Ministry of Industry	1 520	10,1
Ministry of Agriculture and Food	1 057	7,0
Total:	15 072	100

Table 2 – Registered with the National Center of Intellectual Property license agreements in 1993–2020

Establishment	No. of agreements	Pct., %
NASB	550	19,8
Ministry of Industry	501	18,0
Ministry of Agriculture and Food	499	18,0
Food industry concern "Belgospishcheprom"	468	16,8
Ministry of Transport and Communications	71	2,6
Ministry of Education	66	2,4
Light industry concern "Bellegprom"	60	2,2
Other state bodies and state-owned enterprises	563	20,3
Total:	2 778	100

Table 3 – Number of license agreements in NASB organizations in 1994–2020

Licensed IP	No. of agreements	Pct. , %
Inventions	52	9,5
Utility models	41	7,5
Industrial designs	5	0,9
Trademarks	28	5,1
Plant varieties	328	59,6
Know-how (until 2013)	96	17,5
Total:	550	100

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The reason for such low licensing income is that the results of scientific and technological activities (STA), created with government funding, de facto belong to the state, and not to organizations of the NASB [4, 5]. This is also the reason why the NASB does not create spin-off and start-up companies.

The best results of the NASB in patenting and licensing activities is due to the organizational structure of the intellectual property (IP) management system in the NASB.

2 ORGANIZATONAL STRUCTURE OF IP MANAGEMENT SYSTEM

Organizational structure of IP management, technology transfer and commercialization of STA results in the NASB consist of four levels (see figure 1):

- Top management level is the Chairman of the Presidium of NASB and the Deputy Chairman, supervising IP matters;
- Regulation and coordination performs Expert council on IP management;
- Management and control is carried out by the Main department of scientific, scientific-technical, and innovative-production activities, the Main department of international scientific and technical cooperation, the State scientific institution "Centre for System Analysis and Strategic Research" (CSASR), which includes the division "Republican Centre for Technology transfer" (RCTT), the Departments of sciences (7) and the Departments of the NASB apparatus;
- Execution level includes organizations of the NASB.

The Expert council on IP management exists since 2010. Its main activities, specified by the Regulations on the Council (approved in 2014) are to:

- develop and update IP management strategy of the NASB;
- coordinate organization's activities in the field of IP protection and management;
- considerate proposals by NASB organizations to improve legal mechanisms for IP protection and management;
- examine issues related to acquisition of IP rights, and the disposal of those rights;
- approve payment of remuneration to the heads of organizations;
- contemplate other IP issues that require collegial decision-making.

The structure also includes:

- two WIPO Technology and Innovation Support Centers (TISC): on the basis of Yakub Kolas Central Scientific Library of the NASB (since 18 Nov 2021) and on the basis of RCTT (since 31 Jan 2022) [6, 7];
- specialized structural divisions in organizations (patent service, scientific and innovation division, marketing division);
- specialists of non-specialized structural divisions with advanced professional training in the field of IP and technology transfer.

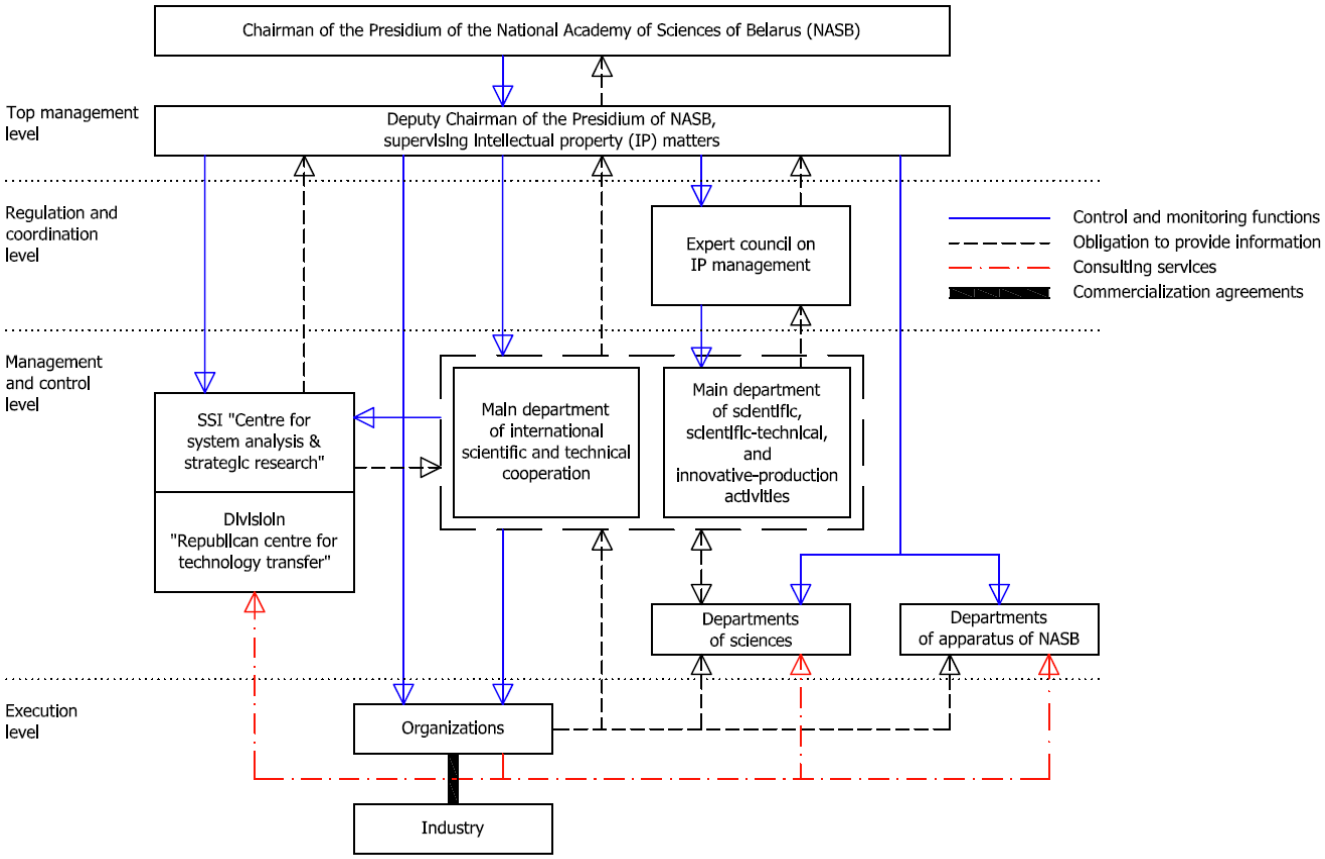

Figure 1: Organizational structure of IP management, technology transfer and commercialization of STA results in the NASB

Services offered by the TISC based on RCTT include:

- access to online patent and non-patent (scientific and technical) resources and IP-related publications;
- assistance in searching and retrieving technology information;
- training in database search;
- on-demand searches (novelty, state-of-the-art and infringement);
- monitoring technology and competitors;
- basic information on industrial property laws, management and strategy, and technology commercialization and marketing;
- support of training seminars on TISC activities organized by NCIP, WIPO, European IP Helpdesk and others, including assistance in the appointment of external speakers from the network of European IP Helpdesk partners (for example, the European Network of National Intellectual Property Offices – INNOVACCESS, European Patent Office / Academy) for specific activities in the field of intellectual property.

3 COMMERCIALIZATION ISSUES

When commercializing the STA results the NASB organizations follow:

1. Regulation on the commercialization of the results of scientific and technical activities created at the expense of state funds (approved by the Presidential Decree No. 59 on 5 Feb. 2013, amended in 2018);
2. Strategy of the Republic of Belarus in the field of intellectual property until 2030 (approved by the Decree of the Council of Ministers No. 672 on 24 Nov. 2021). The Strategy specifies main directions for improving the national IP system, the goals and objectives of the state policy in this area, which provide for the transformation of IP into an effective tool for innovative and socio-cultural development of the Republic of Belarus.

The Regulation defines commercialization as "introduction into civil circulation and (or) use for own needs of the results of scientific and technical activity or goods (services) created (performed, rendered) using these results, ensuring the achievement of economic and (or) social effects". The Regulation stipulates strict deadlines for the commercialization of STA results (created with public funds) subject to mandatory commercialization, i.e. within three years after the creation. Failure to commercialize means violation of budget legislation, and so received public funds should be recovered from legal entities in an indisputable manner to the budget with interest that equals to refinancing rate of the National Bank set on the date of collection.

To keep the list of IP rights on STA results subject to mandatory commercialization and its outcomes the State Committee on Science and Technology (SCST) and the subordinate organization – Belarusian Institute of System Analysis and Information Support for Scientific and Technical Sphere (BelISA) – maintain the State register of rights to the results of scientific and scientific and technical activities. State customers supervise the commercialization and maintain local registers of STA results.

Committee, created by order of organization's head, carries out annual inventory of SDA results in the NASB in 1st quarter (according to internal regulation approved in 2014). Organizations, not later than 15th April, provide the results of inventory to NASB apparatus on five sheets:

- Sheet No. 1 "Sole rights on objects of industrial property";
- Sheet No. 2 "Sole rights on objects of copyright";
- Sheet No. 3 "Organization's rights on STA results obtained via agreements";
- Sheet No. 4 "Organization's rights on potentially patentable STA results";
- Sheet No. 5 "Organization's rights on STA results, which are not objects of exclusive rights" (know-how).

After the adoption of Presidential Decree No. 59 in 2013, almost all STA results subject to mandatory commercialization are commercialized at state enterprises. After mandatory commercialization for STA results begins period of indefinite use – organization does not know when and who will show interest in created technology, and for what amount the organization will be able to sell it. From accounting point of view the STA results represent intangible assets. Putting STA results on accounting can proof that they belong to organization. This procedure is described in the Law of the Republic of Belarus "On accounting and reporting" No. 57-Z from 12 Jul 2013 and in National standard of accounting and reporting "Individual Accounting Statements" (approved by Decree of the Ministry of Finances No. 104 from 12 Dec 2016). The above documents do not allow putting the STA results (intangible assets with an indefinite useful life) on accounting with zero value, and if any private organization wants to purchase the technology, then the minimal license cost should be the sum of all expenses for creation and patenting the technology. As a result, organizations have no interest putting STA results on accounting and concluding license agreements. Technology transfer with private enterprises and foreign companies occurs under commercial agreements with technical assistance, technical cooperation agreements, R&D agreements, and joint ventures. Belarusian legislation also does not allow "gratuitous" transfer of technologies created with public funds to SMEs to attract private investments.

4 FURTHER DEVELOPMENT

In order to proper and on-time implement the Strategy of the Republic of Belarus in the field of intellectual property until 2030, the NASB approved "Plan of the National Academy of Sciences on the execution of priority measures in 2022–2023 for Strategy's implementation" (NASB Order No. 18 from 19 Jan. 2022). The Plan contains actions directed at the:

- development of institutional system in the field of IP;
- development of IP infrastructure;
- improvement of incentive mechanisms for the creation, legal protection and use of IP;
- development of IP management system;
- improvement of legal culture and education in the field of IP.

The improvement of IP management system, in particular, provide for "Development and adoption of institutional IP policies in scientific organizations of the NASB". According to Plan's schedule, all 80 R&D institutions should adopt IP policies: 24 in 2022, 18 in 2023, 17 in 2024, and 21 in 2025.

5 CONCLUSIONS

After the adoption of Presidential Decree No. 59 in 2013 in Belarus, almost all STA results subject to mandatory commercialization are commercialized at state enterprises. After mandatory commercialization for STA results begins period of indefinite use – organization does not know when and who will show interest in created technology, and for what amount the organization will be able to sell it.

To allow de facto access of private SMEs to technologies developed with public funds, after their mandatory commercialization at state enterprises, and attract private capital to adoption of such technologies in SMEs, it is necessary, in addition to recommendation given in [4], to enact legislation that:

1. allows putting the STA results (intangible assets with an indefinite useful life) on accounting with zero value, similar to Generally Accepted Accounting Principles (GAAP) and International Financial Reporting Standards (IFRS);
2. gives the contractor-organization the right to independently determine the cost of license agreements based on the market value of the created technologies;
3. stimulates the involvement of private capital to commercialization of technologies in SMEs.

ACKNOWLEDGMENTS

We would like to thank the National Academy of Sciences of Belarus and the State Committee on Science and Technology of the Republic of Belarus for their constant support of RCTT activities and express gratitude to all our colleagues who work in technology transfer for their help and advice.

REFERENCES

[1] National Academy of Sciences of Belarus, Available from: https://nasb.gov.by/eng/about/glavnaya/ (visited October 5, 2022).

[2] Национальная академия наук Беларуси / А.И. Иванец [и др.]; под общ. ред. В.Г. Гусакова. – Минск: Беларуская навука, 2020. – 92 с.

[3] Нечепуренко Ю.В. Рынок объектов промышленной собственности, созданных в Республике Беларусь. – Минск: БГУ, 2022. – 147 с.

[4] Alexander Uspenskiy, Aliaksei Uspenski, Maxim Prybylski Technology Transfer in Belarus // Proceedings of the 24th International Multiconference INFORMATION SOCIETY – IS 2021 Volume E – 7 October 2021 Ljubljana Slovenia. – p. 62–64. – ISBN 978-961-264-224-2.

[5] Политика и законодательство в сфере трансфера технологий: зарубежный и национальный опыт / Д.М. Вильтовский, Е.П. Машонская, А.А. Успенский; под общ. ред. А.А. Успенского. – Минск : Ковчег, 2010. – 60 с. – ISBN 978-985-6950-40-0.

[6] TISC Derectory: Belarus, Available from: https://www.wipo.int/tisc/en/search/search_result.jsp?country_id=27 (visited October 5, 2022).

[7] The WIPO Technology and Innovation Support Center was established on the basis of RCTT, Available from: https://www.ictt.by/eng/home/news/4804/ (visited October 5, 2022).

Selection and evaluation of technologies for the transfer to the industry

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ABSTRACT

The paper refers to the study of the issue of selection and evaluation of technologies for their transfer to the industry. For low-income countries such as the Republic of Moldova, where the potential for technology generation is low, it is very important to create policies for selecting and evaluating technologies that would facilitate the transfer of technologies that can be assimilated in that country, taking into account human resources and existing technological and financial potential.

This article highlights 27 methods used to select and evaluate technologies, the decision-making issues for which those methods are applied, and the strengths and weaknesses of some methods. Some challenges arise in the process, because the available methods are usually too simple or too elaborate for most managers and companies to be systematically understood and applied. To continue the research, there is a need to combine methods or develop a new method.

KEYWORDS

Innovation, technology transfer, methodology, criteria, descriptors of performance

1 INTRODUCTION

The process of selecting and evaluating technologies is an indispensable component of technology transfer and responds to the issue of identifying the most optimal technologies proposed for transfer within enterprises and industries. This statement is made by the author of this article based on his experience in technology selection and evaluation for at least 10 years.

Various methods of selecting and evaluating technologies from simple ones, such as financial methods, to the most complex ones, such as mathematical programming, have been developed and used to address this issue.

The methods are used to extract and process relevant information about a problem, because the reality is also too complex to manage in its entirety. Therefore, any method, no matter how sophisticated, will always be only a part of the reality it intends to reflect and can only produce an optimal result in its own particular framework.

A technology screening method can thus be a valuable tool for an organization to help choose technologies, especially if it can generate useful information in a timely manner and at an acceptable cost. There are various concerns to consider when selecting a method, as well as several different types, which are discussed below.

2 CHARACTERISTICS AND PRINCIPLES OF TECHNOLOGY SELECTION AND EVALUATION METHODS

After studying the literature presented in references, the following five aspects are considered the most important in a method of selection and evaluation of technologies, which propose the following characteristics and definitions:

Table 1: Characteristics and definitions of technology selection and evaluation methods

Characteristics	Definitions
Realism	*The accuracy of the representation of the real world and in the reflection of the company's decision on the situation, objectives, limitations, risks, etc.*
Capacity	*Ability to analyze different types of decision variables and deal with several factors (multiple time periods, changes in interest rates, etc.)*
Flexibility	*Applicability to different types of technologies and issues and ease of change in response to changes in the business environment*
Use	*Ease of understanding and application of the method. Clear, easy to understand by all members of the organization and executed quickly*
Cost	*The costs of setting up and using the method should be less than the potential benefits of the technology and relatively low in the cost of the technology*

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Easy computerization	*Easy collection, storage and handling of information with readily available software (such as Excel®)*

In the literature there is an extensive list of "good practice" principles for technology management tools observed by several authors, some of which apply in particular to technology selection and evaluation tools, such as:

• Robust (theoretically possible and reliable)
• Economical, simple and practical to implement
• Integrated in other business processes and tools
• Flexible (adaptable to suit the particular context of the business and its environment)

There are a wide range of methods that have been used to select and evaluate technologies, from simple cost analysis to full and linear programming or more flexible methods such as fuzzy mathematical programming.

Research on the selection and evaluation of technologies dating back to 1959, where several criteria and methods of mathematical programming were already used. Reference is made to works that use the following methods: scoring, ranking, decision trees, theoretical approach to the game, Delphi technique, fuzzy logic, hierarchical analytical process (AHP), goal programming, dynamic programming, linear programming 0-1, programming quadratic and nonlinear programming. Some methods can even be used together, which further increases the number of possible techniques to be used for the selection and evaluation of technologies.

The table below shows several methods for selecting and evaluating technologies, which have been used in various decision-making issues, such as evaluating technology offerings, information systems, and research and development.

Table 2: Various types of technology selection and evaluation methods for certain decision-making issues

Technology selection and evaluation method	The decision-making problem
Net present value method	Programming the selection of investments in technologies
Cost analysis (e.g. VNV, DCF and reimbursement)	Technology selection and evaluation
Unweighted ranking and model	Decision to select and evaluate investments in technologies
The analytical ranking process (AHP)	Selection and evaluation of industrial technologies
Multiatributive utility theory in combination with PRICE	Technology selection and evaluation
Linear and full programming	Technology selection and evaluation
Utility method-theory	Bidding decisions
The fuzzy overtaking method	Technology evaluation
Competitive bidding strategy model	Technology selection and evaluation
Multiatributive analysis in combination with regression models	Selection and evaluation of technologies for the public sector
Multicriteria selection and evaluation	Aggregation of expert judgments
The method of fuzzy preferences	Technology selection and evaluation
Fuzzy logic	Selection and evaluation of software technologies
Mathematical programming	The decision to select and evaluate the technology provider
Gray	Selection and evaluation of the technology offer
TOPSIS	Decision making for tenders
Fuzzy stochastic	Technology selection and evaluation
ELECTRE I	Technology selection and evaluation
The theory of possibility	Technology investment decision
Mathematical programming	Selection and evaluation of research and development technologies
Network Analytical Process (ANP)	Selection and evaluation of research and development technologies
Fuzzy-logic	Selection and evaluation of new product development technologies
ANP	Technology selection and evaluation
Packing method - several boxes	Selection and evaluation of research and development technologies
AHP and multi-attribute decision making technique	Selection and evaluation of industrial technologies
Mixed integrated programming method	Optimal selection and evaluation of the research and development portfolio
Zero-one integer programming methods with limited chance	Random selection and evaluation of technologies

As can be seen, there are different methods that are used for different decision issues. Therefore, it can be concluded that there is no specific method for a particular situation, but rather that there is a wide range of possibilities and applications. The advantages and disadvantages of the methods must be weighed against the particular issue of the available decision, in order to choose the most appropriate method. The table below explains some of the above methods, the corresponding advantages and disadvantages.

Table 3: Comparison of technology selection and evaluation methods

Decision method	Description of the method	Advantage	Disadvantage
Cost analysis (eg VNV, DCF and return on investment)	Use accounting data and other relevant information to identify ways to reduce costs and then choose the technology that works best	Controls costs and prevents waste and losses	It focuses only on costs and ignores the cost-benefit principle
		Easy for decision makers	
Linear programming	Linear programming is a technique for optimizing an objective linear function, subject to linear equality and inequality constraints	Get the best result in a mathematical model, give a list of requirements represented as linear equations	An optimal solution may not be found
Integrated programming	Type of mathematical programming whose variables are (in whole or in part) integers in the problem	It greatly reduces time and space for solution	More difficult to solve than linear programming
Fuzzy logic	Fuzzy logic is a form of multivalent logic derived from fuzzy theory, it deals with reasoning that is approximate rather than accurate	It is a powerful tool for managing inaccurate data	Fuzzy logic difficult to achieve on a large scale
AHP	A mathematical decision-making technique that allows the qualitative and quantitative aspects of decisions to be taken into account	Reduce complex decisions in a series of individual comparisons and then summarize the results	It depends on the experience of the expert
			The comparison and the trial process is harsh, which cannot be used for high precision in decision making
ANP	It is a mathematical decision-making technique similar to AHP	It can deal with technology evaluation issues	It requires large amounts of data and the decision depends on the experience of the experts
Gray Target decision	Gray Target decisionhas some original effect on the problem of recognizing the model with small samples, insufficient information and data and in uncertain conditions	It does not need a large number of samples and the samples do not need to be regularly distributed	The optimal solution may not be a global optimization situation
		It can describe in more depth the nature of things with low computational load	
		The results of the quantitative and qualitative analysis will be more consistent	
		It can be used for short and long term predictions and is highly accurate	

While return on investment (ROI) is one of the primary factors for prioritizing technology, other issues should be considered,

such as alignment with strategy, balance between maintenance technologies and technology investments, allocation efficient use of resources and other non-financial benefits.

It is impossible to define a set of criteria suitable for all circumstances, as they will differ greatly from one another in different companies and technologies. As a result, there are an endless number of criteria mentioned in the technology selection and evaluation literature, which vary depending on the type of technology and methods used for selection and evaluation, where scoring methods present the most extensive and extensive set of criteria, including more than just financial and strategic issues. There are also different ways in which criteria can be organized, such as by the type of criterion, which is the most common.

3 CONCLUSIONS

Studying the literature has allowed us to understand the importance of selecting and evaluating technologies for the success of innovation and technology transfer in companies, but also the decision-making issues they face in applying the methods of selection and evaluation of technologies. The challenges arise because the methods available are usually too simple or too elaborate for most managers and companies to be systematically understood and applied. In order to tackle these challenges, the author developed a proprietary method, that includes criteria divided into several groups like financial, strategical, technological, marketing, and external factors, which could be adjusted for a concrete case. Due to the multicriteria evaluation and selection approach, the new method permits to obtain of complex results with fewer efforts and special skills from the company technology managers.

To avoid further selection of technologies "Losers", the key lies in the objectivity of the selection and evaluation process, through a method that incorporates both financial and non-financial criteria and by the awareness that each method may be appropriate in certain situations for a particular company and for the circumstances of the technology. Such a method is proposed in the research conducted by the author of this article in his PhD Thesis „Selection and evaluation of technology for the technological transfer".

REFERENCES

[1] Badri, M., Davis, D., Davis, D., 2001. *A Comprehensive 0-1 Goal Programming Model for Project Selection.* International Journal of Project Management, 19(4):243 – 252.

[2] Bretschneider, S., 1993. *Evaluating R&D Impacts: Methods and Practice.* Chapter Operations Research Contributions to Evaluation of R&D Projects (Chapter 7). Springer Science+Business Media, LLC, New York.

[3] Kerr, C., Farrukh, C., Phaal, R., Probert D., 2013. *Key principles for developing Industrially Relevant Strategic Technology Management Toolkits*. Technological Forecasting and Social Change, 80(6):1050 – 1070.

[4] Souder, E. W., 1972. *A Scoring Methodology for Assessing the Suitability of Management Science Models*. Management Science, 18(10).

[5] Souder, E. W., 1972. *Comparative Analysis of R&D Investment Models*. AIIE Transactions, 4(1):57–64.

[6] Wang, J., Xu, Y., Li, Z., 2009. *Research on Project Selection System of Pre-evaluation of Engineering Design Project Bidding*. International Journal of Project Management, 27(6):584 – 599.

Subsidizing Knowledge Transfer with Public Funds

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ABSTRACT

European state aid law is an important cornerstone enabling the functioning of the European single market and thus the realization of the four basic European freedoms (the movement of goods, persons, services, and capital within the EU). At the same time, as the EU strives to stay competitive in the globalized world ruled by rapid technological advancements, it needs to find ways of facilitating interactions between traditionally publicly funded research and the private sector, which could accelerate our economy and fuel it with new inventions and technologies. This, of course, invokes the 'specter of state aid' as the typically non-profit organizations start to enter the market, albeit only offering their knowledge as a product. To balance these forces, a complex system of rules and exemptions is emerging. In this paper I argue that sometimes the 'spectre' is being summoned by the research organizations themselves and that the current rules of state aid law regulating the field of research, development and innovation do not present a major obstacle in knowledge transfer efforts of the European public research sector.

KEYWORDS

state aid, research, development, innovation, European union, competition law, European single market, public subsidies, knowledge transfer, effective collaboration, contract research, licensing

1 INTRODUCTION

The aim of this paper is to bring the regulation of state aid in the European Union closer to readers working in the field of publicly funded research and knowledge transfer. In addition to the introductory general interpretation of the law of state aid, the paper focuses on the issue of state aid of research organizations, especially in connection with their interactions with companies, particularly when dealing with intellectual property belonging to these organizations. These issues raise a number of practical problems that are relevant for research organizations, especially from the point of view of fulfilling their role in the dissemination of knowledge[1]. These problems also affect those corporations and entities that seek to collaborate with research organizations in the area of knowledge dissemination or transfer. I plan to address this subject in relative detail in this paper and subsequent work. In the field of knowledge transfer, at least in Czechia, the European regulation of state aid is perceived as an obstacle to the effective transfer of knowledge from public research organizations to society. I believe that this obstacle is mostly superficial, and the aim of my paper is to convince the reader of this as well.

I suggest the main aim of the paper is to contribute to understanding the reality of the state aid law of the European Union. This issue is already, in my opinion, sufficiently elaborated in the works of other authors like Wendland, Nicolaides and Schwendinger[2]. This paper may conversly serve as a state aid reference intended for experts in the field of knowledge transfer and management of public research institutions, but also for experts oriented to the issue of industrial property within the academia and also for patent representatives and lawyers whose professional activity falls in this area.

2 STATE AID

Many authors consider the doctrine of neoclassical political economy to be the fundamental ideological source of state aid law [1]. A fundamental place in this ideology is occupied by the phenomenon of a self-regulating market, which should be protected from the efforts of states to intervene in it with public subsidies. Such interventions are justified only in borderline cases, such as market failure or the pressing need to level certain geographical and especially social inequalities.

The first and arguably most important arena in which the negative externalities of selective favoring of international competitors are manifested is the global trade. For this reason, state aid is regulated in relative detail by the World Trade Organization, particularly on the basis of the Agreement on Subsidies and Compensatory Measures, which deals on the one hand with the rules governing the provision of subsidies, i.e. state aid, and on the other hand with the application of so-called compensatory measures to compensate for the damage caused subsidized imports, both in order to maintain healthy international competition.

The European Union ('Union'), unlike the World Trade Organization, has more effective tools for enforcing its standards and similarly uses state aid regulation as a tool to protect the health of economic competition. Articles 107 and 108 of the Treaty on the Functioning of the European Union ('TFEU') governing the provision of state aid by member states can be found in the chapter dedicated to the competition law. Those subsidies that bring negative externalities manifested in the property right of competitors from other member countries are identified as problematic. The main goal here is the protection of the European single market.

[1] Knowledge dissemination, according to Framework, means to widely disseminate the results of research activities by way of teaching, publication or knowledge transfer.

[2] See references below.

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The European single market is based on four fundamental freedoms that enable the free movement of people, goods, services and capital. It is precisely the above-mentioned Article 107 and 108 of the TFEU which, through the prohibition of state aid, creates the environment for its unobtrusive operation. For example, the realization of the free movement of goods will not be quite possible in a situation where the goods in question are competing with an alternative that the subsidized entrepreneur can afford to sell at prices that do not reflect the costs of its production.

On the other hand, there is a need to clearly define the rules applicable to all (member states) for exceptions to the above state aid ban. This happens, for example, in areas where there is an obvious market failure, i.e. for example when supporting the so-called Services of General Economic Interest (SGEI). In connection with the system of exceptions to the prohibition of public aid, this area of legal regulation is thus enriched by an essentially political aspect. These aspects appear both at the level of the Union (for example, the exception for significant projects of common European interest listed in Article 107(3)(b) of the TFEU) and at the level of the Member States.

3 STATE AID OF R&D&I

The European Union generally favors research, development and innovation ('R&D&I'). In its Article 179, the TFEU contains a provision according to which the Union aims to "strengthen its scientific and technological foundations by creating a European research area in which scientists, scientific knowledge and technology move freely". For this purpose, according to this article, it is necessary to support businesses and research organizations in their efforts to cooperate. However, this objective may be in conflict with another important objective of the Union. It is the above-mentioned effort to build and protect the health of the European single market, protected from the negative impact of state or public subsidies.

R&D&I subsidies can therefore potentially distort competition in the European single market. This happens especially in cases where the state aid does not induce additional activities on the part of the beneficiaries beyond those that the recipient would have carried out even if such aid did not exist. The effect of state aid can thus be perceived as an increase on the input side (i.e. supported companies invest more of their own resources in R&D&I as a result of state aid) or an increase on the output side (i.e. more outputs or R&D&I results are created precisely as a result of state aid). Regulation of state aid can ensure its increased effectiveness by requiring providers to focus state aid on projects that would not have occurred in the absence of their state aid[1].

According to the Commission[3], State aid of R&D&I is enabled by the wording of the TFEU itself, specifically in two places. State aid of European R&D&I is enabled by Article 107 paragraph 3 letter b), according to which aid intended to help the implementation of a significant project of common European interest can be considered compatible with the European single market. This fact is also reflected in the wording of the old framework for state aid for research and development and innovation, or its point 4, regulating the compatibility of support according to Article 87 paragraph 3 letter b) of the EC Treaty (today's Article 107 paragraph 3 letter b) of the TFEU). Typically, however, state aid for R&D&I will be evidenced by an exception pursuant to Article 107 paragraph 3 letter b), according to which aid intended to facilitate the development of certain economic activities or economic areas can be considered compatible with the European single market, if they do not change the conditions of trade to such an extent that it would be contrary to the common interest.

The beginnings of state aid regulation of R&D&I go back to the 1980s, when the Commission issued the first framework defining the conditions for the compatibility of public R&D&I support with the common market. The importance of research and development as a general interest of the Union has also been enhanced by the revision of the founding treaties, the consequence of which is the above-mentioned wording of Article 179 of the TFEU. The political dimension of the importance of R&D&I is the reason for the Commission's favorable approach to authorizing public subsidies in this area. This is manifested on the one hand within the current Framework for State aid for R&D&I ('Framework')[4] which represents and examplary of soft-law instrument, in which the Comission reveals its opinions regarding the interpretation and application of R&D&I state aid law. According to the current wording of the Framework, state support for R&D&I can thus be compatible with the European single market if it can be expected to mitigate market failure by supporting an important project of common European interest or by facilitating the development of certain economic activities, and if the subsequent distortion of economic competition and trade is not contrary to the common interest [2].

In 2012, the Commission also decided to modernize state aid law. The aim of this modernization was to regulate those state and public aids, that have the greatest impact on the European single market, so that even after limiting the negative effects of aid, it is still possible to achieve the main priorities of the Union, which are the growth and competitiveness of the Union. At the same time, the new rules were supposed to be "streamlined". The logic behind this justification is that the regulation of state aid can help the efficiency of public budgets and correct the so-called market failure. The process of revising the existing rules lasted almost two and a half years, from the first public consultations at the end of 2011 until the adoption of the new rules in May 2014.

Recently, Commission launched a public consultation inviting all interested parties to comment on a proposed targeted revision of the Framework. Interested parties were called to participate in a public consultation which lasted eight weeks (until 3. June 2021). The goal of this new revision is, according Vice-President Margrethe Vestager, further simplyfication of existeing State aid rules. New framework, which shall be the result of this latest modernization effort, shall concern itsfef with the following:

[3] The European Commission is the executive of the European Union. This text uses the abbreviation "Commission" hereinafter.

[4] Framework for State aid for research and development and innovation was published by the Commission in the Official Journal of the European Union (2014/C 198/01) on 27.6.2014.

- Clarification of definitions, particulary
  - **innovation clusters**,
  - **industrial research** and **experimental development** as well as organizational innovation,
  - innovation activities of **SMEs**.
- Compatibility criteria to allow support for **technology infrastructures** to reflect market and technology evolution and to incentivize research, development and innovation investments [3].

4 RESEARCH ORGANIZATION AND KNOWLEDGE TRANSFER

Accordign to EU law a 'research and knowledge-dissemination organisation' ('RO') means an entity (such as universities or research institutes, but also technology transfer agencies or othe innovation intermediaries, etc.), irrespective of its legal status (organised under public or private law) or way of financing, whose primary goal is to independently conduct R&D&I or to disseminate the results of such activities (e.g. by teaching, publications or knowledge transfer activities) [4]. As stated above, these can be private organizations as well. Nevertheless, companies that can exert a decisive influence upon a private RO, in the quality of, for example, shareholders or members, shall not enjoy preferential access to the results generated by it [4].

In addition to the primary activities of the RO (education, basic research, etc.), according to the Commission, the public dissemination of research results (typically in the form of publications, open access databases, or open software) also has a non-economic nature and can be thus subsidised [2]. Part of knowledge dissemination activities are activities in knowledge transfer ('KT'). However, according to the Framework, KT activities are considere non-economic, only if the profit from these activities is reinvested in the primary activities of the ROs.

Knolwedge transfer is definied in the Framework very extensively as any process which has the aim of acquiring, collecting and sharing explicit and tacit knowledge, including skills and competence in both economic and non-economic activities such as research collaborations, consultancy, licensing, spin-off creation, publication and mobility of researchers and other personnel involved in those activities. Besides scientific and technological knowledge, it includes other kinds of knowledge such as knowledge on the use of standards and regulations embedding them and on conditions of real life operating environments and methods for organisational innovation, as well as management of knowledge related to identifying, acquiring, protecting, defending and exploiting intangible assets [2].

The most important takeaway here is that ROs meeting the conditions set out in the GBER and the Framework are, de-facto, outside of the scope of state aid law regulation. However, the conditions here are, (1) the above mentioned reinvestment and (2) no cross-susidization of their economic activities. Even this rule though, has its exemptions. Under certain circumstances public financing of RO's economic activities can also be allowed. These are cases where the economic activity is purely secondary (ancillary). According to the Commission, such secondary economic activity is an activity that meets the following conditions:

- the same inputs (e.g. material, equipment, labor and fixed capital) used for this economic activity are used for other non-economic activities,
- the economic activity in question is directly related to the operation of the research organization and
  - is necessary for its operation or
  - is inextricably linked to its main non-economic use,
- the scope of this activity will not exceed 20% of the total annual capacity of the given entity.

According to Wendland, we can classify the above criteria into qualitative criteria and quantitative criteria [5]. The result of the qualitative view is thus the answer to the question whether the research organization is really used almost exclusively for non-economic activity and the economic activity is directly related to and necessary for the operation of the research organization, or it is intrinsically linked with its main non-economic use. Based on a quantitative perspective, we then determine whether economic activities consume exactly the same inputs (such as material, equipment, labor and fixed capital) as non-economic activities and the capacity allocated each year to economic activity does not exceed the above-mentioned 20% of total capacities.

In this context, however, Wendland, in my opinion, rightly reminds us that it is necessary to assess quantitative and qualitative criteria cumulatively and that the 20% limit has no support in the decision-making activities of the Commission or the EU courts[5]. In the end, the qualitative criteria mentioned above will always be decisive.

5 (NON) ECONOMIC INTERACTIONS OF ROs AND COMPANIES

According to the Framework, independent research conducted with the aim of obtaining new knowledge and a better understanding of a given topic is the primary activity of a research organization, which is considered non-economic. However, according to the Framework, under certain circumstances it is considered permissible that even research that is financed by private means is not considered an economic activity in the sense of the state aid rules. Such situations are in the case of research that takes place within the framework of **effective collaboration** between a research organization and a company or companies (i.e. in the words of the Comission "undertakings").

In such **research cooperation**, both partners contribute to the success of a joint research project. Both partners in these projects also share the risks and subsequently also the outputs (i.e. project results). Compared to the above, **contract research** is characterized by the fact that the industrial partner (undertaking) unilaterally assigns research tasks to the RO and bears the full costs of this activity, including the usual margin.

[5] Court of Justice of the European Union (CJEU) consists of two separate courts: the Court of Justice and the General Court. Hence the abbreviation "EU courts" is used.

Collaboration is considered to be ‘effective’ if at least two independent parties cooperate:

- for the purpose of exchanging knowledge or technology or
- to achieve a common goal.

In order for the qualitative sign of effectiveness according to the Framework to be fulfilled, the above-mentioned purpose should be achieved on the basis of the division of labor between the parties involved. Collaborating parties should jointly determine the scope of the joint research project, jointly contribute to its implementation and share not only its results, but also the associated risks. On the other hand, according to the Commission, the collaboration is effective even if the costs of the aforementioned research project are borne in full by only one or more parties, thus effectively relieving the other parties of their financial risks. Contractual research and the provision of research services are not considered forms of cooperation.

In contrast to effective collaboration, research carried out on behalf of a company is usually carried out on the basis of an assignment, or contractual conditions set by the company, or by the customer. The company also owns the results of research activities and bears the risk of the potential failure of the research or the possibility of non-application of the results. Such research will therefore be the economic activity of the RO and its, even partial financing from public budgets (typically in connection with the use of equipment or employees' working time), is only possible if it is a purely anciliary activity (see above). Otherwise the status of an RO (i.e. non-undertaking, exempted from the state aid rules) could not be maintained.

The Issue Paper to the Framework also brings a more detailed consideration to the topic of the definition of collaborative research. According to the Commission, effective cooperation does not happen in cases where clearly defined tasks are performed within the framework of a contract. Collaborative research is usually of a long-term nature. It is an "open-ended" collaboration. The Commission emphasizes that it is practically impossible to talk about collaborative research in cases where it was not preceded by a proper contract. Otherwise, the risk or, conversely, the benefit of the given cooperation could be retroactively allocated to the more powerful of the cooperating partners [6].

In my view, the key feature of contract researsch is that, unlike in research collaboration, the company solely determines the research assignment. The fact that the ownership of the results remains with the research organization and the company was "only" granted access rights does not deprive such cooperation of the character of contractual research, but on the other hand justifies the reduction of its price. The same is true in cases of co-ownership of results. These considerations flow from the text of the Framework, which in point 26, within the chapter dedicated to research on behalf of businesses (and in this context, contract research or research services), deals with issues of retention of ownership rights to intellectual property. The Framework literally states that "if the research organization or research infrastructure retains ownership of the intellectual property rights or the relevant access rights, their market value may be deducted from the price to be paid for the services concerned".

The Commission also suggests that for the interpretation, or the definition of the term "effective collaboration in research" it may consider documents that were created (and are being created) within the professional circles of organizations dealing with the cultivation of relations between the academic and private sectors. As an example, the Commission's recommendation of 10 April 2008 on the management of intellectual property in knowledge transfer activities and on the code of good practice for universities and other public research organizations (notified under number K (2008) 1329) is given, as well as the recommendation entitled "Responsible partnerships ” published by European associations of universities (EIRMA and EUA), non-university research organizations (EARTO) and knowledge transfer professionals (ASTP – Proton).

Another example of non-economic interaction of RO and business (i.e. undertakings) is **knowledge transfer**. Knowledge transfer in its current form is closely related to the adoption of the so-called Bayh-Dole Act in 1980 in the United States of America. For the first time in that environment, this law allowed universities to own the results of state-funded research and development. The transfer of knowledge thus resulted from the obligation of proper management of the newly acquired property. The passage of this law was part of a long-term vision of the United States government, in addition to the Bayh-Dole Act, a number of new laws were adopted (for example, the Stewenson-Wydler Act on Technological Innovation), and the goal of this reform was to increase the rate of use of publicly funded research and their transfer to the private sector.

The aim of knowledge transfer activities is to convey knowledge, ideally protected by some sort of intellectual property, into new or improved products and services. Schematically, the above-described path from an idea to a real innovation can be described, for example, using the well-known Technology Readiness Level ('TRL') scheme. Following this scheme, it could be said that the mission of knowledge transfer is the transformation of knowledge into technologies and/or products and the subsequent increase of their technological (and market) maturity.

Pracitically, most of the knowledge trasnfer deals are enabled by some sort of a license agreement in which the RO grants the business partner rights, enabling it to use the knowledge generated by the RO legally. Especially with regard to the provision of licenses, the Commission's statement contained in the so-called Issues Paper on the Framework can be considered slightly confusing. According to the paper, the transfer of knowledge should primarily take place on a non-exclusive basis. Non-exclusive licensing is, or should most certainly be the research organization's preferred way of commercializing intellectual property. Especially when this type of licensing has the potential to maximize the economic benefits. In practice, however, the situation where several partners are willing to compete with each other as non-excklusive licensees occurs only rarely. In addition, it follows from the above consideration contained in the explanatory report that the non-exclusivity of the transfer is meant in relation to the primary activity, or the mission of the research organization, which is the public dissemination of research results on a non-exclusive and non-discriminatory basis - for example through teaching, open access databases, publicly accessible publications or open software.

6 CONCLUSION

The enforcement of the european definition of RO and the emphasis on compliance with the state aid rules brought with it an interesting benefit (at least in Czech Republic where the author is based) in that the organizations are forced to prove the existence of their IPR norms and processes, which typically also deal with the application of rights to inventions. However, the state aid law continues to remain a scarecrow that keeps domestic research organizations in uncertainty regarding the acceptable level of their knowledge transfer and application-oriented activities.

Public dissemination of R&D&I results is the mission of a research organization. Therefore, the goal of knowledge transfer cannot be only the achievement of profit, but a wider, societal effect. In-house lawyers of universities, but also lawyers and legal proffesionals working for ROs, as well as in-house lawyers and representatives of the industry, should thus honor this higher goal and allow modern technology and new knowledge to reach places neglected by the market. These activities should certainly not be hindered by the bureaucracy (whether European or domestic), especially through the formalistic interpretation of competition law.

Non-exclusive licensing is, or should most certainly be the research organization's preferred way of commercializing intellectual property. In my view though, an exclusive patent license which resulted from ‘arm’s length’ negotiation, i.e. the transaction between the contracting parties does not differ from those which would be concluded between independent enterprises and with no element of collusionm, is perfectly non-economic in nature. As mentioned above, all profits from such activities need to be reinvested in the primary activities of the RO.

Finally, it can be recommended that the RO should always reserve at least the right to use licensed invetions for its internal ,non-commercial research and educational activities. Licensing should also not jeopardize the fulfillment of the primary mission of RO’s, which is the dissemination of knowledge in the true sense of the word, i.e. to the general public.

REFERENCES

[1] Bacon, Kelyn and QC, Kelyn Bacon, 2017. European Union Law of State Aid. . Oxford University Press. ISBN 978-0-19-878736-5..Google-Books-ID: p1njDQAAQBAJ.

[2] European Commission, 2014. Communication from the Commission — Framework for State aid for research and development and innovation. Online. 2014.. Available from: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52014XC0627%2801%29.

[3] European Commission, 2021. Explanatory note - Revision of the State aid rules for RDI Online. European Union. Available from: https://competition-policy.ec.europa.eu/document/download/5cf6ccf6-e46e-44ca-8ca3-d4ee5370f642_en?filename=RDIF_consultation_background_note.zip.

[4] Commission Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty Text with EEA relevance, 2014. Online. [Accessed 7 September 2022]. Available from: http://data.europa.eu/eli/reg/2014/651/oj/eng

[5] Wendland, Bernhard von, 2015. New Rules for State Aid for Research, Development and Innovation. European State Aid Law Quarterly. 2015. Vol. 14, no. 1, p. 25–50

[6] European Commission, 2012. Issues paper - Revision of the state aid rules for research and development and innovation Online. Brussels: European Commission - Competition DG

[7] Wendland, Bernhard von, 2015. New Rules for State Aid for Research, Development and Innovation. European State Aid Law Quarterly. 2015. Vol. 14, no. 1, p. 25–50.;

[8] Nicolaides, Phedon, 2016. The Pricing of Access to Publicly-Funded Research Infrastructure and State Aid Rules. European State Aid Law Quarterly. 2016. Vol. 15, no. 1, p. 9–15.

[9] Schwendinger, Gerd, 2013. State Aid and Intellectual Property in Contract Research and R&D&I Collaboration. European State Aid Law Quarterly. 2013. Vol. 12, no. 4, p. 685–698..

Effective collaboration and IP management

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ABSTRACT

This article summarizes the main findings of the national project entitled "Evaluation of IP as a basis for proposing a long-term sustainable state aid model to promote science-business cooperation" (project V7-2145 of the targeted development programme - CRP 2021) supported by the Slovenian Research Agency and the Slovenian Ministry of Education, Science and Sport) [1].

The research was focused to the situations related to the Intellectual Property (IP) management in collaborative projects of the following characteristics:

(i) effective collaboration between undertakings and RKDOs takes place and;

(ii) the project is financed by the state (e.g. cohesion funds through ministries, agencies etc.) and;

(iii) the results of project are expected to contain IP that due to possible commercial interest may or may not be published and widely disseminated, but rather protected (e.g. as a business secret, patent application or other form of IP).The aim of this study was to determine (i) meaningful guidelines for intellectual property (IP) management in collaborative projects and (ii) the most typical way of assessing the market price of IP for the case of licensing or selling IP to third parties interested in using it for commercial purposes.

KEYWORDS

Effective collaboration, collaborative projects, IP - Intellectual Property, Background IP, Results, Foreground IP, State Aid, Undertaking, RKDO - Research and Knowledge Dissemination Organization, GBER - General Block Exemption Regulation [2], R&D&I - Research & Development & Innovation framework [3]

1. INTRODUCTION

The General Block Exception Regulation (GBER) of EC [2] declares certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty on the Functioning of the European Union (TFEU). Aid for research and development and innovation is one of the GBER categories and the principles of its proper implementation are explained in Framework for State aid for research and development and innovation (R&D&I) [3], which has a status of EC communication and as such does not have a direct legal impact. As the content of the R&D&I framework is based on the GBER, it makes sense to consider the points of the R&D&I framework as if they were legally binding in practice.

According to the terminology of GBER [2] and R&D&I [3] the term *"undertaking"* is used describing an entity carrying out an economic activity consisting of offering products or services on a given market (point 17 in R&D&I [3]) such as small, medium-sized and large enterprise (point 15 in R&D&I [3]).

The abbreviation *"RKDO"* stands for "Research and Knowledge Dissemination Organization or Research Organization" as defined in article 2, paragraph 83 of GBER [2] and point 15 (ee) of R&D&I [3].

The phrase *"collaborative project"* means the project carried out through *"effective collaboration"* as defined in point 27 of R&D&I [3] (see the full definition in the following text).

The *"aid intensity"* is the maximum gross amount of state aid that can be granted per beneficiary (undertaking or RKDO), expressed as a percentage of eligible costs, before any deduction of tax or other charge (point 15 c in R&D&I [3]).

For the purpose of this article the term *"consortium"* means a group consisting of at least one or more undertakings and one or more RKDOs that "effectively collaborate" among each other in the framework of national collaborative project funded to certain extent by the state (the type of collaboration as described in article 25, paragraph 6 (b) (i) in GBER [2]).

2. RESULTS AND DISCUSSION

Key characteristics of collaborative projects taking place through effective collaboration between research and knowledge dissemination organizations (RKDO) and companies (undertakings) associated to the maximum allowed intensities of state aid funding were followed by general guidelines regarding management of IP in such projects and more detailed description referring to the management of Background IP – owned by one or more project partners before the beginning of collaborative project; and Foreground IP – jointly created by the partners in the course of the collaborative project. Typical and less common ways of IP commercialization in accordance with the state aid rules were schematically represented along with the types of recommended agreements at individual steps of commercialization. Different options are further described regarding the IP transfer and market price determination.

3. CONCLUSIONS

The most important findings are: (i) the relations between the partners regarding the ownership and access of Background IP

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have to be well regulated in advance prior to the start of the collaborative project; (ii) the typical and most useful path for the transfer of IP includes the following steps: valuation of IP, effective negotiations; determination of the IP market price and conclusion of IP license or IP sales and/or IP exploitation and/or new collaborative project consortium agreement.

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LEGAL DISCLAIMER:

The authors of this paper used reasonable efforts to include accurate information on the state aid rules related to the collaborative projects, but we, however, make no warranties as to the accuracy of the content and statements and assume no liability or responsibility for an error or omission in the content of this article.

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REFERENCES

[1] Pal L., Stres Š., Blatnik R., Lutman T., Justin T. 2022. Evaluation of IP as a basis for proposing a long-term sustainable state aid model to promote science-business cooperation. Final report of the project nr. V7-2145 of the targeted development programme - CRP 2021. Jozef Stefan Institute, University of Primorska, Slovenian Research Agency and the Slovenian Ministry of Education, Science and Sport. *(Slovenian language only and not published yet)*

[2] GBER – General Block Exemption Regulation. COMMISSION REGULATION (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0651-20170710&from=EN (last accessed August 7 2022)

[3] R&D&I - Framework for State aid for research and development and innovation. Information from European Union institutions, bodies, offices and agencies. European Commission. Communication from the commission. (2014/C 198/01). https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0627(01)&from=EN (last accessed August 7 2022)

[4] Guidance How to draw up your H2020 consortium agreement. 2020. European Commission. Directorate-General for Research & Innovation. https://ec.europa.eu/research/participants/data/ref/h2020/other/gm/h2020-guide-cons-a_en.pdf (last accessed September 30, 2022)

[5] Kaiser L., Neu M., Teernstra, F. 2020. State Aid on R&D&I – The Right Way. EARTO - European Association of Research and Technology Organisations. Brussels. https://www.earto.eu/wp-content/uploads/EARTO-Report-on-State-Aid-on-RDI-The-Right-Way-Final.pdf (last accessed August 7 2022)

[6] Kebapci, H., Von Wendland, B., Kaymaktchiyski, S., State Aid Rules in Research, Development & Innovation. Addressing Knowledge and Awareness Gaps among Research and Knowledge Dissemination Organisations. Decision Tree, Kaiser, L. (Ed.), Neu, M. (Ed.), Teernstra, F. (Ed.), Nicolaides, P. (Ed.), EUR 30436 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-25081-4, doi:10.2760/675525, JRC122304: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC122304/kjna30436enn.pdf (last accessed September 11 2022)

[7] Andonova, E., Barrada, M., Bole, D., Gulda, K., Hudson, J., Jimenez, V., Karanikic, P., Kaymaktchiyski, S., Kokorotsikos, P., Koycheva, C., Mladenov, T., Rizzuto, C., Shvarova, O., Taylor, S., Teernstra, F., Strategic evaluation of the Bulgarian Centres of Competence and Centres of Excellence and recommendations for their further development: https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/bulgarian_centres/bulgarian_centres_report.pdf (last accsessed September 11 2022)

[8] Law on employment related inventions (ZPILDR), Uradni List RS, št. 15/07. http://pisrs.si/Pis.web/pregledPredpisa?id=ZAKO361. (last accessed October 4, 2022)

[9] Slovenian accounting standard – SRS, Uradni List RS, šr. 95/15. http://www.pisrs.si/Pis.web/pregledPredpisa?id=DRUG4192. (last accessed October 4, 2022)

[10] International Valuation Standards Council. 2022. International valuation standards,.https://propertyinstitute.nz/Attachment?Action=Download&Attachment_id=5117 (last accessed October 4, 2022)

[11] Flignor P., Orozco, P., 2006. Intangible Assets & Intellectual Property Valuation: A Multidisciplinary Perspective, IPthought.com, https://www.wipo.int/export/sites/www/sme/en/documents/pdf/ip_valuation.pdf. (last accessed October 4, 2022)

[12] Trade Secrets Act (ZPosS), Uradni List, št. 22/19. http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO7758. (last accessed October 4, 2022)

[13] Copyright and Related Rights Act (ZASP), Uradni List, št. 16/07. http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO403. (last accessed October 4, 2022)

[14] Industrial Property Act (ZIL-1), Uradni List RS, št. 51/06. http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO1668

[15] Innovation and Technology Transfer in Central and Southeast Europe, European Commission, Knowledge4Policy. Bratislava, 19.5.2022 https://knowledge4policy.ec.europa.eu/event/innovation-technology-transfer-central-southeast-europe_en

Project support services of a technology transfer office

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ABSTRACT

The Center for Technology Transfer and Innovation (CTT) at the Jožef Stefan Institute (JSI) offers not only services related to technology transfer, but also project support services. Database of project calls established by CTT serves as an important tool to inform researchers about relevant calls. Establishing a consortium of project partners or joining one that is already established is also an important step in project work. Further support such as writing of project proposals, identifying and planning impact of the project, managing data, providing gender equality, management, financial, legal and administrative support is crucial for successfully acquiring and running a project. In June 2022 we performed a survey which targeted researchers at the institute. It provided quantitative and qualitative analysis of project support services available at the JSI.

KEYWORDS

project support services, management, technology transfer, project's impact, public funding

POVZETEK

Center za prenos tehnologij in inovacij (CTT) na Institutu Jožef Stefan (IJS) poleg storitev, povezanih s prenosom tehnologij, ponuja tudi storitve za podporo projektom. Baza projektnih razpisov, ki jo je vzpostavil CTT, je pomembno orodje za obveščanje raziskovalcev o relevantnih razpisih. Pomemben korak pri projektnem delu je tudi vzpostavitev konzorcija ali pridružitev k že vzpostavljenemu konzorciju. Nadaljnja podpora, kot je pisanje projektne prijave, prepoznavanje in načrtovanje vpliva projekta, upravljanje s podatki, zagotavljanje enakosti spolov, upravljanje, finančna, pravna in administrativna podpora, je ključnega pomena za uspešno pridobitev in izvedbo projekta. Junija 2022 smo izvedli anketo, ki je bila namenjena raziskovalcem inštituta. Z njo smo pridobili kvantitativno in kvalitativno analizo storitev projektne podpore, ki so na voljo na IJS.

KLJUČNE BESEDE

storitve projektne podpore, upravljanje, prenos tehnologij, vpliv projekta, javno financiranje

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1 INTRODUCTION

Technology transfer offices and project support offices at the public research organizations are sometimes two units (i.e. National Institute of Chemistry, Slovenia) and sometimes merged in one unit (i.e. KU Leuven, Belgium). Experience in creating impact, management with intellectual property, technical background and good connections with researchers should be values of each technology transfer unit. These kinds of expertise are useful also in preparing R&D project proposals and management of the project consortia. Using national/regional funding is also one of the most common pathways to raise Technology Readiness Level and transfer technology to industry. If technology transfer support and project services are carried out at one unit, a one-stop-shop service can be offered to researchers, which we see as an advantage. Further specialized knowledge in project management is needed, such as legal, financial and other expertise.

2 PROJECT SUPPORT SERVICES

The following project support services are offered at the CTT, JSI.

2.1 Finding right call

Getting a project can result from two options. In the first option the organisation identifies a call, suitable for its expertise and builds a project idea and project partner consortium based on guidelines in the call. The second option occurs when a consortium is already established and the project prepared. In that case the consortium looks for a call that would fit their consortium and project proposal. Often modifications are made in order to correspond to the call.

In both cases a good overview of published and forthcoming calls as well as their conditions and deadlines is needed. This can be delivered to researchers in different ways – using internal database, newsletters, direct communication, etc.

In 2017 CTT established database of research and innovation calls, which is still active [1]. The database is searchable and different filters such as technical field, financer, deadline, opening data, can be applied in order to optimize the set of calls a user is looking for. The database includes calls which are directly relevant for JSI which means that JSI can apply as an applicant. Furthermore, indirectly relevant calls where JSI's role could be in subcontracting are included in the database. The database contains calls published by Slovenian, European and other authorities and bodies. It is designed in a way that calls are automatically archived when the deadline passes. In order to

keep the database up to date, once per month relevant sources are reviewed and new calls inserted in the database. It is offered only to JSI's employees, which is arranged by limited access with institutional Internet Protocol address.
Beside the infrastructure (database) relevant information about the suitable calls should be delivered to researchers. This is done in different ways – through more systematic way using newsletter and mailing lists or for specific technology.
It is necessary that conditions of the calls are studied and most suitable are identified. It is also advisable to establish a link with a contact person or national contact point (usually ministries and agencies) in order to discuss the compatibility of expertise, organisation status and other characteristics with the call. For example, the Horizon Europe programme has a helpful and well organized network of National Contact Points. This is useful for companies as well as research organizations. Usually it is crucial for small companies without experience in project proposals and dedicated units.

2.2 Establishing partnership

Most of the research and innovation projects are done in cooperation with more partners. Sometimes JSI is in position to coordinate the project and in other cases its role is more suitable as a partner, associated partner or subcontractor. The partnership for project proposals can be established with existing partners from past projects or other types of cooperation. It is also good to look for new partners in order to bring new ideas to the project. This can be done in different ways.

Enterprise Europe Network is the largest European network that connects industry with research organizations, operated by the chambers of commerce, technology transfer offices, innovation agencies and similar nodes [1]. Its main tool is a publicly available anonymized brokerage database with business/technology offers/requests as well as partner search publications. Specific guidelines must be followed in order to prepare such publications. This results in well prepared publications so dissemination activities are normally easy and suitable companies, research institutions and other organizations across Europe are quickly informed. CTT-JSI is a member of Enterprise Europe Network and it represents an important tool for establishing partnerships.

Partners can be found also by several other means such as other networks, platforms and communities, brokerage events, direct contact by email/phone – targeted or by e-blast – and other.

Once contacts between possible partners are established, video-call or personal meeting is advised to be organized in order to establish personal relationship and discuss cooperation directly.

The further discussions can require concluding written agreements such as non-disclosure agreements, letters of intent, material transfer agreements etc. which requires legal support in drafting, negotiating and signing such contracts.

2.3 Writing the project proposal

Public authorities expect very well prepared project proposals for published calls. One of the reason is that a financer doesn't want to take the risk of financing unclear and not well planned projects.
A project proposal can be defined in different ways. It can be:

- A document which includes all the information needed by relevant stakeholders to make management decisions.
- A document that transforms an "idea" or "policy" into an effective/doable project.
- A document used to convince a "sponsor" to finance a project or to let you implement it.
- A document which serves as a key management tool ("road-map") for the implementation of a project.

Project proposals of Horizon Europe and other research and innovation funding calls normally consist of three parts: 1) Excellence; 2) Impact; and 3) Quality and efficiency of the implementation. As a rule, researchers prepare scientific parts of the proposal in part 1) and 3). In part 1) it is usually expected to explain also how the data will be managed and how gender equality will be provided. Sometimes also some other non-technical content is expected such as interaction with initiatives, living lab concepts etc. Researchers are often not familiar with these parts. This is usually the case also with chapter 2) Impact.

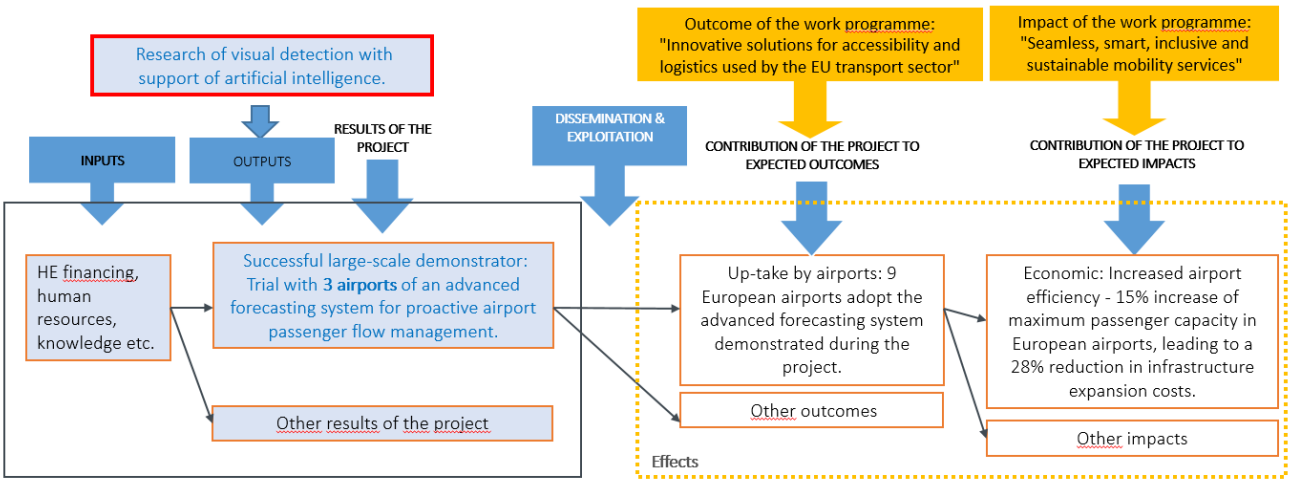

Figure 1: Pathway to impact, example by European Commission [3]

A one-stop-shop service to support these sections of the project is needed. It should be noted that there is no single standardized way/text suitable for all projects. In order to prepare these parts to fit well into the project, suitable partners with relevant expertise should be found and the strategy prepared with effective communication. For a successful project proposal different analysis such as state-of-the art and market analysis should be prepared. Often a research group already has a lot of important information gathered, so having an interview with them is a good start.

2.4 Impact

Generally, a project applicant should describe the qualitative and quantitative impact of the project as well as what measures will be implemented to reach it.

The term impact describes all the changes which are expected to happen due to the implementation and application of a given intervention. Such impacts may occur over different timescales, affect different actors and be relevant at different scales (local, national, etc.). Impact is the last link in the results chain according to the theory of change: inputs–>activities–>outputs(results)–>outcomes–>impact. An illustrative example with artificial intelligence for a forecasting system in airports is shown in Figure 1.

Project proposals usually include scientific, economical, societal, and environmental impacts. Scientific impact includes creating quality new knowledge, strengthening human capital in research and development, and encouraging the spread of knowledge and open science. In EU projects, societal and environmental impacts are expected to be reached by addressing EU policy priorities and global challenges through research and innovation as well as strengthening the acceptance of research and innovation in society. Economic impact involves creating growth based on innovation, creating more and better jobs, and utilization of investments in R&I.

In order to achieve expected impact, suitable measures must be taken. Dissemination, communication and exploitation must be effective and well coordinated. Public dissemination and communication is normally an obligation in publicly funded projects. This request is reasonable, since the public (including relevant stakeholders) funds the research and development activities and should be informed about them. The Open Science principles are gaining on importance. Not just publications about research, but also related data that was acquired during the project is expected to be published. With the help of open science, all stakeholders in society will gain important access to knowledge.

Communication activities are constantly changing and adapting to new trends. In the past, physical promotion materials such as flyers and brochures were more significant. Nowadays, social networks, new internet platforms and other forms are gaining importance. This trend was accelerated during the COVID19 pandemic.

Although dissemination is expected from project partners, suitable protection of intellectual property (IP) and exploitation of results should also be accomplished. In order to accomplish both dissemination and protection of IP, the best way is to file patent applications for developed inventions. Sometimes the generated knowledge is not patentable or patent protection is not reasonable. In case such know-how has a big commercial value or is expected to have one, it should be protected as a secret know-how. Important part of exploitation activities is to have a suitable business model, partners and end-users which are interested in accepting new technologies.

2.5 Data management

In comparison with Horizon 2020 projects, it is expected to better manage data in Horizon Europe projects. The data management should follow FAIR (Findable, Accessible, Interoperable, Reusable) principle. Already in the project proposal, the project consortium should have a good picture of what type and size of

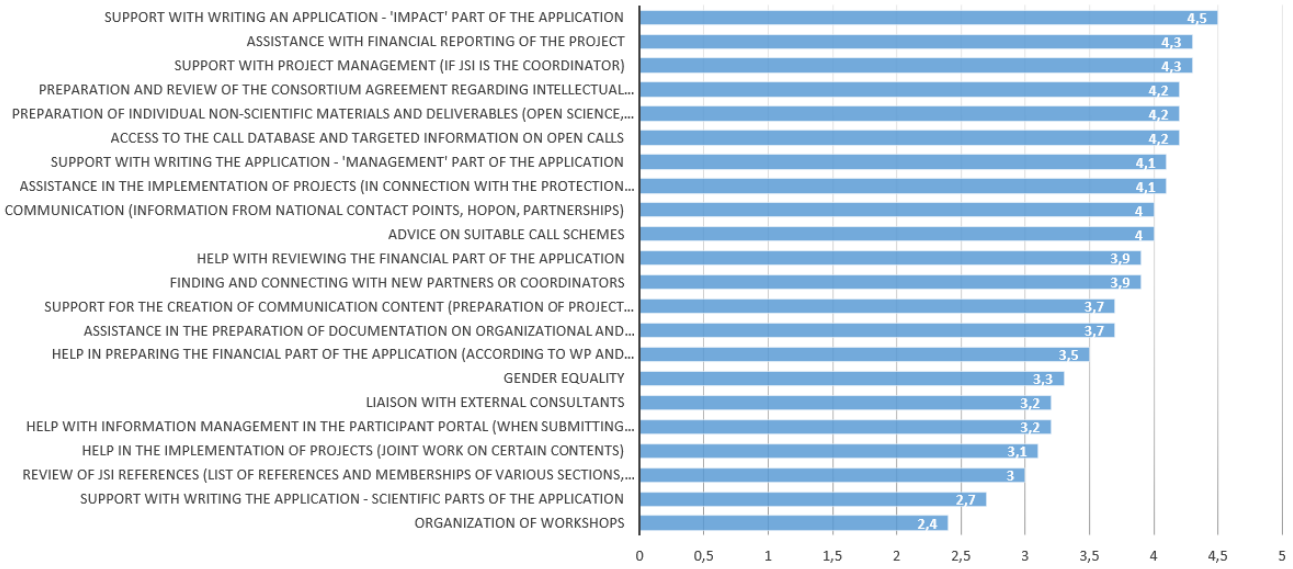

Figure 2. Need for project support service by JSI researchers according to internal survey

data will be generated in the project. The data generated in laboratories and other locations should be well structured and labelled. Metadata should be generated. An appropriate trustworthy repository with possibility to assign persistent identifiers should be chosen and used to upload the data. Good practices for these activities are advised to be reviewed and followed. By consistent upload of data to repository, an effective dissemination is accomplished. These activities should be well aligned with IP protection strategy. An important aspect is also safety which has to be assured in order to protect sensible data including personal data from cyber attacks.

2.6 Gender equality

Articles 2 & 3 of the Treaty of Amsterdam (1997) and other EU policy directives (i.e. COM (96) 67 final) foresee principles of gender mainstreaming which should be incorporated in every project [4], [5]. Gender equality in projects is targeted in two ways. Firstly, the consortium team is expected to be gender balanced in the terms of equal number of women and men. Secondly, the content of the project must take into account gender balance. An example is assuring gender balance of tested persons in clinical trials during validation of a new drug. Another example would be to design an algorithm for car safety which corresponds to a man and woman driver. Gender equality is also empowered by stimulation to establish a gender equality plan. Beginning with Horizon Europe calls in 2022, public bodies, research organisations or higher education establishments (including private research organisations and higher education establishments) must have an established gender equality plan [6]. Different projects, initiatives and platforms such as ATHENA, RePower Women are established to promote gender equality [6], [8].

2.7 Management, financial and administrative support

Management of the project is an important task in performing the project, especially for a coordinator. Planning, monitoring, executing and reporting are activities which should be mastered by a good manager. In case of bigger projects, tasks should be divided and researchers should be supported with management. Different IT tools can be used for the management such as Microsoft Project. Finances should be well planned and expenditure tracked.

3 DEMAND FOR SERVICE, SURVEY AT THE JSI

In June 2022 we performed a survey, in which we asked JSI researchers which project support services they use and by which JSI's unit, which services are important to them and what improvements do they suggest for the future. 44 researchers have filled out the survey. 90% of them expressed their need for support and 95% said that they would like to have an overview of services available at the JSI.

Figure 2 shows the rate of importance of each service for researchers on scale 1-5, where 1 is not important and 5 is very important. As most important the researchers have identified support with the writing section 'impact', assistance with financial reporting and support with project management when JSI is coordinator.

Table 1. Project support of different units at the JSI. Service providers at the JSI in the survey were as follows: U1 - Director's Office; U6 - International Project Office; CTT; SRIP TOP - Strategic Research & Innovation Partnership Factories of the Future; SRIP PMiS - Strategic Research & Innovation Partnership Smart Cities and Communities. Other*: 1) They haven't needed help so far. 2) They were not aware of the possibility of internal assistance. 3) Help from external consultants. 4) They did not apply to this group of calls. ERC - European Research Council; EIC - European Innovation Council; MSCA - Marie Skłodowska-Curie Actions; ESA - European Space Agency; ARRS - Slovenian Research Agency; MIZŠ - Ministry of Education, Science and Sport; MGRT - Ministry of Economic Development and Technology.

	TOP 3 service providers at the JSI			Other*
ERC calls	U1	U6	CTT	
	26%	19%	7%	48%
Horizon Europe Pillar 2	CTT	U6		
	30%	22%		48%
Horizon Europe Pillar 3 (EIC, Pathfinder, ...)	CTT	U6		
	32%	5%		63%
MSCA scheme	CTT	U6	U1	
	24%	13%	3%	60%
Other schemes (ESA, Hop on, ...)	CTT	U6	SRIP TOP	
	31%	6%	3%	60%
ARRS calls	CTT	U1		
	21%	3%		76%
Calls of MIZŠ/MGRT and other Slovenian agencies and ministries	CTT	SRIP TOP		
	32%	3%		65%
Calls of other agencies	CTT	U6	SRIP TOP	
	21%	13%	5%	64%

We were also interested to get feedback from surveyees, from which units at the JSI they get most support for a specific group of projects. The results are shown in Table 1. Based on the survey, major project support providers are CTT, U6 and U1 and in a smaller portion SRIP TOP. The notable results not shown in Table 1 are following: There is no need for support within the JSI: most prominently in ARRS calls (49%), MIZŠ/MGRT calls and other Slovenian agencies and ministries (39%), and projects from other agencies (21%). Researchers are familiar with the possibility to turn to someone within the JSI for help: between 93% (ERC calls) and 77% (ARRS calls). Use of external consultants' services is following: a) mostly for Horizon Europe 3rd pillar (EIC, Pathfinder) and the ARRS scheme (8%) b) rarely for MIZŠ/MGRT calls and other Slovenian agencies and ministries (3%). When external consultants were sought, researchers used different approaches to find them (Figure 3).

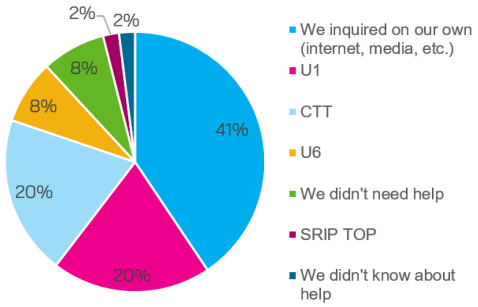

Figure 3. Looking for external consultants to prepare the project application

44% of researchers expressed their willingness to participate in the design of future project support at the JSI. They also proposed some suggestions for improvements:

- Better definition of the services of individual providers of project support services at the JSI.

- Providing comprehensive support in the "non-scientific" parts of the application (impact, finance, GEP, promotion) and faster response regarding contracts (e.g. NDA).
- Possibility of internal review of the entire project application and advice for improvements by a person with experience in EU project reviews. List/analysis of the most common reasons for project rejection.
- Better support in the financial part of the project, review of finances, consulting for certain types of projects
- Support in finding suitable calls (which are more suitable, in what composition of consortia, which are the priority topics).

Main findings of the survey are that (i) researchers need support with project management, (ii) CTT is recognized as the main service provider, but also other units at the JSI are very important, (iii) project support services of JSI's units should be better represented and communicated.

The pre-grant project support services provided by CTT are currently not charged to researchers. Financing of this is not adequately addressed and is expected to be properly resolved. In October 2022 Slovenian Ministry of Education, Science and Sport published a call for project support service, which is a good start to improve this field.

ACKNOWLEDGMENTS / ZAHVALA

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REFERENCES

[1] OVERVIEW AND SEARCH OF CURRENT PUBLIC CALLS. Center for Technology Transfer and Innovation at the Jožef Stefan Institute. Available 2.9.2022 on webpage http://tehnologije.ijs.si/?page_id=3028

[2] ENTERPRISE EUROPE NETWORK. Available 2.9.2022 on webpage https://een.ec.europa.eu/

[3] Horizon Europe Programme Guide. Version 2.0. 11 April. Available 30.8.2022 on webpage https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/programme-guide_horizon_en.pdf

[4] Treaty of Amsterdam amending the Treaty on European Union, the Treaties establishing the European Communities and certain related acts - Contents Official Journal C 340, 10/11/1997 P. 0001 – 0144

[5] COMMUNICATION FROM THE COMMISSION "INCORPORATING EQUAL OPPORTUNITIES FOR WOMEN AND MEN INTO ALL COMMUNITY POLICIES AND ACTIVITIES Available 2.9.2022 on webpage https://op.europa.eu/en/publication-detail/-/publication/3fc7ca58-d2a7-418c-b02d-1f075b50619c/language-en

[6] Horizon Europe Work Programme 2021-2022. 13. General Annexes. (European Commission Decision C(2022)2975 of 10 May 2022). Available 2.9.2022 on webpage https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/wp-call/2021-2022/wp-13-general-annexes_horizon-2021-2022_en.pdf

[7] Implementing gender equality plans to unlock research potential of RPOs and RFOs in Europe (ATHENA). Grant agreement ID: 101006416. European Commision. Available 2.9.2022 on webpage https://cordis.europa.eu/project/id/101006416

[8] RePower Women. Possibilities for Women in Technologies and Innovation. Available 2.9.2022 on webpage https://www.gov.pl/web/ncbr-en/repower-women-possibilities-for-women-in-technologies-and-innovation

Challenges of Legal and Regulatory Framework for Blockchain Technology in the EU

Izzivi zaščite tehnologije veriženja podatkovnih blokov v EU

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ABSTRACT

While blockchain is one of the crucial emerging technologies shaping Europe's digital future, blockchain protection in the domain of IPR is not clearly defined. This status quo, therefore, necessitates an examination of this field – to arrive at a clear legal basis which would regulate blockchain technology protection it is necessary to define and address the crucial points. The following paper presents the challenges of blockchain protection in the EU. It starts by introducing blockchain technology from theory to practice, followed by the existing conditions of the current legal and regulatory framework and the most common challenges for blockchain technology protection, and concludes with proposals for further research in this field.

KEYWORDS

Blockchain Technology, Intellectual Property Rights (IPR), Protection, Challenges, EU

POVZETEK

Četudi je blockchain tehnologija oz. tehnologija veriženja podatkovnih blokov na eni strani ena izmed ključnih (še vedno nastajajočih) tehnologij, ki oblikuje digitalno prihodnost Evrope, na drugi strani njena zaščita na področju pravic intelektualne lastnine še vedno ni povsem jasno opredeljena. Da bi v prihodnosti prišli do vsem deležnikom jasne pravne podlage, ki bi urejala zaščito tehnologije veriženja podatkovnih blokov, je zato treba opredeliti in obravnavati najpomembnejše kritične točke. V prispevku predstavljamo izzive na področju zaščite tehnologije veriženja podatkovnih blokov, ki jo predvideva trenutni pravno-formalni okvir EU. Najprej se osredotočamo na tehnologijo veriženja podatkovnih blokov od teorije do prakse, nato na obstoječe pogoje veljavnega pravno-formalnega okvira ter najpogostejše izzive pri zaščiti, na koncu pa podajamo predloge za nadaljnje kritične točke, ki zahtevajo raziskave tega področja.

KLJUČNE BESEDE

Tehnologija veriženja podatkovnih blokov, pravice intelektualne lastine, zaščita, izzivi, EU

1 INTRODUCTION

Blockchain technology as one of the technologies of Industry 4.0 significantly affects how businesses operate while revolutionizing numerous innovation ecosystems[1] [1].

In 2018, 21 Member States and Norway agreed to sign a declaration to establish a *European Blockchain Partnership* (EBP) and to work together to establish a *European Blockchain Service Infrastructure* (EBSI) to support the delivery of cross-border digital public services with the highest standards of security and privacy. Since then, eight more countries have joined the partnership [3]. EBP nowadays consists of the EU 27 Member States, Liechtenstein, and Norway.

The European Union (EU) and Europe have taken a step forward in balancing the legal, regulatory and policy frameworks of the EU Member States in crypto assets [4]. In 2020, the European Commission (EC) has published a new proposal for "*Regulation of the European Parliament and the Council on markets in crypto assets*" [5]. This proposal is part of the *Digital Finance Package*, a comprehensive package of measures to further enable and support the potential of digital finance in terms of innovation and competition while mitigating risks [6]. In addition to the proposal, the *Digital Finance Package* also includes a proposal to pilot the regulation of market infrastructures using "*Distributed Ledger Technology*" (DLT), a proposal for digital operational resilience and a proposal to clarify or amend specific related EU financial services rules. The EC's priorities ensure that the EU regulatory framework for financial services is innovation-friendly and does not produce barriers to use of new technologies. The proposal to pilot DLT regulation represents the first concrete action in this field. [4]

The World Intellectual Property Organization (WIPO) points out that blockchain technology affects all industries and it is in the interest of the intellectual property (IP)

[1] Given that this paper is written in the context of the innovation ecosystem it should be understood as the evolving set of actors, activities, and artifacts, the institutions and relations, including complementary and substitute relations, that are important for innovative operation of an actor or a population of actors [2].

community to investigate the impact of blockchain technology on IP and to find appropriate models for the application of blockchain technology in the field of IP [7].

Blockchain technologies impact every industry and have been extensively used in IP; the WIPO Member States have established a blockchain technology task force under the *Committee on WIPO Standards* (CWS). Its purpose is to develop reference models for the use of blockchain technology in the field of IP and to propose a new WIPO standard that would support the potential use of blockchain technology in IP ecosystems. [1]

Even though blockchain technology is recognized as a technology with a relatively low maintenance cost, increased transparency, reduced administrative burden, resilience to fraud, and as versatile technology deployed in many sectors and businesses [8]; there are crucial questions which guide us in this review-oriented paper:

1. How is blockchain technology prepared for IP?
2. How is IP prepared for blockchain technology?
3. How can blockchain technology help protect IP?

Irrespective of the three questions above and crucial for the paper is the status quo, as follows: the number of inventions involving blockchain technology (in the EU) is increasing [9]. At the EU level, those responsible for this field have taken this status quo seriously – even though the growth of blockchain patent applications started in 2016.

The official beginnings of blockchain technology protection in the EU date back to 2018 when the European Patent Office (EPO) organized the first conference on blockchain technology [9]. At the conference, the EPO expressed its desire for organization of blockchain technology to ensure that patent-granting authorities grant blockchain patents that are legally robust in a predictable manner [9]. The EPO has highlighted computer-implemented inventions (CII) as the challenge researchers in this field face today regarding IPR. When we talk about blockchain inventions, we are talking about CII. The EPO has therefore developed stable criteria in this respect based on the case law on CII. "*Blockchain patent applications*" refer to a group of generic patent applications related to blockchain technology [9]. This group can be divided into two sub-groups:

1. patent applications related to core blockchain technologies (e.g., public key decryption, access control and block construction), and
2. patent applications related to application (use) of blockchain technologies (e.g., drug tagging, audit registration and food tagging).

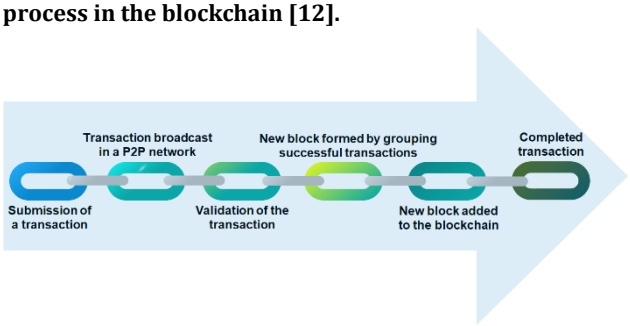
In the following part of paper we, therefore, pay attention to both sub-groups – chapter 2 contains the introduction of blockchain technology from theory to practice.

2 BLOCKCHAIN TECHNOLOGY: FROM THEORY TO PRACTICE

Based on the available peer-review literature, blockchain technology can be defined as [10]: "A distributed database, which is shared among and agreed upon a peer-to-peer network. It consists of a linked sequence of blocks, holding timestamped transactions secured by public-key cryptography and verified by the network community. Once an element is appended to the blockchain technology, it cannot be altered, turning a blockchain technology into an immutable record of past activity". The concept of decentralized blockchain technology has been firstly introduced by Satoshi Nakamoto in 2008 to provide technological support for Bitcoin – a peer-to-peer (P2P) electronic cash system [11].

A schematic illustration of the blockchain technology basics is shown in Figure 1, based on a very general introduction [12]. One can broadly define blockchain technology as a distributed system to record transactions. After a transaction is issued, it is announced inside the P2P network made of nodes that record transactions in blockchain technology. The validator nodes decide if the transaction is valid or not based on the consensus protocol, i.e., a set of defined rules implemented by all nodes that regulate how new transactions are added. If the transaction is deemed valid, it is grouped with other recently approved transactions inside a new block linked to the previously approved block. A completed transaction is made public on blockchain technology.

Figure 1: The flow of the transaction confirmation process in the blockchain [12].



The primary and most known application of blockchain technology is in the field of cryptographic digital currency. There are over 10 thousand cryptocurrencies as of 2022 [13] (Figure 2a) with the total market cap of all currencies reaching more than 1 trillion dollars (as of August 2022 [14]). The two leading cryptocurrencies Bitcoin (BTC) and Etherium (ETH) alone both have market caps above 200 billion dollars and have a market share of 38 % and 19 %, respectively (Figure 2b). These data show a growth of blockchain-based cryptocurrencies.

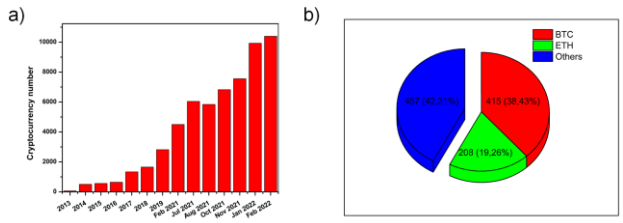


Figure 2: a) Number of cryptocurrencies and b) market cap (in billion dollars) of Bitcoin and Etherium, together with their respective percentages of the total market cap (as of August 2022) [13, 14].

Since the technological benefits of blockchain technology can be implemented into many services, it has stimulated the interest of many industries. Some proposals for applications of blockchain technology also include [15] the Internet of Things (IoT), Healthcare, Supply Chain and even Tourism [16]. However, despite the growing interest, there are few business solutions [17]. Examples of promising live blockchain solutions are presented in Table 1.

Slovenia is, for example, recognized worldwide for its blockchain companies. The Member State promotes its economy as "Green, Creative, Smart" and one that leans towards higher adoption of blockchain technology. Slovenia ranks second in the world for the number of searches for the term Initial Coin Offering (ICO) – surpassed only by Singapore. The country is also home to the second-largest bitcoin scene within Europe based on Google search queries. [4]

Table 1: Examples of successful blockchain technology applications outside cryptocurrencies [17, 20, 21].

Name	Application Field	Reference
TradeLen	Supply Chain	[17]
Solve Care	Healthcare	[20]
Slock.it	IoT	[21]

One of the reasons for this backlog in other areas is that – from a development point of view – blockchain technology is in its early rudimentary stage, still actively seeking new cryptographic algorithms to build reliable, flexible, secure, and stable systems [18]. Another issue is the handling of sensitive data that is highly regulated to ensure the privacy of the customer (for example medical patients). Thus, for blockchain applications to operate within the EU, they are required to be compliant with regulatory frameworks such as General Data Protection Regulation (GDPR) [19].

The status quo in this field is presented in the following chapter no. 3.

3 STATUS QUO OF LEGAL AND REGULATORY FRAMEWORK FOR BLOCKCHAIN TECHNOLOGY IN EU: CHALLENGES

The EU is convinced that blockchain technology can play a crucial role in building Europe's Single Digital Market and drive essential market innovations. If blockchain-enabled markets are to mature, policymakers and businesses must create the rules of engagement together [22]. EC emphasizes that the EU supports an EU-wide rule for blockchain to avoid legal and regulatory fragmentation. The EC, therefore, adopted a comprehensive package of legislative proposals for regulating crypto-assets to increase investments and ensure consumer and investor protection. This package updates specific financial market rules for crypto-assets and creates a legal framework for regulatory sandboxes of financial supervisors in the EU for using blockchains in trading and post-trading securities. [23]

As noted by Timsit and Herian (2019), while the overall goal in the EU is clear, there is the crucial question of how to achieve the goal [22]. These proposals in the context of legal and regulatory relate, as a matter of priority, to the need for legal and regulatory clarity for blockchain technology and less to blockchain protection – a field with recognized challenges. We therefore briefly present some of these challenges which from our perspective are crucial for clarifying legal and regulatory framework in the future [22]:

1. *Challenge no. 1: Legal Value of Blockchain Technology as Registers*
   This challenge assumes the prerequisites for blockchains acquiring legal status would be the legal recognition of blockchain-based signatures, timestamps, validations, and "documents".
2. *Challenge no. 2: Territoriality*
   This challenge assumes that cross-jurisdictional harmonization is crucial. In turn, it requires regulators and legislators to work together across borders to harmonize legal and regulatory regimes and manage potential risks, including monopolies and market manipulation. Addressing them would require significant legal and organizational changes and a cooperation mechanism to ensure harmonization.
3. *Challenge no. 3: Enforceability*
   This challenge assumes the possibility of pseudonymity and, in some cases, complete anonymity in blockchains has given rise to the impression in some quarters that they can be used to create law-free zones for the benefit of criminals.
4. *Challenge no. 4: Liability*
   This challenge assumes core developers make attractive access points for enforcement laws and regulations. Depending on their role in the design, development, and maintenance of the blockchain platform, they are also accessible enforcement targets for accountability issues. Although it is generally – not always – possible to identify the actors in a blockchain network, this takes time and effort and is therefore not always practical. This can consequently be an obstacle to enforcing accountability for actors in blockchain-based networks.
5. *Challenge no. 5: Data Protection*
   Although the GDPR is supposed to consider significant developments in the field of the online world, it was written before blockchain was implemented and was therefore designed with more traditional, centralized data processing paradigms. This has led to, what many believe,

several tensions between blockchains and the GDPR.

6. *Challenge no. 6: Competition*
   Should competition policy be implemented, new norms or tools will depend on the nature and effects of economic activity that will take place in blockchains. No two cases are likely to be the same, so in any case the assessment of competition law will depend entirely on the specific circumstances of each blockchain and the relevant market.

As blockchain technology becomes increasingly widely used to support new types of decentralized applications and platforms, legislators and regulators will increasingly be confronted with the complex issues dictated by the above challenges [22]. The challenges illustrated above undoubtedly result in challenges related to the protection of blockchain technology – especially when it comes to the following cases where we address CII:

1. Patent applications related to core blockchain technologies, and
2. Patent applications related to application (use) of blockchain technologies.

As a reminder, the CII presents any invention that involves the computer, computer network, or other programmable apparatus, the invention having one or more features that are realized wholly or partly using a computer program or computer programs [24]. In the EU there is still no appropriate legal instrument governing such inventions which are highly specific and for which demonstrating technical contribution and industrial applicability may pose different interpretations – for the inventor and the end user. The lack of such a legal and regulatory framework results, among other things, in challenges related to blockchain technology protection.

There is no single legal and regulatory framework for protecting intellectual property rights and this can lead to potential disputes between different countries. Blockchain technology does not necessarily provide a check on the integrity of the information initially entered – it only provides assurances that this information has not been compromised or altered. [25]

At the outset, a certain level of internal trust needs to be established between the parties to ensure that there are no underlying issues with the original information that triggered the blockchain. As industries continue to rely on blockchain technology, IP law will need to address the relevant legal issues arising from this new "language" of authentication and verification. [25]

Although the idea of creating a more efficient blockchain-based system for managing and monetizing IPR is still new, new applications of blockchain-based IPR management continue to emerge with remarkable frequency. However, several issues remain unresolved, such as the necessary processing power of blockchains, the compatibility and interoperability of different blockchain platforms, and legal issues such as data ownership, privacy, liability, and jurisdiction. [8]

4 CONCLUSION

While blockchain technology has already demonstrated its potential to be one of the promising emerging technologies, its legal and regulatory foundation is still in the early phase of development.

From the EU perspective, the crucial challenge is the lack of a single legal and regulatory framework for protecting IP, resulting in disputes between countries.

While it is difficult to predict all potential IP-related applications of blockchain technology (especially if we don't know all the pitfalls of IPR), we found three specific fields of application pertinent to technology transfer and IP professionals and relevant for our further work [8]:

1. Blockchain technology can help with IP rights management and technology transfer and commercialization practices.
2. Blockchain as an IP registry.
3. Establishing authorship, proving ownership and provenance of creative works.

Although the idea of creating a more efficient blockchain-based system for managing and monetizing IPR is still new, new applications of blockchain-based IPR management continue to emerge with remarkable frequency [8].

However, several challenges remain unresolved, especially the necessary processing power of blockchains, the compatibility and interoperability of different blockchain platforms, legal issues such as data ownership, privacy, liability, and one of the crucial challenges – jurisdiction [8].

However, on the one hand, it should also be borne in mind that technology transfer created using blockchain technology positively impacts company performance. In 2021, Ceptureanu and colleagues, in a study entitled '*Influence of Blockchain Adoption on Technology Transfer, Performance and Supply Chain Integration, Flexibility and Responsiveness: A Case Study from IT&C Medium-Sized Enterprises*' showed that entrepreneurs have a perception that the adoption of blockchain technology will help them increase technology transfer, they will have better traceability of research, development and production phases, and reduce the likelihood of technology transfer failures that can lead to better business performance [26].

On the other hand, Technology Transfer Offices (TTOs) are closely involved in technology and knowledge transfer activities and, as such, are key link members between research organizations and companies. We believe TTOs based on their experience in helping researchers with inventions, IP protection and capitalization of inventions could also contribute to the development of legal and regulatory frameworks. Initially, could provide practical examples of researchers developing CIIs and thus contribute to a constructive decision-making process on the future of blockchain technology protection in the EU. However, it would be necessary to further explore how they could contribute to the development of legal and regulatory frameworks at the EU level with their knowledge and experience. Undoubtedly, we would like to explore this further in the remainder of this work.

REFERENCES

[1] World Intellectual Property Organization. 2022. *Blockchain Technologies and IP Ecosystems: A WIPO White Paper*. https://www.wipo.int/export/sites/www/cws/en/pdf/blockchain-for-ip-ecosystem-whitepaper.pdf

[2] Granstrand, O. and Marcus Holgersson. 2020. Innovation Ecosystems: A Conceptual Review and the New Definition. *Technovation* 9–91 (2020), 3. DOI: https://doi.org/10.1016/j.technovation.2019.102098

[3] European Commission. 2018. *European Countries join Blockchain Partnerships*. https://digital-strategy.ec.europa.eu/en/news/european-countries-join-blockchain-partnership

[4] EU Blockchain Observatory and Forum. 2021. *EU Blockchain Ecosystems Developments. A Thematic Report*. https://www.eublockchainforum.eu/sites/default/files/reports/EU%20Blockchain%20Ecosystem%20Report_final_0.pdf

[5] European Commission. 2020. *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Markets in Crypto-assets, and amending Directive (EU) 2019/1937*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020PC0593

[6] European Commission. 2020. *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on digital operational resilience for the financial sector and amending Regulations (EC) No 1060/2009, (EU) No 648/2012, (EU) No 600/2014 and (EU) No 909/2014*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52020PC0595

[7] World Intellectual Property Organization. 2022. *Blockchain and Intellectual Property*. https://www.wipo.int/cws/en/blockchain-and-ip.html

[8] Stankovich, M. 2021. *Is Intellectual Property Ready for Blockchain?* https://dai-global-digital.com/is-intellectual-property-ready-for-blockchain.html

[9] Coppenholle, F. W. 2022. *Protection of Blockchain Innovations in European Union*. https://www.lexology.com/commentary/intellectual-property/european-union/gevers/protection-of-blockchain-inventions-in-european-union

[10] Seebacher, S. and Ronny Schüritz. 2017. *Blockchain Technology as an Enabler of Service Systems: A Structured Literature Review*. In Proceedings 8th International Conference on Exploring Service Science, IESS 1.7 (pp. 12–23). Cham, Switzerland: Springer. DOI: https://link.springer.com/chapter/10.1007/978-3-319-56925-3_2

[11] Nakamoto, S. 2008. *Bitcoin: A Peer-to-Peer Electronic Cash System (White Paper)*. https://bitcoin.org/bitcoin.pdf

[12] Ghiro, L., Restuccia, F., D'Oro, S., Basagni, S., Melodia, T., Maccari, L. and Renato L. Cigno. 2021. *What is a Blockchain? A Definition to Clarify the Role of the Blockchain in the Internet of Things*. https://arxiv.org/abs/2102.03750

[13] Statista. 2022. *Number of Cryptocurrencies Worldwide from 2013 to February 2022*. https://www.statista.com/statistics/863917/number-crypto-coins-tokens/

[14] CoinMarketCap. 2022. *Today's Cryptocurrency Prices by Market Cap*. https://coinmarketcap.com/

[15] Abou Jaoude, J. and Raafat G. Saade. 2019. Blockchain Applications – Usage in Different Domains. *IEEE Access*, 20 (2019), 45360–45381. DOI: https://ieeexplore.ieee.org/document/8656511

[16] Peceny, U. S., Urbančič, J., Mokorel, S., Kuralt, V. and Tomi Ilijaš. 2019. Tourism 4.0: *Challenges in Marketing a Paradigm Shift*. In Consumer Behavior and Marketing, IntechOpen, 1–19 DOI: http://dx.doi.org/10.5772/intechopen.84762

[17] Jensen, T., Hedman, J. and Stefan Henningsson. 2019. How Tradelens delivers Business Value with Blockchain Technology. *MIS Quarterly Executive*, 18 (4), 221–243. DOI: https://aisel.aisnet.org/misqe/vol18/iss4/5

[18] Cherukupally, S. 2021. Blockchain Technology: Theory and Practice. *Handbook of Statistics*, 44 (2021), 75–103, Elsevier. DOI: https://www.sciencedirect.com/science/article/abs/pii/S0169716120300456?via%3Dihub

[19] Rieger, A., Lockl, J., Urbach, N., Guggenmos, F. and Gilbert Fridgen. 2019. Building a Blockchain Application that Complies with the EU General Data Protection Regulation. *MIS Quarterly Executive*, 18 (4), 263–279. DOI: https://aisel.aisnet.org/misqe/vol18/iss4/7/

[20] Solve Care. 2022. *Blockchain Platform for Digital Health Networks*. https://solve.care/

[21] Bahga, A. and Vijay K. Madisetti. 2016. Blockchain Platform for Industrial Internet of Things. *Journal of Software Engineering and Applications*, 9 (10), 533–546. DOI: 10.4236/jsea.2016.910036

[22] Timsit, T. and Robert Herian. 2019. Legal and Regulatory Framework of Blockchains and Smart Contracts. A Thematic Report prepared by the European Union Blockchain Observatory and Forum. https://www.researchgate.net/publication/344338974_LEGAL_AND_REGULATORY_FRAMEWORK_OF_BLOCKCHAINS_AND_SMART_CONTRACTS

[23] European Commission. 2022. *Legal and Regulatory Framework for Blockchain*. https://digital-strategy.ec.europa.eu/en/policies/regulatory-framework-blockchain

[24] Fric, U. and Nina T. Starc. 2020. *Computer-Implemented Inventions: From the Patent to the Copyright*. 13th International Technology Transfer Conference. http://library.ijs.si/Stacks/Proceedings/InformationSociety/2020/IS2020_Volume_E%20-%20ITTC.pdf

[25] Arseven, M. 2021. *The role of Blockchain Technology in Intellectual Property Protection*. https://www.lexology.com/library/detail.aspx?g=512ab4b1-d234-4962-a4ff-0f4836618db9

[26] Ceptureanu, C. U., Cerqueti, R., Alexandru, A., Popescu, D. I., Dhesi, G. and Eduard-Gabriel Ceptureanu. 2021. Influence of Blockchain Adoption on Technology Transfer, Performance and Supply Chain Integration, Flexibility and Responsiveness: A Case Study from IT&C Medium-Sized Enterprises, *Studies in Informatics and Control*, 30 (3), 61–74. DOI: https://doi.org/10.24846/v30i3y202106

Technology Transfer: Start and Stop of Deep Well Pumping Through GSM System

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ABSTRACT

The aim of this project was to create a long-distance control through a cell phone in order to turn on a water pump or any kind of machine. The present work documents the low-cost technology transfer (TT) project of a three-phase deep-well pumping system for drinking water supply at the Technological University of Tecamachalco, (TUT) this project was achieved through the collaboration of teachers and students of the Technological University of Tecamachalco of the Mechatronics career, in itself of daily interaction, focused on solving a need for the benefit of the university community, taking advantage of the experience of the teachers and the impetus and attitude of the students who collaborated, It also managed to make learning significant and thereby strengthen professional academic training, successfully achieving and, where appropriate, reproducibility of the project. It is important to mention the use of the Arduino platform and devices for the design and development of the project with which the cost was accessible, since for budget reasons it was necessary to optimize economic resources.

KEYWORDS

GSM Communication, Arduino Platform, Technology Transfer.

1 INTRODUCTION

The development of collaborative projects in the Public Higher Education Institutions (PHEI, where the collaboration of teachers and students, to obtain both an academic impact and also solve a need, is usually not very common, especially because of the economic cost and the lack of resources. However, when the project and the appropriate materials are chosen to cover a need, the project turns out to be viable. The project developed in collaboration between students and teachers, was an automated start-up system via remote using (Global System for Mobile Telecommunications GSM technology, for a three-phase deep well pumping equipment, which is a considerable distance away, and which supplies drinking water to the Technological University of Tecamachalco*. At first place, the importance of the TT, the concept, and the considerations to have according to different authors and perspectives, the communication system via GSM is described. Then, its characteristics as, applications, standards, and their comparison with other communication protocols. Finally, the methodology for the development of the project is described, starting with the identification of the problem, the bibliographical research, the technical proposal of the solution, the operation tests, improvement actions and finally the start-up of the communication and control system for the deep well three-phase pumping equipment. In conclusion, the commissioning of the system was successfully achieved, remaining in operation without any problems except for a failure of the GSM network and a power outage, which makes it necessary for the system to be restarted.

2 TECHNOLOGY TRANSFER

TT is strongly related to knowledge transfer. [1] The country's public PHEI seek, to the extent of the availability of material and human resources, to promote the development of the area of influence, and to achieve this effectively, it is necessary to efficiently carry out technology transfer activities, all PHEI must distinguish the next five items [2]

• The generator of knowledge or technology, being the institution that has generated and seeks its transfer.

• The beneficiary of the knowledge, in this case the beneficiary will be some public institution if the objective of the project is a social benefit

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• The resources used to carry out the transfer, which can be a license, creation of a company, etc.
• The object of transfer, which can be scientific knowledge, equipment, know-how, etc.
• The intermediary agent, which is the body in charge of putting the parties in contact.
• The facilitators of the process, being the institutions that do not intervene directly in the transfer process, but that stimulate or service it. [3]
Technology transfer can take place between universities, companies, government in a formal and informal way with the aim of sharing skills, knowledge, technology, manufacturing processes and more. [4]

2.1 Communication System through GSM System (global system for mobile communication)

They are digital systems capable of supporting voice, short messages (SMS) and data transmission, which allows; large user capacity, wide coverage, efficient use of the spectrum, based on cellular technology, allows the use of a SIM card (Subscriber Identity Mode). At the moment GSM cells are not being deactivated, there are too many security and automation applications based on this technology, [4] in use, in Figure 1 we can see the characteristics of the different technologies.

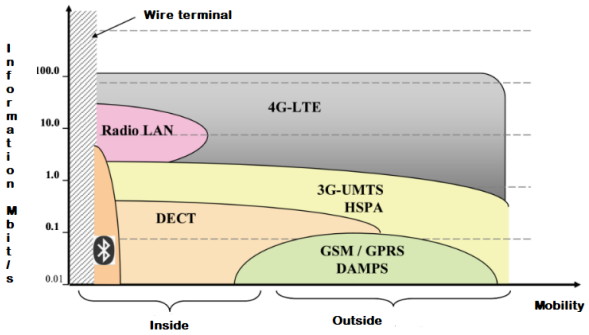

Figure 1: Standards used for Mobile communications (taken from Mobile Communications. GSM, UMTS and LTE Systems, José Manuel Huidobro Moya)

2.2 Arduino Platform

It is a low-cost, free access technology that allows the implementation of electronic projects through the use of predesigned boards, with the advantage of using free access software. It has a graphical development environment that uses a processing/wiring programming language and a bootloader; (IEEE specctrum 2011) regarding the hardware is composed of a microcontroller and input and output ports, through the Arduino IDE (Integrated Development Environment) software. [6] It is possible to develop automation projects, one of the disadvantages that it presents is that when using free access tools, it is not possible to patent a development based on this type of platform, it is recommended for its low cost and a not so complex operation, such as integrating components to be able to make a control card at the same time. Customized and with a unique design, it can be programmed in Windows, macOS and GNU/Linux.
A project that promotes the philosophy 'Learning by doing' (Interactive Design Institute of IVREA) [6]

3 METHODOLOGY

3.1 The Problem

The area where the Technological University is located is part of the Tecamachalco Valley aquifer, according to data from the National Water Commission (CONAGUA), the aquifer has severe problems of contamination, overexploitation. For this reason, it is considered a water risk, so it is important to consider actions for water care, in the case of the University to have a constant supply. Actions have been considered to supply water for the service of the students and collaborators of the University, at some point water pipes were bought, but the cost was high and the supply insufficient, so it was considered to bring the water from a well that is removed from the premises.
This implies that University personnel will have to travel to put into operation and after supplying the vital liquid return to close the well, this gives an opportunity for Mechatronics career collaborators and students to collaborate on a knowledge transfer proposal. that implies the collaboration between teachers, students and the administration to carry out the implementation of a solution that simplifies the task of turning the well on and off.
In figure 2, in the first stage the students supported by a teacher, identify the problem, analyze the solution and make the technical proposal, in the next stage the proposal is compared with the existing technical solutions and a feasibility analysis is carried out. Finally, once the proposal is made, the prototype is made, functionality tests and experimental tests are carried out to detect areas for improvement, once the prototype is tested, it is implemented in the system to be solved.

Figure 2: Development process diagram

3.2 Starting and stopping system of a pumping system via GSM, based on the Arduino Platform

Due to the need to bring the water supply to the University from a considerable distance, a remote start-up system is necessary for the personnel in charge of maintaining the water service to the facilities from their cell phone with wireless technology. [8]

Therefore, the objective of the technology transfer project is to develop a remote control system based on the GSM communication platform capable of turning on the well to pump water to the University, from the cell phone of the technician responsible for the pumping equipment or the staff of the Technological University of Tecamachalco, by means of a text message, from any location within the range that the technology allows, which must be effective, easy to use and low cost.
For this system, the GSM 800l module was used, this allows a global communication network to be connected to the GSM network, the module has a tray where a SIM card is placed, which will allow coverage of a mobile telephone company, this depends on which company telephone is the SIM card.

3.3 Materials

For the development of the project, materials and devices were used for the implementation of the power, control, communication and protection stages of the starting system and for remote means using GSM communication technology, for the communication stage a DC Voltage Converter was used. -DC, GSM 800l Module, Arduino Uno Card, LED display, for the communication and control stages, in the power stage Thermomagnetic Switches, Contactors, Fuses, single-phase and three-phase, were selected, according to the specifications of the pumping equipment that is held for operation

4 RESULTS

Once the materials and equipment to be used were selected, they were all integrated to proceed with operation tests, but not in site due to the problem of not having the availability of the well, once the operation tests were carried out, improvements were made to the system, once these improvements were made, the operation tests were carried out to verify the operation and that it was in accordance with what was required, these tests turned out to be satisfactory since the device did not present any failure with a repeatability of 100%. [7]
After carrying out the operation tests and improvements to the system, the assembly of the system continued in the cabinet that contains the entire system, communication, control and power stage to be protected and functional.
Once the above was done, on-site tests were carried out, because the pumping system was already in operation and the proposal was made subsequently, it was not possible to carry out these tests, so they had to be carried out and verify the proper operation. of the integrated system, which was satisfactory, being able to turn on the pumping equipment remotely using communication via GSM.

5 CONCLUSIONS

Finally, we conclude that the development of the project was hard work since the development of the programming code, was not simple due to the needs that had to be covered. This part of the programming code for the microcontroller was modified several times to fulfill with the functions required for the correct operation of the pumping system.
During the development of the project, involving the students turns out to be a strategy that, through constructivism, achieves significant learning in them and that this low-cost technology transfer project also meets the needs that exist in this institution. Managing to successfully develop and apply to a need in collaboration between teachers and students to investigate, document and execute a remote start-up system using free platforms and GSM technology that although many of the industrial automation applications are based on this is why there is still time left that, although in the medium term, will give an opportunity to the process of improving and updating the system. We learned that the technology development with materials available of low cost y human resources in formation, is feasible to applied to cover our need and to low cost.

6 FUTURE WORKS

As a result of this project, the stated objective was achieved, but the use of GSM technology that, although it is still in force due to the enormous number of industrial applications that are developed under this technology, it will be necessary in the short or medium term to update the system. of communication according to the availability and characteristics of the project to be necessarily accessible, viable, economic and functional. change the Arduino devices for Microcontrollers to be able to carry out the patent application, this is because these devices are generic and their programming is done in free access software, as an experience in Mexico, a university generated a project based on Arduino devices and the company when patenting they made the observation of the use of free platforms.

REFERENCES

[1] WIPO, «World Intellectual Property Organization,» [En línea]. Available: https://www.wipo.int/portal/en/index.html. [Último acceso: 11 05 2022].
[2] B. B, «Technology Transfer and Public Policy: A Review of Research and Theory,» Research Policy, vol. 29, pp. 627-655, 2000.
[3] W. S. X. P. X. S. Xiaopei Gao, «Technology Transferring Performance of Chinese Universities: Insights from Patent Licensing Data,» Advances in Applied Sociology, vol. 4, nº 12, 2014.
[4] J. M. H. Moya, « Sistemas GSM, UMTSy LTE,» de Comunicaciones moviles. Sistemas GSM, UMTSy LTE, Ra-Ma, 2012.
[5] twi-global, «TWI LTD,» TWI Ltd (Head Office), [En línea]. Available: https://www.twi-global.com/. [Último acceso: 14 06 2022].
[6] IVREA, «interactionivrea,» [En línea]. Available: https://interactionivrea.org. [Último acceso: 16 06 2022].
[7] W. A. L. German L. Cuzco, «Sistema de Alarma, Automatizacion y control de equipos a distancia a traves de linea telefonica y pagina web,» Universidad Politecnica Salesiana, Ecuador, 2012.
[8] D. J. Bolaños, «APUNTES DE ELECTRONICA - INFORMATICA - TECNOLOGIA,» 15 03 2021. [En línea]. Available: https://www.bolanosdj.com.ar/index2.htm. [Último acceso: 05 02 2022].
[9] J. B. Conejos, «Sistema de seguridad perimetral Inteligente,» UPV, Valencia, 2014.

Advanced 3D sensor system for visual control of geometrically complex products

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ABSTRACT

A prototype of an advanced 3D sensor system for visual bypass quality control of geometrically complex products was developed using an innovative combination of 2D and 3D machine vision methods. We present this optical measuring system named EAGLE and its implementation into a simulated industrial environment. We emphasise the importance of vibration analysis for efficient quality control.

KEYWORDS

visual control, geometry, 3D sensor system, machine vision, vibration

1 INTRODUCTION

The automotive industry took up the smart factory initiative (i) to improve the productivity of old factories through modernizing and digitizing their operations, (ii) to deal with the quality issues that are difficult for people to detect, (iii) to incorporate made-to-order or mass-customization capabilities [1]. Repetitive and exhausting work operations are being replaced by automated and robotized systems. At the same time, customers' habits have changed as customers give more priority to quality and reliability of vehicles. This is the reason why the assurance and automated quality control of components have become of the utmost importance.

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3D scanning technologies are increasingly being used as suitable for quality control in industrial environments [2,3]. Most scanning procedures for 3D geometry control of the products, currently present on the market, work on the principle of 3D image derivation by means of trigonometric processes of triangulation [4], using a large number of cameras, e.g., FARO [5], Smarttech 3D [6]. As a source of lighting, lasers systems, e.g., ZEISS [7] are used in active procedures, while in most cases the projection of structured light patterns on the scene is made with a projector, e.g., Shining 3D [8], GOM [9]. The technology has already been actively integrated in production processes and quality control as part of smart factories [10].

2 PROBLEM STATEMENT

An important part of industrial processes is constant inspection of products to assure required quality. The leading partner of the EAGLE project, TPV Automotive d.o.o., uses geometry and visual surface control of their products on a daily basis. In the production of stamping parts, being geometrically highly complex objects with cavities, embossments and notches, the dimensional control is demanding and time-consuming process. The established procedure for periodic verifications of the product dimensions requires specially-made and maintained mechanical inspection instruments. The weakness of this method is a time-consuming and expensive manufacturing of measuring instruments, periodic wear testing of these tools, and rather long testing time for each inspected product. The stamping parts, made of sheet metal, are sometimes also painted. Despite an accurate examination, controllers are facing big problems due to light reflection, e.g., missing a poor-quality part, which may in turn lead to a quality claim. This is the reason why needs have arisen for new approaches and concepts in terms of visual quality management of products.

The objective of the EAGLE project was to develop a prototype of an advanced 3D sensor system for automated frequency geometry control of complex products, by using novel machine vision approaches.

3 RESULTS AND DISCUSSION

3.1 Machine vision EAGLE system

Optical measurement methods represent a modern approach in dimensional and geometrical inspection. The project partner Alpineon d.o.o. has got rich experience in developing innovative user interfaces and machine vision systems, being a patent holder of geometry control of tubular objects and innovative 3D sensor [11,12]. In the EAGLE project we explored the usefulness of the combination of 2D and 3D measurement methods. The 2D measurement method is based on a parallel projection of the product image on the camera image plane (see Fig. 1). Such a projection is achieved by using a system of telecentric lenses and transmissive lighting with parallel light beams. The 3D measurement method is based on a binary pattern projection using an industrial HD projector, two high-resolution cameras and blue LED lighting (see Fig. 1). The 2D method allows accurate measurement of cut-outs and comparison with 2D drawing, and the 3D method enable shape and surface measurement and comparison with 3D model.

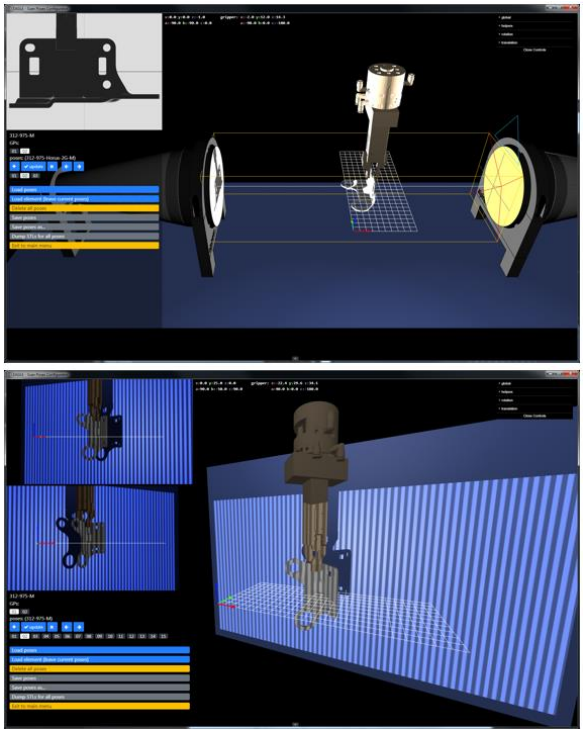

Figure 1: (up) 2D and (down) 3D measuring method

The computer analyses the acquired images, determines the specific areas of interest on the product, measures predetermined tolerance distances, and determines whether the product is within the tolerance range. In order to register the corresponding projections of the measured object, the robotic arm places the object in specific positions according to the optical image acquisition system.

The system allows the accuracy of distance measurement of 20 µm order. The product verification is carried out in 10 sec order time and involves storage of measurements for further statistical analysis and reporting. This procedure does not affect the inspected product and contain wear resistant elements which do not require frequent maintenance or recalibration. The preparation of the procedure for new type of product to be inspected takes less than 1 hour and does not require assigned equipment. Dimensions not visible on the parallel projections of the product shall be checked by additional optical measurement procedures, which are slightly slower and less precise, but they record the entire 3D model of the product.

3.2 Sensor system EAGLE in industrial environment

The prototype of the measuring system EAGLE consists of the following components: 2D and 3D scanning and measuring systems, robotic arm with grips (mechanical and magnetic tongs, quick rotation clutch), measuring system base, carriers for components, dump for inspected parts, and computer with communication, process and measurement software.

In addition to the measuring system, we virtually designed the periphery of the future industrial measuring cell, which intends to be placed into industrial environment, namely: the energetic system (electricity, compressed air), the protection rail and conveyor belt for delivering inspected parts. We also envisaged the possibility of integrating the EAGLE measuring cell with the system for picking inspected parts from the conveyor belt, resulting from joint development between TPV and Alpineon.

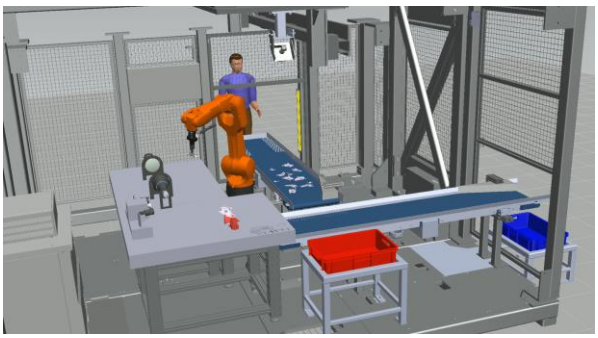

Figure 2: A virtual model of advanced sensor system EAGLE in industrial environment

In Tecnomatix, a tool for modelling and simulation of production processes, a model system according to the following assumptions was designed (Figure 2):

- inspected products are transported by conveyor belt,
- the system for picking scattered inspected parts recognizes and locates products on a conveyor belt,
- a robot with magnetic grip picks a product from a conveyor belt and place it onto a special base,
- a robot with mechanic grip picks a product from the base and transfer it to the sensor system EAGLE to perform geometry and surface measurements,

- a product with desired specifications is placed to the conveyor belt, while the unsuitable product is removed.

3.3 The influence of environment on the measuring method

Before the mechanical integration of the components, we integrated components in a virtual environment. We simulated different environmental influences, such as light and vibration. We also simulated different paths of the robotic arm and accelerations. Optimal movements and turns of the robotic arm depending on the mass of inspected object were determined with the aim of making the measurement as fast as possible and minimizing vibration. The model was prepared using the final element method (FEM) on the basis of the 3D Solid robot model, and simulations were performed using the Abaqus software tool. The results of the simulations were tested using measurements on the prototype measuring system (Figure 3). A single-axle accelerator was installed on the robotic arm in the directions of all three axes, which is connected to the computer with appropriate software for capture and display measurements via a data acquisition and processing device (DAQ).

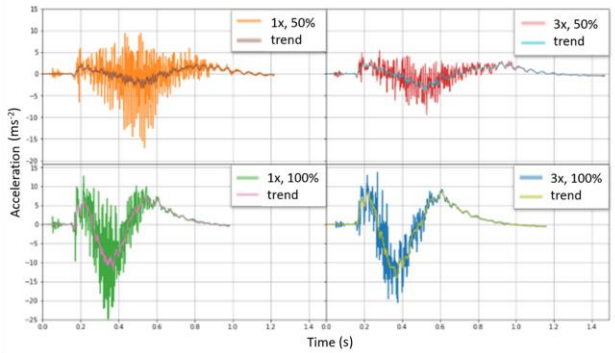

Figure 3: Vibrations during motion of robotic arm for single mass (1x) and triple mass (3x) at half speed (50%) and full speed (100%)

We measured and analyzed the vibrations of the robot's motion, the robot's eigenfrequencies for different masses of inspected object, and the impact of vibrations caused by the robot's servo drives, on the accuracy of measurements. A comparison with the situation when the robot's brakes are turned on for resting was also made. In this way, we were able to compare the results from the simulation model and the prototype.

3.4 Experimental investigation of industrial vibrations with simulator

The vibrations which occur in an industrial environment cannot be completely avoided, therefore it is important to control and manipulate them properly. This requires appropriate vibrations levels determination and further consideration of structural dynamics in the evaluation of quality of products or processes. In the area where some devices cause vibrations, while others require stable surrounding due to precise measurement techniques, it is necessary to understand how these vibrations propagate throughout the room and how they can affect the working process. It is crucial to understand the vibrations propagation process over the whole production area also for proper design and manufacturing of improved industrial building constructions and hardware of industrial processes.

The specific conditions of real industrial environment in which the EAGLE system is supposed to be operating, pose a serious challenge in ensuring the appropriate quality and reliability of optical measurements. This advanced 3D sensor system, designed to carry out quality control of geometrically complex products, shall be subjected, for example, to vibrations caused by heavy devices (e.g., presses) continuously operating in the industrial surrounding in which the sensor system is installed.

A basic starting point for planning and implementation actions in industrial environment is established methodology for determining vibrations which includes the determination of the following characteristics:

- eigen frequencies of the ground,
- the levels of acceleration amplitudes,
- locations in the industrial area, most suitable for the installation of measuring equipment as regards vibrations,
- vibrations at the point of measuring equipment installation.

We established a measurement methodology to analyze the impact of vibrations or disturbances on the quality of product optical control by implementing a system for simulation of disturbances propagation in the industrial environment. A model system, developed at laboratory level, was developed to simulate key elements from the industrial environment that cause vibrations, transmit vibrations and respond to vibrations. It consists of piezoelectric accelerometers, signal analyzer and experimental data evaluation system.

As a basic model, simulating the ground in the industrial area, we used a measuring plate of 150 cm in length and 75 cm in width, with the thickness of 18 mm. The plate consists of a chipboard base to which the plastic plate is glued. The simulator of the press allows falling of the weights from five different positions, which are 10 cm incremental. The lowest position is thus at 10 cm and the highest at 50 cm. The location of the attachment of the impulse exciting simulator to the base plate is shown as a red frame in Figure 4.

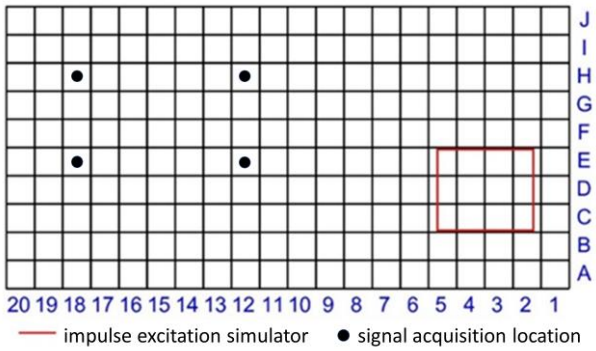

Figure 4: The location of an impulse excitation simulator and signal acquisition on the measuring plate

At impulse excitation of the measuring plate, caused by the weight falling on the plate, the energy that causes wave propagation over the plate surface is released. The measurements

of oscillation which occurs after the impulse excitation with two different loading masses, i.e., 632 g and 1085 g, having the same height, were performed at four measuring points in accordance with the mapping shown in Figure 4. The black dots in Figure 4 represent signal acquisition locations with coordinates E12, E18, H12 and H18.

By analyzing the measured signals of response, it was observed that the intensity of the impulse, caused by heavier weight, is higher in comparison to the intensity of the impulse, caused by lighter weight, as expected (see Figure 5). Figure 5 shows the measured average acceleration values which correspond to the maximum impulse amplitudes at each measuring point for lighter and heavier weight. Higher amplitudes of impulse excitation increase the final accelerations which consequently affect the operation of simulated device, representing optical measuring system in real industrial environment.

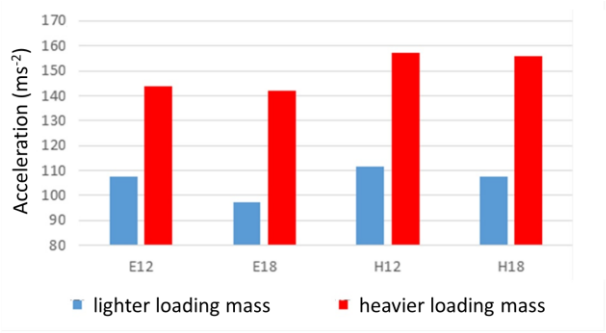

Figure 5: The influence of the location of signal acquisition (E12, E18, H12, H18) and the weight mass on the dynamic response of the measuring plate

The experimental analysis shows that the eigenmodes of measuring plate oscillation affect the experimental results, and therefore the measured values of the oscillation accelerations at the impulse excitation with the same weight differ in measuring points. The eigenmodes of measuring plate oscillation therefore have significant influence on the development of the resonance oscillation response.

4 CONCLUSSIONS

The EAGLE measurement robot cell represents a complete novelty in the global market. It enables visual bypass quality control of the geometry of complex objects using the innovative design of the machine vision system. As a use case we chose metal stamping parts, i.e., geometrically complex products in the automotive industry which are technologically attractive due to their innovative lightweight design. Some breakthrough solutions, contributing to the significant state-of-the-art progress in technology, were developed [13,14].

The advantages of the advanced 3D sensor system EAGLE for geometric inspection of complex products are: (i) successive implementation of several optical measurement methods on the same inspected object without intermediate intervention by the operator, (ii) fully autonomous operation, (iii) accuracy and time stability due to fixed optical measuring components, (iv) a robotic arm movement and measurement system eigenfrequencies do not affect the speed and the accuracy of the measurement method.

We also established an experimental methodology for multiparametrical analysis of structural dynamics which enables investigation and evaluation of the effect of vibrations on the technological processes in the industrial environment. For that purpose, a model system for simulating disturbance sources and monitoring disturbances, which propagate over the base plate, as appear in different locations in real time, was developed. This model system, developed at the laboratory level, enables simulation of the key elements from the industrial environment that cause vibrations, transmit vibrations and respond to vibrations.

ACKNOWLEDGMENTS

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REFERENCES

[1] Chris Middleton. 2020. *Smart factories - driving the automotive industry into the fast lane*. Diginomica (Feb 14, 2020). https://diginomica.com/smart-factories-driving-automotive-industry-fast-lane (cited: Aug 10, 2022)

[2] K. R. Srinivas. 2017. *Blue Light Optical Scanning for High Resolution 3D Measurement*. Quality magazine (Sept 1, 2017). https://www.qualitymag.com/articles/94202-blue-light-optical-scanning-for-high-resolution-3d-measurement (cited: Aug 10, 2022)

[3] Andrei Vakulenko. 2017. *The Future of 3D Scanning and Its Impact on Industrial Quality Control*. Manufacturing Business Technology (July 18, 2017). https://www.manufacturing.net/industry40/article/13227099/the-future-of-3d-scanning-and-its-impact-on-industrial-quality-control (cited: Aug 10, 2022)

[4] Francesco Malapelle, Diego Dall'Alba, Denis Dalla Fontana, Ivano Dall'Alba, Paolo Fiorini, Riccardo Muradore, 2017. Cost Effective Quality Assessment in Industrial Parts Manufacturing via Optical Acquisition. *Procedia Manufacturing*, 11, 1207-1214. https://doi.org/10.1016/j.promfg.2017.07.246

[5] http://factory-metrology.faro.com/us/ (cited: Aug 10, 2022)

[6] http://smarttech3dscanner.com/ (cited: Aug 10, 2022)

[7] http://optotechnik.zeiss.com/ (cited: Aug 10, 2022)

[8] https://www.shining3d.com/ (cited: Aug 10, 2022)

[9] https://www.gom.com/ (cited: Aug 10, 2022)

[10] Bruce Morey. 2016. *Why Optical Metrology Is on the Move. Advanced Manufacturing*. SME (Mar 16, 2017). https://www.sme.org/technologies/articles/2017/march/optical-metrology-move/ (cited: Aug 10, 2022)

[11] Mario Žganec, Jerneja Žganec Gros, Alpineon. 2016. *Method and equipment for monitoring suitability of a tubular object geometry*. Patent EP2950042 (B1) - 2016-12-14. Munich: European Patent Office

[12] Mario Žganec, Jerneja Žganec Gros, Alpineon. 2011. *Active 3D triangulation-based imaging method and device*. Patent EP 1997322 (B1), 2011-12-28. Munich; Hague; Vienna: European Patent Office. US7483151 (B2)

[13] Mario Žganec, Aleš Mihelič, Stanislav Gruden, Boštjan Vesnicer, Žiga Golob, Jaka Kravanja, Černe Tomaž, Žganec Gros Jerneja. 2021. Priprava za samodejno preverjanje dimenzij kovinskih odpreškov, Zahteva za podelitev patenta, št. 202100067, Urad RS za intelektualno lastnino, Ljubljana, April 2021

[14] Anton Juratovac, Mateja Koblar, Jurij Kranjc, Hidajet Kurbegović, Vili Malnarič, Rajko Marinčič, Anton Petrič, Boštjan Piletič, Tomaž Savšek, Urška Florjančič, Anatolij Nikonov, Stanislav Gruden, Jaka Kravanja, Aleš Mihelič, Boštjan Vesnicer, Jerneja Žganec Gros, Mario Žganec, Žiga Golob et al. *Robotska merilna celica za nadzor kakovosti EAGLE*. Produktna inovacija. Novo mesto: TPV AUTOMOTIVE, 2021. Srebrno priznanje za inovacije Gospodarske zbornice Dolenjske in Bele Krajine, Otočec, 2021. https://www.gzdbk.si/media/pdf/projekti/inovacije/2021/gzdbk_katalog_inovacije_2021_webpdf.pdf (cited: Aug 10, 2022)

DODATEK / APPENDIX

ITTC 15

15th International Technology Transfer Conference

LET'S INNOVATE THE FUTURE

INTRODUCTION AND AIM OF THE CONFERENCE

Conference topic:

The role of TTOs in maximizing impact of science, technology and innovation on society.

Objectives of the Conference

The Conference brings the awareness of importance of professional technology transfer activities which must be appropriately placed in a national innovation system. The Conference program includes exchange of knowledge, good practice, and opportunities for collaboration between representatives of academia, industry and government about cooperation and transfer of knowledge and innovations from publicly funded research labs into industrial exploitation. The Conference goal is also further strengthening the knowledge base and experiences of technology transfer professionals at public research organisations.

Since 2008, we hosted more than 2600 participants from Slovenia, Europe and the world, including researchers, students, inventors, technology commercialization and intellectual property experts, investors, start-up funders, industrial development experts etc. Since 2009 we have successfully organized fourteen annual international competitions in which till this year have participated a total of ninety-three (93) teams from PROs throughout Europe with their technology and business proposition with the biggest commercial potential. We are particularly proud some of them made their first steps at the Conference and have later advanced to spin-out companies and licensing agreements. Biannually we organise pre-scheduled Research2Business (R2B) meetings. The meetings are additional matchmaking opportunity for representatives of industry and researchers to meet and identify opportunities for collaboration, cooperation and business synergies.

Additionally, in a special session, the researchers are presenting their work which is being financed by Slovenian Research Agency (ARRS). This is another opportunity for enterprises to get insight to recent discoveries in the PROs and development opportunities.

Conference prize for the best innovations in 2022

The main objective of the special prize for innovation is to encourage commercialization of inventive/innovative technologies developed at PROs and to promote cooperation with industry. One of the main objectives is also promoting the entrepreneurship possibilities and good practices in the PROs. Researchers are presenting their technologies and business models to an international panel of experts in a pitch competition. They need support in many aspects of their path from research to industrial application. The researchers and their team need assistance, knowledge and tools to develop business models, find appropriate partners, form a team, and secure financial resources to bridge the gap from publicly funded research to the market, either in their own start-up (spin-out) company or by licensing out their technology. How shall they do it and how can we help them?

The Conference pitch competitions in the last fourteen years led to the establishment of a spin-out company, conclusion of a licensing agreement or further development of a business opportunity in at least one case per competition each year. In many cases, young researchers that participated in the pitch competition in the past years, have been involved for the first time in an organized and structured development of a business model around their technology

and preparation and delivery of the targeted (pitch) presentation about their planned venture to investors and technology commercialization experts.

WIPO IP Enterprise Trophy

The aim of the WIPO IP Enterprise Trophy is to stimulate Slovenian enterprises to intensify their cooperation with public research organisations. We wish to expose as a good practice those enterprises that are constantly and methodologically using the IP system in their business activities.

WIPO Medal for Inventors

The goal of the WIPO Medal for Inventors is to award inventive and innovative activity of Slovenian public researchers and to recognize their contribution to national wealth and development.

Opportunities arising from publicly funded research projects / presentations of successful scientific projects

Researchers are presenting their work that is being financed by Slovenian Research Agency.

Scientific papers on technology transfer (TT) and intellectual property rights (IPR)

Experts on TT, IPR, researchers that cooperate with industry and others have been invited to submit their scientific papers. The accepted papers have been presented by the authors. This year's topics were: Key factors for successful technology transfer from different points of view (researchers, knowledge transfer experts, enterprises); The role of TTOs in maximizing impact of science, technology and innovation on society; IP value vs price; Incentives for contract and collaborative research / cooperation with industry; IP negotiation with industry; State Aid in contract and collaborative research; Current status of public investments into research and technology infrastructures; European or national frameworks to transform breakthrough technologies developed for fundamental research purposes into breakthrough innovations with strong industrial applications and societal added value; Examples of IP protection in Artificial Intelligence; Other, chosen by the contributor

Connecting the education system with academia

A parallel section "Connecting the education system with academia: Presentations of selected research topics from the Jožef Stefan Institute and proposals for cooperation" took place. The section was aimed at primary and high school teachers where selected research topics from the Jožef Stefan Institute (JSI) and proposals for cooperation were presented.

Key stakeholders

The conference involves different key stakeholders in the process, public research organizations as knowledge providers, technology parks as infrastructure providers, business accelerators, intellectual property offices, IP attorneys, agencies, consultants, capital (venture capital companies, agencies, business angels, development banks), SMEs, international enterprises, private innovators, and others. The key stakeholders co-create the conference and share with other co-organisers, partners and audience their knowledge, expertise and thoughts. They also spread the word about the conference among their contacts. Through their activities the awareness about knowledge transfer and IPR is rising in their organisations, in Slovenian and European innovation eco-system.

Target audience and benefits

Target audience of the conference are researchers, students and post-graduate students with entrepreneurial ambitions, technology transfer managers, representatives of industry, established and future entrepreneurs, innovators and also representatives from governmental institutions and policy-making organizations.

Organization of the International Technology Transfer Conference

The International Technology Transfer Conference (ITTC) is organized by the **Jožef Stefan Institute** (Center for Technology Transfer and Innovation) for the 15th year in a row. The first ITTC was organized in 2008. The ITTC has, through the years, been presented in different formats and it is currently organized as part of the International multiconference Information Society (IS2022), organized by the Jožef Stefan Institute.

The Conference has been organized with the support of partners from the Enterprise Europe Network project (EEN). The project's mission is to help businesses innovate and grow on an international scale. It is the world's largest support network for small and medium-sized enterprises (SMEs) with international ambitions. The Network is active worldwide. It brings together experts from member organisations that are renowned for their excellence in business support. The ITTC is complementary to the mission of the EEN project which is to support SMEs and researchers through a) finding appropriate business partner, b) international technology transfer and c) finding partners/coordinators to apply to EU calls, while providing support on IPR, Access to finances, regulation and legal support.

ACKNOWLEDGEMENTS

The editors and organizing committee of the Conference would like to express cordial thanks to all who helped make the 15th International Technology Transfer Conference a success.

We would like to acknowledge the valuable contributions to the members of the **SCIENTIFIC PROGRAMME COMMITTEE**:

- Niko Schlamberger, President of Slovenian Society INFORMATIKA
- Doc. Dr. Tamara Besednjak Valič, Faculty of Information Studies in Novo Mesto
- Prof. Alexandru Marin, University POLITEHNICA of Bucharest

for their contribution to the scientific programme and review of the scientific contributions and selection for publication in this Conference proceedings.

Our special thanks go to the **EVALUATION COMMISSION MEMBERS**:

- Alexandre Massart, co-founder and director, Blend Ventures,
- Jurij Giacomelli, Investment Manager, META Ingenium,
- Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission,
- Nina Urbanič, Adviser for equity investment monitoring and reporting, Slovene Enterprise Fund,
- Vladimir Jančič, CEO, Publikum Korpfin,

for their evaluation of written technology commercialization proposals and selection of winning teams, authors of inventive technologies with the best potential for commercialization of the technologies, developed at Public Research Organizations.

We are particularly grateful to the members of the **WIPO EVALUATION COMMISSION**:

- Alojz Barlič, Slovenian Intellectual Property Office (SIPO)
- Nina Urbanič, Slovene Enterprise Fund
- Christoph Kempf, IPEK – Institut für Produktentwicklung, Karlsruher Institut für Technologie (KIT),

for their evaluation and selection of the awardees of the WIPO IP ENTERPRISE TROPHY and WIPO MEDAL FOR INVENTORS.

Special thanks go also to Slovenian intellectual property office for their help with the organisation, communication with WIPO and presence at the Award ceremony. We thank also to ARRS for their presence at the Award ceremony and WIPO for their video for the Award ceremony.

Day 1

OVERVIEW OF THE PROGRAMME

12 October 2022 (hybrid teleconference, virtual and live)

MAIN SESSION

08.30 – 09.00	**Registration**
09.00 – 09.15	**Welcome address** (in Slovene language) Dr. Tomaž Boh, Director-General Science Directorate, Ministry of Education, Science and Sport Prof. Dr. Boštjan Zalar, director, Jožef Stefan Institute Dr. Špela Stres, Jožef Stefan Institute, EIC Board member
09.15 – 10.00	**Keynote speech: CEA's experience in effective collaboration with industry** Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission
10.00 – 12.00	**Best innovation with commercial potential: pitch competition**
12.00 – 13.00	Lunch break
13.00 – 13.20	**Award announcement: Best innovation with commercial potential** **Award announcement: WIPO IP Enterprise Trophy**
13.20 – 14.30	**Opportunities arising from publicly funded research projects / presentations of successful scientific projects (partly in Slovene, partly in English)** **Award announcement: WIPO Medal for Inventors**
14:30 – 16:50	**Paper presentations: scientific papers on technology transfer and intellectual property**
16.50-17:00	Closing

PARALLEL SESSION

13:20 – 14:30	**Connecting high-school education system with academia: Presentations of selected research topics from Jožef Stefan Institute and proposals for cooperation**

WELCOME ADDRESSES

From 9:00 to 09:15

Honourable Speakers:

Dr. Tomaž Boh, Director-General Science Directorate,

Ministry of Education, Science and Sport / generalni direktor Direktorata za znanost, Ministrstvo za izobraževanje, znanost in šport

Povzetek uvodnega pozdrava / Abstract of the Welcome address

Hvala lepa za povabilo. Spoštovani direktor, spoštovana kolegica Špela, spoštovani raziskovalci in raziskovalke, spoštovani domači gostje in gostje iz tujine. V veliko veselje in čast mi je, da sem lahko danes tule v imenu Ministrstva za izobraževanje, znanost in šport in vas pozdravim na 15. Mednarodni konferenci o prenosu tehnologij. Pomembno je oboje, petnajst in prenos tehnologij.

Število petnajst pomeni, da je vaša institucija ena tistih, ki na področju prenosa tehnologij, inovacij in znanja že dolga leta orje ledino, postavlja nove standarde in nenazadnje postavlja protokole kako in na kakšen način povezovati raziskave z gospodarstvom. Iz vašega znanja in iz sadov preteklih konferenc se lahko vsi iz širše raziskovalne sfere v Sloveniji marsikaj naučijo. S tega vidika je izjemno pomembno, da sodelujete, da ste ena izmed vodilnih institucij tudi v inštrumentih, ki jih ministrstvo v tem kontekstu financira in ki jih bo podpiralo tudi v prihodnje. V naslednji kohezijski perspektivi si zelo želimo, da povečamo obseg, da damo novo kvaliteto temu, kar je bilo v dosedanjem obdobju že narejeno in naredimo še pomemben korak naprej.

Prenos tehnologij kot drugi del besedne skovanke je ključnega pomena zaradi tega, ker v zadnjem času vedno bolj pridobiva na pomenu, čeprav je moje prepričanje, da za raziskovalce in tiste, ki se s prenosom tehnologij ukvarjate na institucijah, pravzaprav to ni nekaj novega, s čimer bi se začeli ukvarjati in s čemer bi sledili temu kar je politično zaželjen besedni termin na področju raziskav. Ravno zaporedna številka petnajst v imenu konference kaže, da je zavedanje o pomenu prenosa tehnologij bistveno daljše kot pa je to postala moderna politična beseda.

Pa vendar, tudi politični odločevalci se vedno bolj zavedajo, da je potrebno podpirati ne samo bazične raziskave, ki so brez dvoma osnova in temelj vsega, in ne samo gospodarstvo v smislu direktnih spodbud nepovratnih sredstev, ampak da je polje prenosa tehnologij tam nekje v sredini. To mejno področje oz. področje na sredini, ki se ga žal pogosto obravnava kot da ni pristojnost nikogar (a upamo, da se stvari izboljšujejo), je pravzaprav pristojnost obeh, tistih ki podpirajo gospodarstvo in tistih, ki imamo pristojnosti financiranja znanosti.

Ravno tovrstne konference kot je današnja pokažejo, da je svet tam vmes še kako živ, da še kako dobro veste kako in kaj početi v tem kontekstu. Tudi današnji program, ki je sestavljen iz predstavitev dobrih primerov, tekmovanja, ocenjevanja najboljših dosežkov kaže na to kako zelo je to področje živo.

Z vidika Ministrstva za izobraževanje, znanost in šport in predvsem z vidika našega Direktorata za znanost lahko rečem, da bo tudi v prihodnje prenos tehnologij oz. prenos znanja ena izmed

pomembnih aktivnosti in sestavni del znanstveno-raziskovalne dejavnosti. V kontekstu stabilnega financiranja raziskovalnih institucij verjamemo, da bomo v letih, ki sledijo, vzpostavili tudi ustrezne načine sodelovanja kako to zapisati v strateške cilje institucij, kaj od tega lahko tudi centralno država, ministrstva v procesu pogajanj oz. bolj v dogovoru naredimo kot pomemben korak k stabilnosti financiranja, k stabilnosti upravljanja tega področja in k stabilnosti podpore, ki jo v tem kontekstu potrebujete.

Želim vam uspešno konferenco in uspešno delo še naprej. Before I finish I would like to welcome all the guests from abroad while it is important to also have a mirror to compare our national system with systems abroad and learn from your experiences. Because of that I would in the name of the Ministry of Education, Science and Sport warmly welcome you in Slovenia and thank you for all the work, for all the cooperation with Slovenian institutions.

Prof. Dr. Boštjan Zalar,

Director, Jožef Stefan Institute

Povzetek uvodnega pozdrava / Abstract of the Welcome address

Dear guests, dear researchers, dear technology transfer experts, we are very glad to have you here again at this annual event. Two years ago, we were fighting with the covid epidemy, last year there's the situation in Europe that has changed a lot the geostrategic points of view of development of our scientists. So, it seems to be that we will be encountering different troubles on and on. Maybe you read a few weeks ago there was a report that NASA was trying to crash a satellite into an asteroid so one would think that probably it's the next crisis that is coming that an asteroid would hit our earth. Anyway, from the technology transfer view crashing a bunch of pounds of high technology into a rock this is what you call technology transfer I would say.

Our institute has been hosting this event for several years and we are really glad to have you here again. I wish you a lot of fruitful discussions and as a part of the technology transfer debates I anticipate and I really hope that there will also be in all these debates suggestions how to improve the transfer of common sense that our humanity really needs in recent years. Thank you very much. I am glad to have you here again and I wish you all the best in your work.

Dr. Špela Stres,

Jožef Stefan Institute, EIC Board member

Povzetek uvodnega pozdrava / Abstract of the Welcome address

I would like to welcome everyone from my heart. Through the years we had a lot of collaboration in particular with many famous institutions from the western part of Europe or from the USA. We had guests from MIT, Leuven RD, Cambridge. I am very pleased to see that in particular our scientific section is expanding a lot towards the widening countries. The

internationalization of the efforts in the field of professionalization of knowledge transfer is really an important step for all of us, because knowledge transfer in itself is not just a profession, it's a scientific field in itself. As soon as we are ready to acknowledge that fully also in the widening countries it will be much easier to establish a professional system of knowledge transfer and valorization.

We've had fifteen years of this conference and not all events that happened during that time were totally happy. For example, I remember when we've first asked whether we can organize such an event in the field of technology transfer and whether we can award a prize for best innovation from public research organizations the answer was - a simple no. But here we are fifteen years later and we've organized numerous business to research meetings. We've published many scientific articles in this field. We've had twenty-eight teams awarded. And those teams did not just receive an award here, they went on and received several other awards elsewhere and they attracted venture capital and they took the name of all the major public research organizations that they came from in the first place to the Slovenian economy and also wider, some of them even won very prominent European funding.

But the story does not end here. As we've heard from the Director General I do also acknowledge the fact that knowledge transfer and valorization is in a transitional period right now. That's also influenced by the fact that we have the new legislation. The new legislation does imbed knowledge transfer a bit more into the system of the public research organizations, but it does not assure that it's going to really be imbedded. So, I think that in this transitional period it's really important that additional funds are available for knowledge transfer that should be used in particular to connect different efforts and to professionalize those efforts. Also, it would make so much easier if the Slovenian system of financing the research would follow the steps that were taken by the European Commission. The European Innovation Council is an example of that how the research throughout the technology readiness levels can be supported in an integrative connected way throughout the TRLs. Improving our own system in such a way would give our researchers much needed security to become more imbedded in the innovation part of their efforts.

And last but not least it's important that the Center for Technology Transfer and Innovation keeps up the good work at the institute in whichever form it will continue because the researchers need the professional assistance in this field. In fact, in Slovenia we don't have the gap between academia and industry, we just somehow need to learn how to shake hands between the two fields and that's also a question of the professionalization that I spoke before about. So welcome everyone here and I hope that after fifteen more years we'll be looking at the totally different situation. Thank you.

KEYNOTE SPEECH: CEA's experience in effective collaboration with industry

From 09:15 to 10:00

Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission

Abstract of the Keynote speech

The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation collaborative partnerships in defence and security, low carbon energies (nuclear and renewable energies), technological research for industry and fundamental research in the physical sciences and life sciences.

CEA comprises of 9 research centres with 21.148 employees CEA filed 710 priority patents filed in 2019, created 228 start-ups since 1972 and operates a 5,6-billion-euro budget.

The CEA is one of the leading patent applicants in France and Europe having 6,980 active patent families. CEA is 1st patent-granting research organization in France and 1st French patent applicant in Europe.

As a major player in innovation, the CEA promotes the technologies it develops and transfers them to industry. CEA supports business competitiveness, job creation and national and European technological sovereignty. By encouraging spin-offs, it has supported and promoted creation of start-ups for the past twenty years.

Management of intellectual property is a key element of CEA's strategy, used for the benefit of innovation transfer to companies. CEA has chosen to retain ownership of the results (Foreground) obtained by its sole researchers during collaborative partnerships financed by industry. The Foreground created in a given RDI collaborative partnership with one company is therefore added to CEA's IP portfolio and can be used by CEA as Background for other collaborative partnerships with other companies, for very diverse applications.

The model of Industrial RDI Collaborative Partnerships enables a wide technological dissemination, not only benefiting strategic industrial sectors but also smaller enterprises (SMEs, start-ups) that gain easy access to technological IP Portfolio without having to finance their development.

The company finances only the new RDI collaborative partnerships where new Foreground is created from CEA's Background. This model contributes to CEA's autonomy in its research and valorisation policy, while preserving its industrial partners' competitive advantage through the implementation of adapted and secured exploitation rights.

"Post RD" licence after a collaborative RDI Partnership, covering results of the collaboration carried out with a partner, as well as the pre-existing knowledge required to use these results, is the most frequent mean of transferring CEA's technologies to industry. It represents more than 70% of CEA's commercial licences whilst licences to start-up companies represent 20% and 10% regarding "straight" licences" with existing companies, where no prior RDI collaboration has taken place .

CEA licensing terms (field of use, exclusivity, duration, etc.) are adapted on a case by case basis to meet the needs and exploitation prospects of its partners. CEA grants a licence to the partner on the Foreground and Background needed to exploit the Foreground after a given collaborative Partnership. Licences may also be granted where no prior collaboration has taken place ("straight" licences).

Access to Foreground (or a part of it) can be exclusive in a particular field, with mandatory exploitation thresholds. In the case of insufficient exploitation, the licensee loses exclusivity in its domain. In the event of absence of exploitation, the license is terminated and CEA can then seek a new partner in the Public Interest. In general, access to Background needed to exploit particular Foreground, is non-exclusive.

Commercial and industrial exploitation licences always give rise to payment. The budgets of CEA's collaboration activities only take into account the costs of the R&D work. Licence remuneration must therefore not only cover CEA's IP costs but also contribute to a fair return, for CEA and its inventors, on the value created by the exploitation. This also enables CEA to comply with European legislation on State aid.

CEA royalties' policy is very compliant to the article 28 d) of the EC Framework:

"The research organisations or research infrastructures receive compensation equivalent to the market price for the IPR which result from their activities and are assigned to the participating undertakings, or to which participating undertakings are allocated access rights. The absolute amount of the value of any contribution, both financial and non-financial, of the participating undertakings to the costs of the research organisations or research infrastructures' activities that resulted in the IPR concerned, may be deducted from that compensation".

CEA shares royalties with researchers whilst participating in licensed knowledge.

CEA envisages different payment modalities (lump sum, proportional royalties, minimum, caps, conditional upon an event, etc.) and combine them to meet its partners' business prospects. Large enterprises with sufficient financial resources prefer lump sum payment term whilst start-ups and SMEs prefer proportional royalties.

CEA undertakes to apply preferential remuneration conditions for post R&D licenses compared to "straight" licenses to ensure a differentiation with a licensee who has not participated in the R&D program.

In order to comply with point 29 (compensation at market price), CEA uses generally point 29 c). In those cases, the arm's length negotiation is often based either on a method of comparable royalty fees in the field of the license (there are international databases for that) or by carrying out a detailed study of the provisional exploitation of the company: turn over, margin…. Generally, the international good practice is that the amount of the compensation for CEA (owner) is 1/3 of the margin of the licensee when exploiting IP.

The valorisation of CEA's technologies has also occurred through the creation of new companies, with 228 spin-offs created (89 over the last 10 years) including 2 with more than 1.000 employees (SOITEC and LYNRED) that enabled 5.500 direct jobs created.

CEA start-ups accomplished record fundraising in 2018 accounting to 144 million euros whilst record fundraising of 120 million euros in 2020 was achieved by only one (Aledia).

7 start-ups arising from the CEA are listed on the stock exchange: Soitec, Kalray, Theranexus, Fermentalg, Tronics, Pixiumand Arcure. 70% of the 200 start-ups created over the past 20 years are still active. Since 2000, 50% of CEA start-ups have raised funds, for a total of nearly 1,2 billion euros (excluding SOITEC).

CEA invests significant sums, directly via its internal development/incubation programme (before creation of the start-up) or, at the creation of the start-up by taking equity in the start-up via its CEA Investissement private subsidiary. CEA is therefore a significant stakeholder in the creation and development of these start-ups and shares in the risks.

Success story of CEA start-ups is based on challenging requirements for creating a start-up:

- Innovation must be disruptive and protected by strong exclusive IP (patents, secret know how, copyright for software…);
- Marketing study must have been done showing good market prospects (sometimes start-up creates a new market);
- Research organization must have a sound process to support the creation of the start-up;
- Researchers who participated in the development of the technology transferred to the start-up when it was created and who wish to carry out the start-up project, must have a strong entrepreneurial spirit.

For an R&D partnership with a start-up, CEA applies the same principles of strong IP management and protection as for its other partners with regard to attributing ownership of research results.

CEA keeps the ownership of this IP and grants a license on it to the start-up, generally exclusive in a field (for a part of the technology) since most often start-ups don't have financial resources to pay IP fees for patent costs. On the other hand, start-ups may be developing very fast and be counterfeited by their competitors. In this case, CEA protects (and enforces when needed), its patents effectively. In the event of an infringement lawsuit, the exclusive licensee (the start-up) has the same rights as an owner to assert its rights. The advantage for the exclusively licensed start-up is that in this case, the CEA could also be part of the lawsuit where it intervenes to defend its patents with convergent interests with the start-up. The CEA was thus able to defend several of its start-ups in lawsuits for infringement by big international companies of its patents used exclusively by its start-ups. Of course, a single start-up would have had a much harder time defending itself in these lawsuits in the case where CEA would have waived its ownership to the start up.

CEA has an internal marketing department carrying out a detailed marketing study for each start-up creation. CEA runs regular (4 times per year) internal seminars to increase awareness of researchers in start-up creation and empowering their entrepreneurial spirit. CEA internal PoC fund may be engaged if necessary, depending on the TRL of the technology.

CEA has an 100% owned affiliate CEA Investissement that takes equity in the start-up at creation.

Most of CEA's start-ups have a RDI collaborative partnership with CEA and enjoy RDI support post-creation. Therefore, improvements of the first licensed technologies or additional technologies can be licensed later to the start-up.

Collaborative partnerships may be very different regarding IP background and foreground, having very versatile content or government rules. Thus, CEA does not have developed model contract/ articles for collaborative partnerships or a model process for creating start-ups.

PITCH COMPETITION: BEST INNOVATION WITH COMMERCIAL POTENTIAL

From 10:00 to 12:00

Moderator:

Marjeta Trobec, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission:

Alexandre Massart, co-founder and director, Blend Ventures

Jurij Giacomelli, Investment Manager, META Ingenium

Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission

Nina Urbanič, Adviser for equity investment monitoring and reporting, Slovene Enterprise Fund

Vladimir Jančič, CEO, Publikum Korpfin

Presentation of six (6) selected business model proposals from public research organizations to the members of the evaluation commission.

Course of the competition

Robert Blatnik, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

The 14th annual competition for the best innovation in 2022 at public research organizations (PROs) aims at stimulating the researchers from PROs to develop business models for commercialization of their inventions. Each year the competition is initiated with a public call for the teams with inventive technologies. Eligible authors are individuals, employed at PROs, which are developing innovative technologies into a viable business model. The proposed business models are either licensing the technology to industrial partners or commercialization in their spin-out company. The teams have prepared description of their technology and the key discoveries that underpin the commercial activity (licensing or spinning-out). An important part of description is the proposed business model and customer value proposition. The pitch presentations are following the guidelines, which were introduced by the Organizer of the Conference at the dedicated preparatory webinar and individual consultancy which was organized for the teams. At the webinar and consultancy, the researchers learned the guidelines to prepare their pitch presentation and improvements of their business model. In a series of individual consultation and rehearsal of the pitch session we went through the process of preparing a pitch of their invention and business model to a potential investor or a partner in a future venture; either licensing the technology to an industrial partner or via commercializing of the technology in their own spin-out company. We have discussed which are the stronger points in the specific business model of participants and how to prepare an effective and appealing presentation for the intended audience of their pitch. The guidelines for preparing a pitch included the following elements: Cover / Introduction slide (name & compelling tagline); Deal (what you are selling, to whom, for what price); Market & segmentation (target customer, market size, trends); Customer value proposition and why now; Product (the solution); Financials; Impact; Competitive advantage; Team & founder's/inventor's dream; Summary / three key points to remember. The written description of the proposed invention/innovation included the following chapters: Title of the idea with a brief commercial tagline; Summary; The Science; The Opportunity (problem and solution); The Plan (Development stage and Business model); The Team; Impact.

The teams and their applications with the proposed business models were evaluated by an international panel of experts which constituted the evaluation commission. The members of the evaluation commission are the following experts: Alexandre Massart, co-founder and director, Blend Ventures, Jurij Giacomelli, Investment Manager, META Ingenium, Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission, Nina Urbanič, Adviser for equity investment monitoring and reporting, Slovene Enterprise Fund, and Vladimir Jančič, CEO, Publikum Korpfin.

The experts evaluated the proposals in two phases. The 1st phase was the evaluation of written descriptions and the 2nd phase was the evaluation of the five-minute pitch at the Conference. The evaluation experts used the predetermined evaluation criteria which were already defined in the public call. The Criteria for evaluation are Application with weight of 10 points, Value Chain with weight of 3 points, Market size and development costs with weight of 2 points, Competition with 1 point, the Team with 3 points, IPR and Regulatory with one point. All criteria together bring at the most 20 points for written application. After the pitch

the experts exchanged their views and opinions and selected the winner(s). The Criteria is presented in the Table 1.

The traditional pitch competition, which this year had its 14th anniversary, motivated six innovative and entrepreneurial research teams to prepare their pitch and apply for competition. Members of the teams have participated in the preparatory workshop and rehearsal to develop their pitch and receive comments for improvements of their proposed business model. The workshop was organized by Center for Technology Transfer and Innovation as part of the Enterprise Europe Network (EEN) project, financed by European Commission. Members of the teams are entirely or partly employed at the following PROs: Fondazione Bruno Kessler, Gdynia Maritime University, National Institute of Chemistry, National Institute of Biology, University of Ljubljana and its Faculty of Chemistry and Chemical Technology and Jožef Stefan Institute.

Criteria	**Short description of the criteria**	**Max. points**
Application	Which problem is the technology solving? Has this been verified with end users? What is the Technology Readiness Level (TRL)? How many different applications can the technology be used for? Is there a well-defined end-user for this technology? Is there any barrier to the end-user adopting this solution? Is there a clear existing end user need for this solution? How well does this solution match the users' needs? When will this solution be ready for market? Will this solution have a social impact or bring other benefits to people?	10
Value chain	Where does the technology fit in? How well does the technology fit the existing value chain?	3
Market size and development costs	How is the market size in relation to the development costs? How large is the potential customer community for this product? 1000, 100K, 1M, 100M? How strong is the competition in this market? How receptive will the market be to your idea? What total market share do you expect to get in 5 years? How aligned are the market drivers to the proposed solution? What Is the perceived value by the end user? What is the perceived Strength level overall? What is the perceived Weakness level overall? What is the perceived Opportunity level overall? What is the perceived Threat level in your overall? Only limited development is required before an investor will commit. Funds are available to complete the development investor or other sources (e.g. PoC). The time to market Is shorter or comparable to the time scale for any competition. For VC's: The costs associated with taking the product to market is at least 25 times smaller than the value of the market.	2

Competition	What do the end users use today? Any other technology underway? Which is the expected competition level when you will hit the market How good is the present solution (not yours) in solving the problem? How good will any expected future solutions (not yours) be in solving the problem? How good will your solution be in solving the problem? How strong is your market differentiator?	1
The team	Are the inventors, members of the team, dedicated to the idea? The researchers have unique skills, have experience with tech transfer, and are enthusiastic about following the project through The team has the technical, business, marketing, financing skills needed to understand and develop the idea into a marketable product?	3
IPR & Regulatory	Can the intellectual property of the technology be protected? How strong is the patent likely to be? How dense is the IPR landscape in this technology area in terms of pending and granted patents? How strong is the IPR competition? How complex is the regulatory system in this area Is the technology ready for investment?	1

Table 1: Criteria for evaluating the applications (source: Jon Wulff Petersen, TTO A/S, Denmark)

Abstracts of the competing teams and their technologies

Innovative equipment of intervention/service watercraft: Mobile Electromagnetic Mooring System and Batychron

Authors/inventors: Paweł Kołakowski, Grzegorz Rutkowski

PRO: Gdynia Maritime University

Abstract:

The innovative equipment is designed for use on a floating intervention unit coming to the aid of a vessel in danger (collision, grounding) or a ship requiring a specific service (underwater inspection, cleaning, or cargo and crew transfer). This comprehensive solution includes two inventions: a Mobile Electromagnetic Mooring System and a Batychron. The Mobile Electromagnetic Mooring System is used for mooring the service unit at the side of the serviced ship using a system of electromagnetic grippers with a unique set of mooring lifts ensuring constant rope tension. The invention enables the service unit to move quickly along the side of the serviced vessel, shortening the time needed for mooring and unberthing, limiting the crew's involvement in mooring operations, improving safety, and accelerating intervention to provide proper service. The Batychron is a flexible underwater bell used for underwater transport and diving with high safety standards. Thanks to the lightness and portable structure resulting from the use of new generation materials and integrated systems, it can be used in open and internal waters for underwater transport and various types of diving. These ground-breaking solutions have a global reach and no competition in this field yet. Despite improvements in maritime safety, maritime accidents occur daily around the world. Moreover, both devices can be used in sectors such as marine services, repair interventions, cargo and/or people transfer offshore, diving services - recreational, training, repair or excavation work, and underwater transport. The wide range of use of these devices creates promising opportunities for their manufacturers.

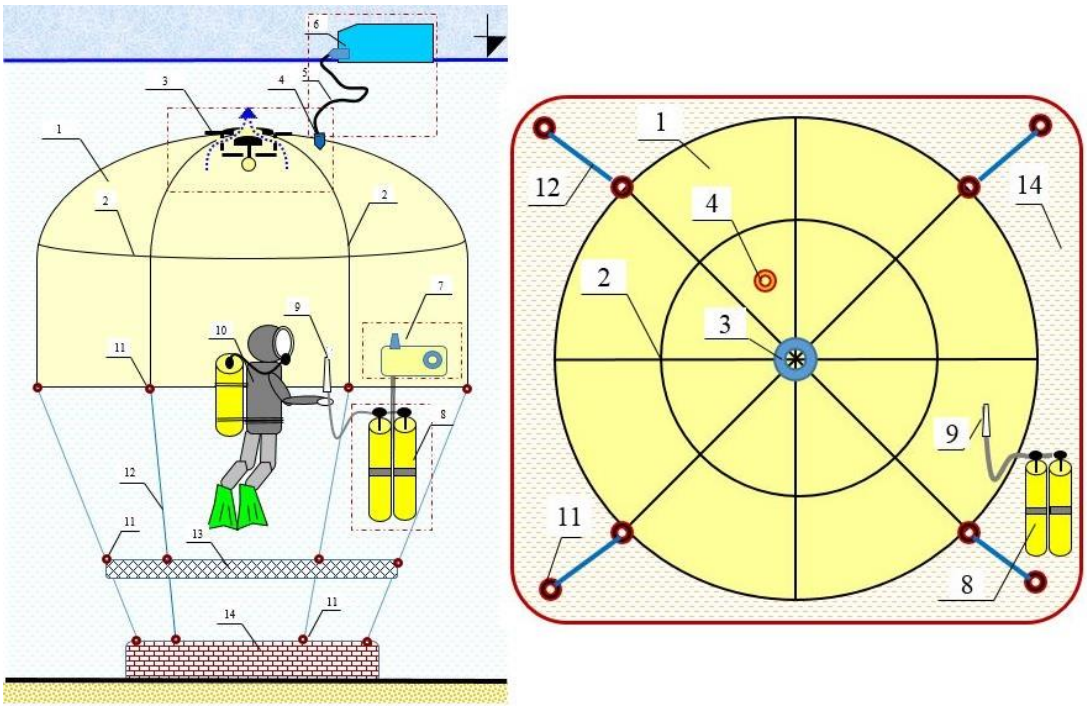


Figure 1: The Batychron. G.Rutkowski. 2022.

Figure 2: Batychron main components A) transparent dome, B) openwork mesh, and C) flexible diving bell – the Batychron. P.Kolakowski. 2022.

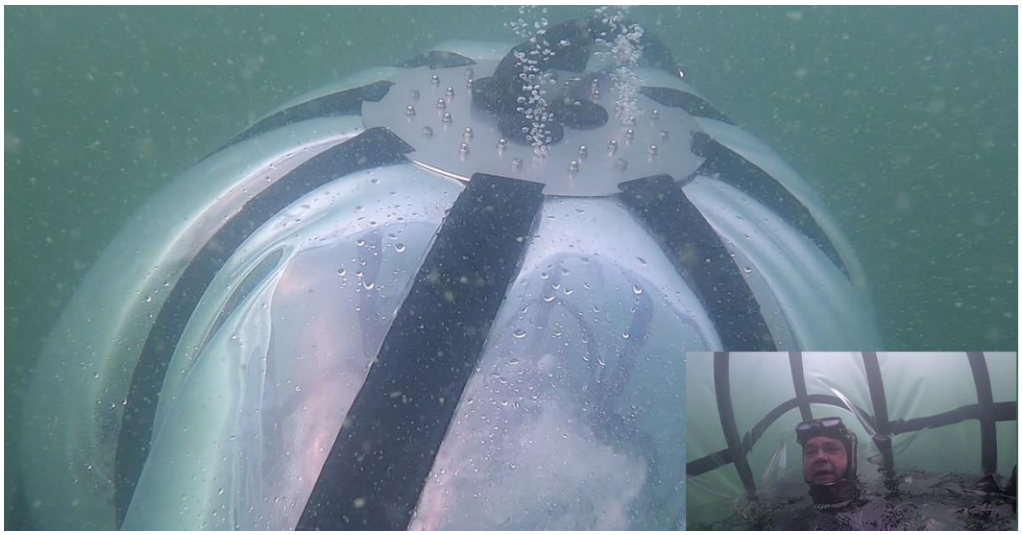


Figure 3: Research conducted in a real environment on the invention of Batychron. G. Rutkowski. 2022.

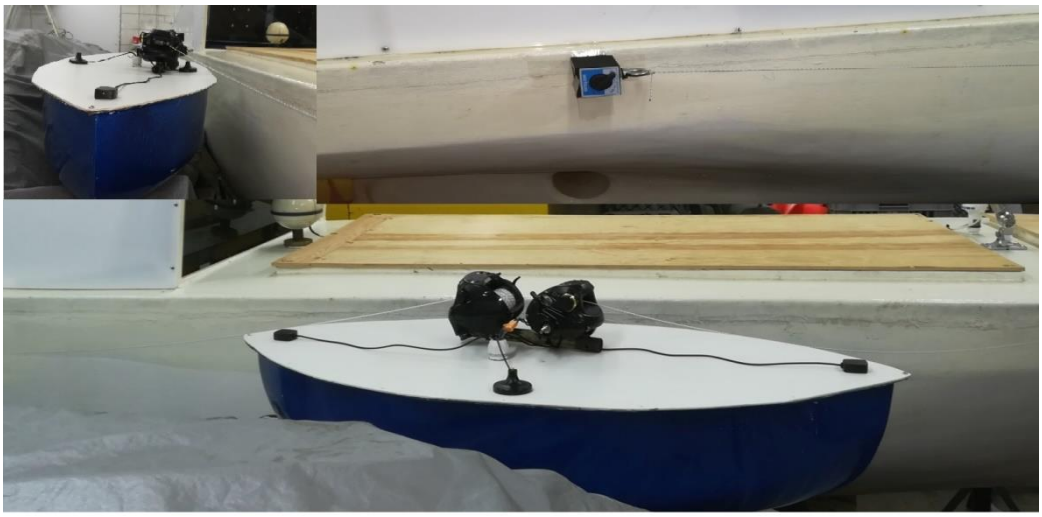


Figure 4: Mobile Elecromagnetic Mooring System (MEMS) – laboratory model in scale 1;30. P.Kolakowski. 2022.

Antiviral surgical masks, gowns and drapes

Authors/inventors: Mark Zver, Rok Zaplotnik, Miran Mozetič, Alenka Vesel, David Dobnik, Arijana Filipić, Polona Kogovšek, Maja Ravnikar and Gregor Primc.

PROs: Jožef Stefan Institute, National Institute of Biology

Abstract:

The COVID-19 pandemic showed we lack methods to prevent the spreading of airborne pathogens. Face masks and covers are currently employed to protect the wearer from pathogenic organisms. The issue lies in the survivability of pathogens, which remain viable on medical textiles for several hours or even days, serving as a potential source of infections.

Our team has developed a technique to prepare functional textiles which successfully inactivate viruses upon contact. These are standard materials (non-woven textiles) for production of disposable medical masks, which are treated according to our method of invention. The treatment does not disrupt the filtering efficiency. We performed biological tests, demonstrating that the final product is safe.

The innovative method is safe, low-cost, and scalable, addressing the single-use medical face mask market with a total size of over 5 billion EUR (Y2029, futurebusinessinsights.com). We believe that our innovative technology will be instrumental in combating current and future airborne infectious diseases, resulting in over 1 million mortalities yearly (World Health Organization, 2022). As experts in plasma technologies, developing custom plasma systems, and virology, we are an excellent partner for co-developing a commercial-scale production system and see that it fulfils the necessary regulatory requirements of the medical sector. At present, the technology is at TRL 4. The current team consists of academic staff at the Jozef Stefan Institute (JSI) and the National Institute of Biology (NIB). We seek for a partner to possibly establish a joint venture or to license the technology to producers of respiratory masks and medical textiles. Alternatively, we consider establishing a company for producing medical textiles according to our method – the patent application was filed recently.

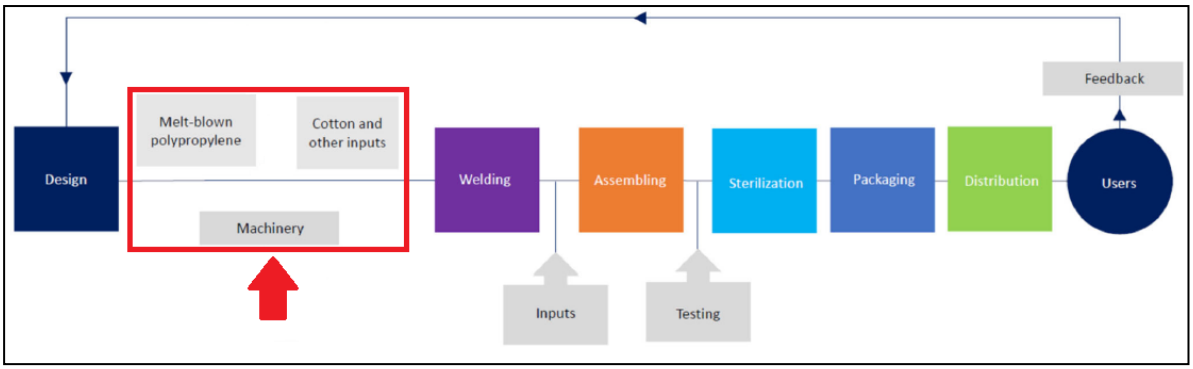


Figure 1: Facial masks value chain. Our solution is implemented in the space marked in red (Adapted from Findlay et al. 2021).

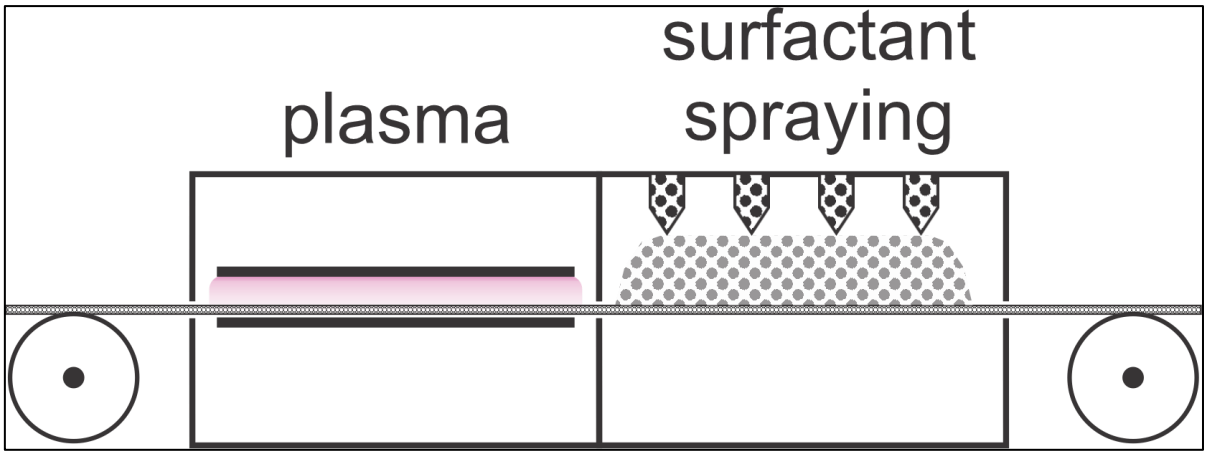


Figure 2:Proposed treatment process for producing antiviral textiles. Gregor Primc. 2022.

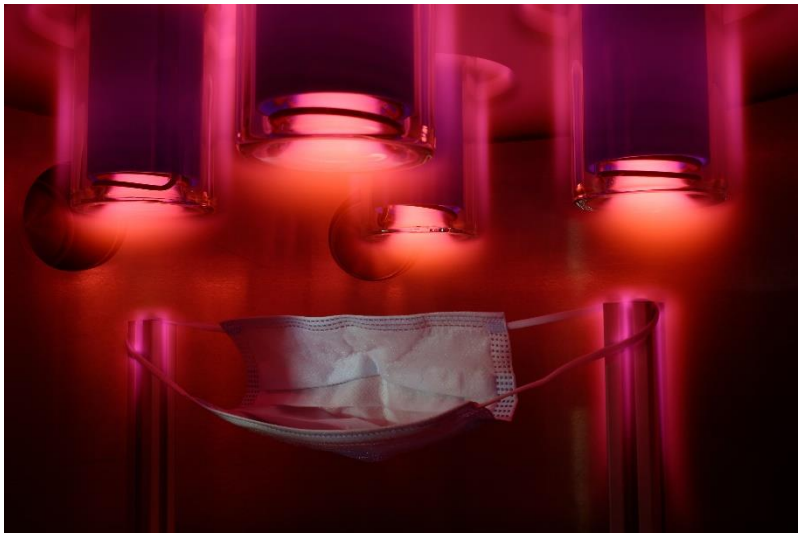


Figure 3: Our department at JSI is a great partner for designing robust and precise plasma treatment systems. Showcase: quadruple inductively coupled plasma system. Dane Lojen. 2022.

MEEVA - Measurable Enhanced Virtual Reality platform for teens with Autism and Neurodevelopment Disorders

Author/inventor: Elio Salvadori

PRO: Fondazione Bruno Kessler

Abstract:

The rate of kids diagnosed with Autism and Neurodevelopment Disorders (NDD) is increasing worldwide together with the demand for psycho-behavioral therapies provided by Specialised Centers (SC). However, the current operation of SC suffers from lack of scalability both in term of therapists involved and space occupied. Moreover, the recent pandemic has accelerated the adoption of digital technologies in all sectors; in healthcare, novel solutions for telemedicine are emerging where Virtual & eXtended Reality (VR/XR) is expected to play a major role, e.g. to perform mental health therapies from remote. VR-based mental health therapy (VRT) for people with NDD is a well-studied subject in research which has proved to be effective in improving their life quality.

MEEVA is building a teletherapy platform exposing children and teens with NDD to role-play XR games aimed at improving their social skills. The solution increases the geographical reach of SC and optimizes their operations, while families of NDD individuals can save travel time and costs. The unmet need addressed by MEEVA is twofold: (i) excess demand of psycho-behavioral therapies to people with NDD (ASD, ADHD,...), not matched by capacity for therapeutic services by the Specialised Centers; (ii) current teleconference systems are highly ineffective with these individuals, as demonstrated in the experiences during the pandemic.

The developed platform is composed by: (i) an app running on top of a VR headset exposing NDD teens to role-play games aimed at improving their social & emotional skills in a playful environment; (ii) a data-analytics software analysing biometrics data collected via wearables and correlating the emotional status of an NDD teen with the experience s/he is having during the session. The aim is facilitating ex-post session assessment by the therapist while enabling predictive therapy methodologies based on quantified data.

Compared to existing VR-Therapy tools (like C2Care, Amelia Virtualcare, Floreo) dealing with general mental health issues in settings where the patient is alone, we focus on NDD-specific treatments by engaging small groups of patients in VR based multi-player games performed under the supervision of a therapist properly tuning the scenarios.

MEEVA business model is based on subscription agreements with SC (such as private clinics, Foundations and social cooperatives) which provide tele-therapy service to families of NDD teens. For each teen receiving the remote therapy, MEEVA will charge a monthly fee (pay-per-use) to the SC plus a flat yearly fee to cover maintenance and updates of the service. The economic benefits obtained by both SC (in terms of additional earnings enabled by the extended reach, without increasing their headcount) and the families (in terms of time & transportation costs savings) can compensate the costs incurred by adopting our solution.

The team behind MEEVA is currently involved in a project supported by EIT Digital (XR4A, www.xr4a.eu) coordinated by FBK with the involvement of Xenia Reply (Italy) and iED (Greece). An MVP has been released at the end of June 2022 (TRL4-5) and a preliminary validation pilot has been organised already which involved 30+ kids and teens with the support

of a rehabilitation center. The MVP is currently being enriched with new functionalities and we plan to organise further pilots in Italy and in Greece within the end of 2022.

Figure 1. An excerpt of VR scenes from MEEVA platform: (left) Coin hunt (right) Space station. E. Salvadori, M. Dianti. 2022.

From polyurethane waste to high value added raw materials

Authors/inventors: Maja Grdadolnik, Blaž Zdovc, David Pahovnik, Ema Žagar

PRO: National Institute of Chemistry, Department of Polymer Chemistry and Technology

Abstract:

Extensive use of inherently non-biodegradable plastic leads to an excessive accumulation of plastic waste in the environment, which is associated with related climate change. In Europe, the production of about 1.1 million tonnes of polyurethane foams (PUFs) results in more than 600,000 tonnes of PUF waste per year. PUFs are used in a variety of durable applications such as upholstered furniture and insulation. The most common way of PUF waste disposal is landfilling, which is, along with incineration, unacceptable from environmental pollution point of view. An alternative is chemical recycling, which converts PUF waste into high value-added raw materials.

Our solution for PUF waste management is an energy- and cost-efficient microwave-assisted chemical recycling process using a small amount of specialty reagents. Our innovative process enables highly efficient PUF degradation in a short time, which results in about 80% lower energy costs compared to recycling processes based on conventional heating of reaction mixtures. State-of-the-art chemical recycling technologies for PUF waste produce low-quality recycled polyols, while our technology is distinguished by high-quality polyols with properties comparable to the corresponding commercially available polyols. This enables production of high-quality flexible PUFs exclusively from recycled polyols, which has not been possible up to now.

Behind the innovation is a team of experts in polymer synthesis, degradation and characterization, with extensive experience in working with industrial and research partners. Our plan is to transfer IPR to companies dealing with PUF recycling and/or manufacturers of polyols or PUFs.

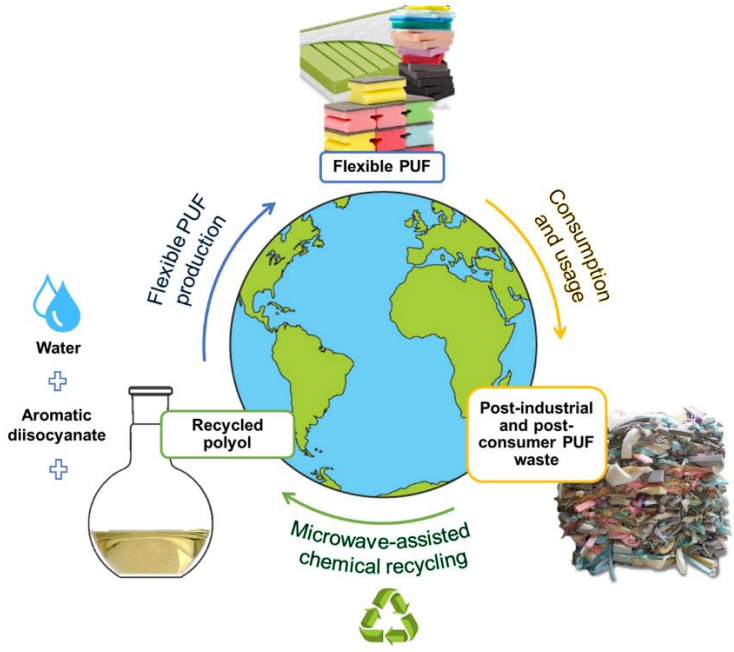


Figure 1: Recycling of polyurethane foams as proposed in our innovation. Maja Grdadolnik. 2022.

Figure 2: The high quality of recycled polyols produced by our method was confirmed by Repsol in Spain, a multinational company that produces commercial polyols for the synthesis of polyurethanes. Repsol synthesized flexible PUFs that were tested for their mechanical properties. The mechanical properties of PUFs made from our recycled polyols are comparable to PUFs made from virgin polyols. Company Repsol. 2021.

Water soluble cannabinoids with increased stability

Authors/inventors: Mitja Križman, Jure Zekič, Primož Šket, Alojz Anžlovar, Barbara Zupančič, Jože Grdadolnik

PRO: National Institute of Chemistry

Abstract:

Our technology relates to the field of water-soluble cannabinoids. Cannabinoids have become an important global commodity, and found their place in the food & beverage, food supplement and cosmetics industry, but also elsewhere (e.g. pharmaceutical industry). The major inherent problem related to cannabinoids is their very low water solubility. Our invention provides cannabinoid and hemp resin water solutions, with increased stability and bioavailability. We seek to commercialize the technology through spin-out company on EU market (waterborne cannabinoids and hemp resin with increased stability), taking our share of the 2 billon USD worth EU market (2021) with expected annual growth of 30 % (CAGR), and through licensing with technical assistance for US, Canadian, Australian and Asian markets (selling knowledge and IPR so companies in these geographic areas can utilize local hemp production and develop their own products). The global market is estimated at 13 billion USD (2021) with CAGR at 20 %. Since the market for cannabinoids is well established and growing we will be able to take the advantage of existing marketing and distribution routes to reach our customers and business partners. The team of highly qualified scientists that has developed present patent pending technology is supported by NIC's Knowledge Transfer Office, by Ljubljana University Incubator and by a local CBD utilizing company. The technology is currently at TRL 5. We also have the capability and facility for production quantities of the final product(s) in multi-kilogram quantities.

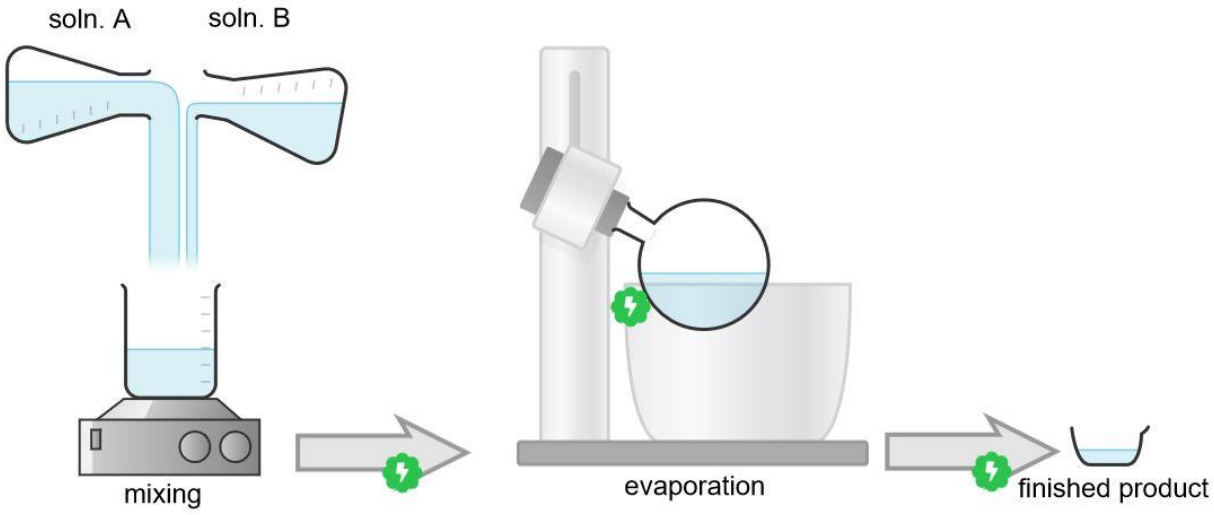


Figure 1: Schematics of our process. Mitja Križman. 2022.

Figure 2: Comparison in water solubility between unmodified (left) and modified (right) hemp resin. Mitja Križman and Jure Zekič. 2022.

Rationally designed lutein esters: “The onset of improved and sustainable eye health remedy”

Authors/inventors: Alen Albreht, Valentina Metličar, Krištof Kranjc

PROs: National Institute of Chemistry; University of Ljubljana, Faculty of Chemistry and Chemical Technology

Abstract:

Lutein and other carotenoids are natural antioxidants with many beneficial effects on human health. Lutein is especially efficient in the prevention of age-related macular degeneration, which currently affects 15% of the EU population alone (67 million). The global lutein market was valued at $354 million in 2022 and is predicted to double by 2032.[1] The existing lutein-containing products are sold mainly as food supplements, but owing to lutein’s intrinsic physicochemical properties, these products have limited shelf-life and bioavailability. Additionally, the main ingredient is obtained through processes that are harmful to humans and to the environment. The overarching motivation behind our innovation is the production of an improved line of lutein supplements that overcome the above hurdles by chemically tweaking lutein’s structure in a sustainable manner through esterification. The main targeted partners (customers) are large food supplement producers that aim to introduce improved products into their portfolio and/or integrate a green, inexpensive, and sustainable technology into their manufacturing process, reducing carbon footprint. The partners’ financial and market gain stems also from the revenues of unique, efficient, and trustworthy lutein-based ingredients, backed by scientific research. The founding team, consisting of three scientific researchers from two PRO’s backed by their TTOs, established a means to various lutein ester compounds with improved chemical stability (over 20-times). Future efforts will be focused on the determination of activity and bioavailability of lutein esters which will drive further technology development and demonstration at a higher TRL level, promoting technology transfer and product commercialization, predicted for 2026.

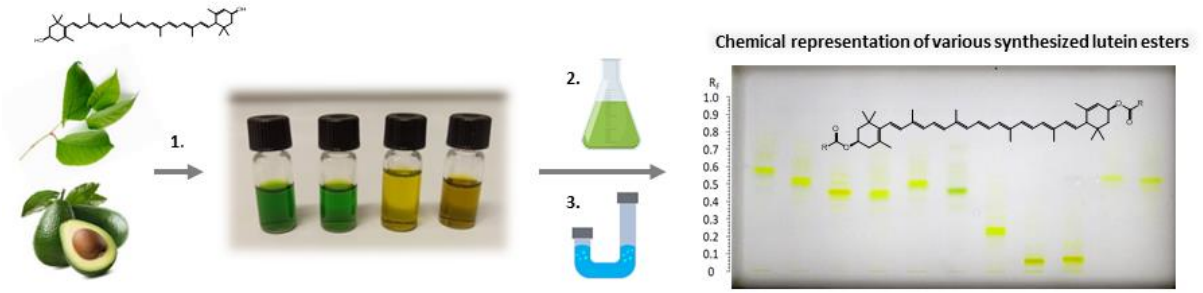


Figure 1: Sustainable platform for the production of lutein esters; Step 1: Extraction, Step 2: Synthesis, Step 3: Purification. Authors: Alen Albreht, Valentina Metličar, Mirica Karlovits. 2022.

[1] https://www.futuremarketinsights.com/reports/lutein-market

Award announcement Best innovation with commercial potential

13:00 to 13:10

Moderator:

Marjeta Trobec, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Evaluation commission members:

Alexandre Massart, co-founder and director, Blend Ventures,

Jurij Giacomelli, Investment Manager, META Ingenium,

Michel Neu, International Technology Transfer Expert, CEA Alternative Energies and Atomic Energy Commission,

Nina Urbanič, Adviser for equity investment monitoring and reporting, Slovene Enterprise Fund,

Vladimir Jančič, CEO, Publikum Korpfin.

ANNOUNCEMENT OF THE WINNERS

The evaluation commission weighed all the criteria in the evaluation process and selected two equally ranked winning teams.

The award of 2000 Euro goes to the team members:

Maja Grdadolnik, Blaž Zdovc, David Pahovnik and Ema Žagar, **National Institute of Chemistry** for **from polyurethane waste to high value added raw materials.**

The award of 500 Euro goes to the team members:

Paweł Kołakowski and Grzegorz Rutkowski, **Gdynia Maritime University** for **Innovative equipment of intervention/service watercraft: Mobile Electromagnetic Mooring System and Batychron.**

Congratulations!

Award announcement: WIPO IP Enterprise Trophy

From 13:10 to 13:20

Moderator:

Marjeta Trobec, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

ANNOUNCEMENT OF THE WINNER WIPO IP ENTERPRISE TROPHY

By celebrating the achievements of inventors, creators and innovative companies around the world, the WIPO Awards aim to foster a culture in which innovation and creativity are encouraged and appreciated at every level of society.

Two years ago, at the 13th International Technology Transfer Conference the WIPO awards were given in Slovenia for the first time.

The members of the selection committee were Mrs. Nina Urbanič, Slovene Enterprise Fund, Mr. Alojz Barlič from the Slovenian Intellectual Property Office and Christoph Kempf, Karlsruher Institut für Technologie (KIT).

The WIPO IP Enterprise Trophy is awarding a Slovenian enterprise for its good practice in constant and methodological use of the IP system in its business activities.

The main criteria for the selection were the following for the last 10 years:

- the number of cooperations with public research organisations,
- no. of employments of your PhDs from public research organisations,
- new products or services launched to the market based on TT and IP protected,
- public campaigns to promote the appreciation of companies' IP assets,
- encouragements for creative and inventive activity among staff,
- programs to use the IP-based business also for public goals and
- commercial/marketing strategies based on effective use of the IP system.

Among the applications, the jury has decided to give the IP Enterprise Trophy to company **Elan, d. o. o.**.

Short justification: Elan is actively cooperating with several public-research organisations. Their products have a suitable IP protection and are promoted at different fairs and events. Through the social responsibility programs, they cooperate with schools and youth clubs and are having a Reducing carbon footprints program. And finally, they constantly and methodologically encourage the creativity and innovativeness among their staff.

Opportunities arising from publicly funded research projects / presentations of successful scientific projects

From 13:20 to 14:20

Moderators:

Tomaž Lutman, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

France Podobnik, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Katja Cergol, University of Ljubljana, Knowledge Transfer Office

Successful Slovenian scientific projects were presented in short popular lectures. The goal of the presentations is to further promote the science to economy and general public. The future steps towards higher TRLs were also discussed in order to stimulate researchers to bring their technologies closer to the market with different steps that can take place like networking with other PROs to create interdisciplinary teams, by applying for additional EU or national funds.

Title	Presenter(s)	Organization
Karstology in the Classical karst	Assoc. Prof. Nataša Ravbar, PhD	Karst Research Institute, ZRC SAZU
Antecedents of environmentally and socially responsible sustainable consumer behaviour	Prof. Žabkar Vesna, PhD	Faculty Of economics, University of Ljubljana
Why the World Needs Anthropologists	Prof. Dan Podjed, PhD	Institute of Slovenian Ethnology, ZRC SAZU
New halogen bonds in biological systems	Assoc. Prof. Martina Hrast	Faculty of pharmacy, University of Ljubljana & National institute of Chemistry
Ionically charged topological defects in nematic liquids	Prof. Miha Ravnik, PhD	Faculty of Mathematics and Physics, University of Ljubljana, Jožef Stefan Institute

Table 1: List of presentations of successful scientific projects

Award announcement: WIPO Medal for Inventors

From 14:20 to 14:30

Moderator:

Marjeta Trobec, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

ANNOUNCEMENT OF THE WINNER WIPO IP MEDAL FOR INVENTORS

The WIPO Medal for Inventors is awarding a Slovenian public researcher for his contribution to the national wealth and development.
The selection committee members were Mrs. Nina Urbanič, Slovene Enterprise Fund, Mr. Alojz Barlič from the Slovenian Intellectual Property Office and Christoph Kempf, Karlsruher Institut für Technologie (KIT).

The entry criteria for the selection were granted patents or utility models in the last 10 years. Further the patented invention had to show a significant economic and technological impact in Slovenia via:

- creation of a new company or
- creation of new jobs in the companies that cooperate with the researcher or
- the number of new products and services launched to the market.

The committee ranked all applications and decided that the "WIPO Medal for Inventors" goes to **Prof. Dr. Miran Mozetič**.

Short justification:
Prof. Mozetič has over 10 granted patents with examination in the last 10 years and additional 5 without the examination. He is a co-founder of a company Plasmadis. His inventions had impact also on 4 new jobs created in different companies.

Connecting education system with academia: Presentations of selected research topics from the Jožef Stefan Institute and proposals for cooperation

Parallel session from 13:20 - 15:00

Moderator:

Urška Mrgole,

Center for Technology Transfer and Innovation, Jožef Stefan Institute

About

In accordance with the Jožef Stefan Institute's mission, the Center for Technology Transfer and Innovation promotes scientific work and research accomplishments among young people and the rest of the interested public.

The event

At the 15th International Technology Transfer Conference a parallel section "Connecting education system with academia: Presentations of selected research topics from Jozef Stefan Institute and proposals for cooperation" took place. The section was aimed at primary and high school teachers where selected research topics from the Jožef Stefan Institute (JSI) and proposals for cooperation were presented.

For the introduction the development of breakthrough technologies at the Jožef Stefan Institute video was presented. After the video, activities for the promotion of science and research work, which Center for Technology Transfer and Innovation at the Jožef Stefan Institute carries out independently or in cooperation with the research departments at JSI, were presented. School visits: every Thursday during the school year, the Center for Technology Transfer and Innovation, with the help of other JSI departments, organizes visits to the Institute that are intended for primary and high schools, faculties and everyone else from the school sphere. Open day at JSI: each year at the end of March, traditional Stefan's Days take place at the Institute, marking the birthday (24 March) of the great Slovenian scientist, Jožef Stefan. In the scope of Stefan's Days, the Center for Technology Transfer and Innovation, in cooperation with the JSI research departments, organizes the Open Day at JSI. Visitors can choose from a number of visit programmes and look at the laboratories at Jamova cesta in Ljubljana and at the Reactor Center near Ljubljana. Open Week at JSI: In the scope of Stefan's Days an open week at JSI is organized, where every day of the week one school is welcomed to JSI for a visit. Participation in various European projects and initiatives such as "Science with and for Society": the Center for Technology Transfer and Innovation at the Jožef Stefan Institute enthusiastically participates in various European projects and initiatives with the aim of promoting science and research work among Youth, e.g. the research festival Znanstival, the European Researchers' Night, and European projects such as STEM4Youth. Within the STEM4Youth project nine chemistry modules were prepared and implemented in 19 Slovenian primary and secondary schools, with 20 mentors and over 500 elementary and

high school students participating. The modules are now available online for all schools to implement them.

In the second part researchers from various research departments presented their work.

Rok Novak, mag. inž. teh. var. okolja, Department of Environmental Sciences, O2: The multidisciplinary research of the Department of Environmental Sciences focuses on the combination of physical, chemical and biological processes that influence the environment, man and human activities. One of the presented ongoing research projects was related to the investigation of the presence of mercury in the environment. As part of the presentation, various possibilities for cooperation with schools were presented, such as: mentoring, technical day and similar.

Žiga Ponikvar, mag. kem, Materials Synthesis Department, K8: The research at the Department is devoted to the development of advanced materials. Their main focus of the research are nanoparticles, especially magnetic nanoparticles which can be easily influenced from a distance with a magnet.

dr. Janez Kokalj, The Reactor Engineering Division, R4: The Division, who plays a leading role on the nuclear energy stage in Slovenia, is focused mainly on fundamental and applied nuclear engineering and safety research, with special emphasis on the safe operation of the Krško nuclear power plant. At the conference various interdisciplinary researches were presented, that integrate thermal-hydrodynamical, structural and probabilistic safety analyses.

Mark Zver, MSc, Department of Surface Engineering, F4: The main activities are focused on plasma generation, sustenance and characterization of the plasma which is later used for tailoring surface properties of various materials. Plasma is the most common state of matter in the visible universe. Low-temperature plasmas are usable for substance removal, surface cleaning, compound application, etc.

Junoš Lukan, MSc, Department of Intelligent Systems, E9: The principal goals of the Department are to contribute to the computational theory of intelligence and to develop high-impact practical applications in various areas such as intelligent information systems, data analysis, intelligent web retrieval, intelligent agents, language technologies, etc. Main focus of the presentation was about the Artificial intelligence and its use in the education.

Center for Technology Transfer and Innovation at the Jožef Stefan Institute and similar organisations in Europe represent a bridge in connecting researchers on the one hand and education system on the other. One of our goals is to bring the scientific work and accomplishments as close to the youth, teachers and other interested public as possible, believing that nothing can beat the personal experience and direct contact with the laboratories and top-level researchers. The event proved to be very useful and instructive for teachers who gained new ideas for the implementation of lessons at schools and learned new opportunities to cooperate with the Jožef Stefan Institute.

Paper presentations: research papers on technology transfer and intellectual property

From 14:30 to 16:50

Moderator:

Tomaž Lutman, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Technology transfer officers presented the research papers on technology transfer and intellectual property. The research papers comprised the following topics:

- Key factors for successful technology transfer from different points of view (researchers, knowledge transfer experts, enterprises)
- The role of TTOs in maximizing impact of science, technology and innovation on society
- IP value vs price
- Incentives for contract and collaborative research / cooperation with industry
- IP negotiation with industry
- State Aid in contract and collaborative research
- Current status of public investments into research and technology infrastructures
- European or national frameworks to transform breakthrough technologies developed for fundamental research purposes into breakthrough innovations with strong industrial applications and societal added value
- Examples of IP protection in Artificial Intelligence
- Other, chosen by the contributor

The papers as presented in the Table 1 are published in the main part of the 15.ITTC proceedings.

Title	**Authors**
Technology transfer offices as a facilitator of knowledge triangle integration in the knowledge valorisation era: focus group discourse analysis	Ivana Vuka, Nikola Balić, Andras Havasi, Marie Mifsud, Leandra Vranješ Markić
Proof of Concept typology: a method for classification of PoC activities according to a technology cycle timeframe	Linas Eriksonas
The “Incubator of Innovativeness” program driving technical readiness levels of the Cracow University of technology innovations	Jacek Kasz

Science meeting the needs of entrepreneurs	Magdalena Kukowska-Kaszuba, Agnieszka Piotrowska-Kirschling, Paweł Kołakowski, Grzegorz Rutkowski
Commercialization of R&D results created with public funds in the National Academy of Sciences of Belarus	Alexander Uspenskiy, Aliaksei Uspenski, Maxim Prybylski
Selection and evaluation of technologies for the transfer to the industry	Vadim Iatchevici
Subsidizing Knowledge Transfer with Public Funds	Michal Belusky
Effective collaboration and IP management	Levin Pal, Robert Blatnik, Špela Stres
Project support services of a technology transfer office	Tomaž Lutman, Špela Stres
Challenges of Legal and Regulatory Framework for Blockchain Technology in the EU	Urška Fric, Jurij Urbančič
Technology Transfer: Start and Stop of Deep Well Pumping Through GSM System	Pedro Maldonado, Silvestre Sarabia, Emmanuel Costilla, Roberto Avelino
Advanced 3D sensor system for visual control of geometrically complex products	Urška Florjančič, Mario Žganec, Vili Malnarič, Hidajet Kurbegović, Anatolij Nikonov, Jerneja Žganec Gros, Tomaž Savšek

Table 1: List of research papers on technology transfer and intellectual property

Scientific Review Programme Committee representative has selected and ranked the best three papers of the Conference:

1st place: **Advanced 3D sensor system for visual control of geometrically complex products** for a great example of knowledge transfer.

2nd place: **Subsidizing Knowledge Transfer with Public Funds** for deep and wide knowledge and understanding of technology transfer processes

3rd place: **Challenges of Legal and Regulatory Framework for Blockchain Technology in the EU** for competent insight into the perspective area of blockchain technology.

The Conference closing

From 16:50 to 17:00

Moderator:

Marjeta Trobec, Jožef Stefan Institute, Center for Technology Transfer and Innovation (CTT)

Overview of the conference: In 2022 the conference took place at the Jožef Stefan Institute and via Zoom and attracted 100 participants. Among them 30 attended the section Connecting education system with academia. The key note speaker, Mr. Michel Neu from CEA French Alternative Energies and Atomic Energy Commission presented their experiences in collaboration with companies and spin-out creation. Two awards for the best innovation with the business potential from PROs were given to the two winning teams (out of six competing). The six competing teams consisted of 25 team members all together. Two teams came from the PROs abroad. This year, for the first time, the team from abroad was awarded. WIPO IP Enterprise Trophy and WIPO Medal for Inventors were given. 12 research papers on TT and IPR from several countries and 5 successful scientific projects of Slovenian researchers were presented.

Day 2

CONFERENCE CEREMONY

Overview of the Conference Ceremony

14 October 2022

Jožef Stefan Institute, Ljubljana, Slovenia

Location: Main Lecture room at the Jožef Stefan Institute (A-building)

12:00 – 12:05	Musical performance / Glasbena točka
12:05 – 12:10	**Welcome Speech** Prof. Dr. Boštjan Zalar Director of Jožef Stefan Institute
12:10 – 12:20	**Opening Speech / Slavnostni govor** dr. Igor Papič Minister za digitalno preobrazbo Republike Slovenije Minister for Education, Science and Sport
11:20 – 12:25	**Greetings / Pozdravni govor** prof. dr. Mojca Ciglarič Chair of the Programme Committee of IS2022 / Predsednica PO IS 2022 Dean of Faculty of Computer and Information Science / Dekanica FRI Ljubljana
12:25 – 12:55	**Awards of IS2022 / Nagrade IS2022** prof. dr. Mojca Ciglarič, IS Programme Chair prof. dr. Matjaž Gams, IS Organization Chair prof. dr. Sašo Džeroski, SLAIS President Niko Schlamberger, President of Slovenian Society Informatika prof. dr. Andrej Brodnik, President of ACM Slovenia dr. Mark Pleško, President of Slovenian Academy of Engineering Awards “Hall of fame of Slovenian Computer Science and Informatics” prof. dr. Borut Žalik, president of “Hall of Fame” **15. ITTC: Awards ceremony – competition for the best innovation with commercial potential in the year 2022, WIPO Medal for Inventors and WIPO IP Enterprise Trophy**

	15. ITTC Organising Committee World Intellectual Property Organisation representative / Slovenian Intellectual Property Office representative
12:55 – 13:00	Musical Performance / Glasbena točka

Zbornik 25. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2022

Zvezek F

Proceedings of the 25th International Multiconference

INFORMATION SOCIETY – IS 2022

Volume F

Demografske in družinske analize
Demographic and Family Analyzes

Uredniki / Editors

Janez Malačič, Mari Jože Osredkar, Matjaž Gams

http://is.ijs.si

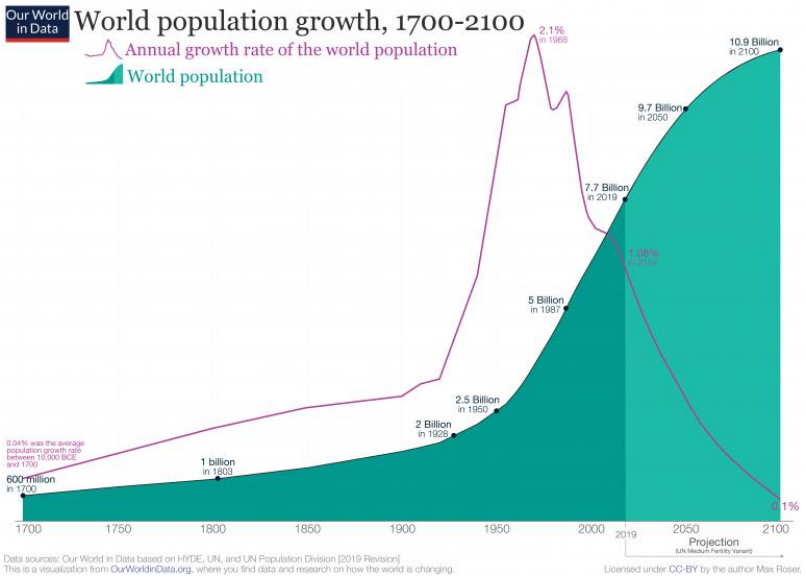
12. oktober 2022 / 12 October 2022
Ljubljana, Slovenija

PREDGOVOR

Število prebivalcev Zemlje zadnja desetletja raste linearno in dosega 7.9 milijarde, novembra letos pa naj bi doseglo 8 milijard. Leta 2023 bo Indija postala številčnejša kot Kitajska. Deset najštevilčnejših držav: Kitajska, Indija, Združene države, Indonezija, Pakistan, Brazilija, Nigerija, Bangladeš, Rusija in Mehika.

Za Slovenijo sta med najbolj perečimi tematikami begunska problematika in skoraj pol stoletja premajhna rodnost Slovenije, ki preti z dolgoročnimi uničujočimi posledicami. Demografske odločitve bodo pomembno krojile kakovost življenja ljudi v prihodnjih desetletjih tako v Sloveniji kot Evropi. Če Japoncev s sedanjo rodnostjo po napovedih leta 3000 ne bo več, bodo Slovenci s sedanjo rodnostjo izumrli čez 200 let, podobno kot drugi mali evropski narodi.

Demografske spremembe so običajno dolgotrajne. Vsako leto in vsak dan pa čutimo posledice depopulacije: število starejših raste, število mlajših upada, razmerje med delovno in vzdrževano populacijo se poslabšuje. Nekaj napotkov je jasnih: potrebno je poskrbeti za dovolj veliko delovno populacijo in vzdržnost pokojninskega sistema, za krepitev družine in skrbi za otroke in starše za povečanje rodnosti, za spodbujanje starejših, da nadaljujejo z delom, dokler gre. Nihče pa ne ve, kaj bodo prinesla prihodnja stoletja, ali bodo Slovenci res izumrli čez nekaj generacij, ali bomo skupaj našli primerne rešitve. Vsekakor so pred nami težki časi, ko so odprta znanstvena debata in analize ključnega pomena za iskanje dobrih rešitev v slabi situaciji in še slabši perspektivi.



Slika kaže rast svetovne populacije in letne rasti. Vir: Max Roser, Lucas Rodés-Guirao: Future Population Growth.

Janez Malačič, Mari Osredkar in Matjaž Gams

PROGRAMSKI ODBOR / PROGRAMME COMMITTEE

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Jože Sambt, sopredsednik

Mari Osredkar, sopredsednik

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Božidar Voljč

O nekaterih dilemah interpretacije podatkov o družini : ankete javnega mnenja in podatki statističnega urada Republike Slovenije

On some dilemmas of interpreting data about family: public opinion polls and data from the Statistical Office of the Republic of Slovenia

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ABSTRACT / POVZETEK

Podatki anket javnega mnenja in Statističnega urada RS in so temeljni viri razumevanja stanja družine in trendov spreminjanja. Namen prispevka je pokazati na pomembnost pravilnega razumevanje vprašanj in odgovorov, saj se pojavljajo interpretacije, ki so le deloma točne ali so celo napačne. V ospredju sta dve vrsti dilem: 1) dileme, ki so povezane s branjem posameznega oziroma več anketnih vprašanj; 2) dileme, ki obstajajo zaradi razlik v definicijah. Analizirali bomo vprašanja, ki se nanašajo na otroke in starše ter na družino v celoti.

KEYWORDS / KLJUČNE BESEDE

Družina, ankete javnega mnenja, rodnost, otroci, antropološka in statistična definicija družine.

ABSTRACT

Data from public opinion polls and the Statistical Office of the Republic of Slovenia are the basic sources of understanding the state of the family and changing trends. The purpose of the paper is to show the importance of a correct understanding of the questions and answers, as interpretations appear that are only partially correct or even incorrect. Two types of dilemmas are at the fore: 1) dilemmas related to reading a single or several survey questions; 2) dilemmas that exist due to differences in definitions. We will analyze the issues that relate to children and parents and to the family as a whole.

OPTIONAL: KEYWORDS

Family, public opinion polls, birth rate, children, anthropological and statistical definition of family.

1 Uvod

Empirično raziskovanje stanja družinskega življenja sestavljata dva temeljna vira podatkov: ankete javnega mnenja in podatki, ki jih zbira Statistični urad. Čeprav imajo ti podatki veliko mero zaupanja, pa vendar v javnosti, včasih pa tudi v strokovni literaturi prihaja do dilem ali celo napak interpretacij razumevanj podatkov. V prispevku se osredotočamo na dva vidika napak: 1) dileme in (potencialno) napačno interpretacijo anketnih vprašanj in 2) napake zaradi nerazumevanja razlik med definicijami. Najprej bomo podali nekaj konkretnih primerov, v zadnjem delu prispevka pa podajamo povezano interpretacijo celotne vsebine prispevka..

2 Otroci in vzgoja, otroci kot izpolnitev življenja oziroma želja

Med najbolj zaupanja vrednimi mednarodnimi raziskavami javnega mnenja gotovo spadata Evropska raziskava vrednot (EVS) in svetovna raziskava vrednot (WVS). Obe potekata v daljšem časovnem obdobju, tako da imamo za večino vprašanj odgovore iz več let. Za Slovenijo imamo podatke EVS za leta 1992, 1999, 2008 in 2017.

Vse raziskave kažejo, da je družina bolj pomembna kot prijatelji, delo, prosti čas in druge vsebine. Vendar to ne pomeni, da vsi, ki si želijo družinsko življenje to tudi uresničijo. Vseeno mnogi še vedno povezujejo otroke in družino kot del izpolnjenega življenja. Vendar se je pogled javnega mnenja na to v zadnjih desetletjih zelo spremenil. Tabeli 1. in 2. kažeta koliko ljudi meni, da je izpolnitev življenja žensk in moških še vedno precej povezana z otroki. Podatki se nanašajo na Slovenijo – enako kasneje.

Tabela 1: Ali mislite, da ženska za izpolnitev svojega življenja mora imeti otroke, ali to ni nujno? (EVS, v %, podatki za Slovenijo)

	1992	1999	2008	2017
potrebuje otroke	54,3	36,5	33,7	Vprašanje ni bilo zastavljeno
ni nujno	39,7	59,5	63,1	
ne vem	6	3,7	3	
b.o.	-	0,3	0,2	

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Information Society 2022, 10–14 October 2022, Ljubljana, Slovenia
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Opomba: V raziskavi EVS 2017 tega vprašanja ni bilo. V vseh naslednjih tabelah so izpuščeni stolpci za leta, ko vprašanje ni bilo zastavljeno.

Tabela 2: Moški mora imeti otroke, da bo njegovo življenje izpolnjeno (EVS, v %)

	1999	2008
potrebuje otroke	36,3	37,6
NITI-NITI	29,5	23,9
ni nujno	31,3	36,5
ne vem	2,8	1,8
b.o.	0,1	0,2

Vidimo dve zanimivi zadevi: velik padec mnenja, da mora ženska za izpolnitev svojega življenja imeti otroke (iz več kot 50% leta 1992 na okoli 35% v letih 1999 in 2008). Še bolj zanimivo je, da celo nekaj več vprašanih otroke povezuje z izpolnitvijo moškega kot izpolnitvijo ženske (2008: moški zaokroženo 38%, ženske 34%). Podatki po drugih evropskih državah zajetih v raziskavo sicer v veliko večji meri kot v Sloveniji povezujejo izpolnitev življenja z otroci (1999: za ženske 55%, za moške 48%). To kaže, da je Slovenska situacija daleč pod evropskim povprečjem.

Vseeno pa ljudje v prevladujoči meri vzgojo otrok povezujejo z domom obeh staršev. Soglašanje o tem, da otrok za odraščanje potrebuje dom obeh staršev je sicer nekoliko padlo, a vseeno je po zadnjih znanih podatkih (2008) okoli 86%.

Tabela 3: Otrok potrebuje dom tako z očetom kot tudi z materjo, da bo srečno odrasel - ali s tem soglašate ali ne soglašate (EVS, v %)?

	1992	1999	2008
soglašam	92,2	87	85,7
ne soglašam	6	11,8	12,5
ne vem	1,8	1,2	1,2
brez odgovora	-	-	0,7

Samo ti podatki so premalo za celoviteje utemeljeno interpretacijo. Kot kažejo ankete, je v letu 2017 dobra polovica vprašanih odgovorila, da »so tisto, kar si ženske najbolj želijo, dom in otroci« (Tabela 4). Odgovori niso povsem skladni z odgovori na vprašanje o izpolnitvi življenja zgoraj!

Še večja razlika pa obstaja, ko odgovore na vprašanje glede pomena doma z očetom in materjo za vzgojo otrok primerjamo z vprašanjem o tem, da skoraj 60% vprašanih odobrava naj ima ženska otroka tudi v primerih, ko »si ne želi stalnega odnosa z moškim« (Tabela 5).

Kako pojasniti precej velike razlike v odgovorih? Zakaj ljudje po eni strani v menijo, da je za otroka boljša dvostarševska družine (2008: 86%), po drugi pa v skoraj 60% odobravajo željo ženska po otroku, ki bi rastel v enostarševski družini? Zdi se, da v prvem primeru ljudje vidijo dobrobit otroka, v drugem pa pravice žensk – mnogi ljudje obeh vprašanj ne vidijo skupaj. Odgovori jasno kažejo, da se je glede interpretacij treba omejiti, in da je primerno postaviti več vprašanj o istem vidiku družinskega življenja, ker šele iz odgovorov na vsa lahko presodimo, ali so odgovori vprašanih celovito notranje koherentni ali ne.

Tabela 4: Je že v redu, če je ženska zaposlena, toda tisto, kar si ženske najbolj želijo, so dom in otroci (EVS, v %).

	1992	1999	2008	2017
Soglašam	70,0	61,5	61,5	51,1
ne soglašam	21,5	33,5	33,6	44,8
(ne vem)	8,4	4,8	4,7	3,6
(b.o.)	0,0	0,2	0,3	0,5

Tabela 5: Če bi ženska sama rada imela otroka, ob tem pa si ne želi stalnega odnosa z moškim, ali vi to odobravate? (EVS, v %)

	1992	1999	2008
odobravam	55,7	54,3	59,1
ne odobravam	22,4	19,3	31,9
odvisno	14,9	23,8	7
ne vem	7	2,5	1,8
b.o.	-	0,2	0,2

Glede tega vidika družinskega življenja je primerno pogledati podatke statističnega urada R Slovenije. S kratkih preračunom lahko sestavimo tabelo koliko otrok živi v dvostarševskih in koliko v enostarševskih družinah (Tabeli 6 in 7). Podatki kažejo, da je po podatkih zadnjega popisa na terenu leta 2002 velika večina otrok (80%) živela v dvostarševskih družinah, in to če gledamo na otroke mlajše od 6 let ali na otroke mlajše od 25 let. Dobro desetletje kasneje se je delež nekoliko zmanjšal: po podatkih Statističnega urada R Slovenije (SURS) je živelo leta 2015 okoli 75%. Dejansko jih je nekoliko več, kajti podatki odražajo stanje glede na podatke upravnih enot in ne stanje na terenu. Strokovnjaki na slovenskem SURSu poudarjajo, da je enostarševskih družin dejansko manj kot kaže statistični podatek, ker nekateri pari žive skupaj, prijavljeni so pa na različnih naslovih [1; 2].

Tabela 6: Deleži otrok (mlajših od 6 in od 25 let), ki žive v različnih tipih družin (popis 2002, vir SURS, lastni izračuni).

	do 6 let	do 25 let
Poročena starša z otroci	64,6%	72,0%
Izvenzakonska skupnost z otroci	15,3%	8,5%
Mati z otroci	18,1%	16,9%
Oče z otroci	2,0%	2,6%
Dvostarševska družina (skupaj)	79,9%	80,5%
Dvostarševska družina (skupaj)	20,1%	19,5%

živijo skupaj v skupnem gospodinjstvu (domu), "a skupno bivališče ni določujoča značilnost družin" [3, str. 329].

Tabela 7: Število otrok v starostnih skupinah 0 do 4 leta in 0 do 24 let po različnih oblikah družin, 1.1.2015. (Vir: SURS, Prebivalstvo po gospodinjskem statusu, petletnih starostnih skupinah in spolu, Slovenija, lastni izračuni)

	Otrok v zakonski skupnosti	Otrok v enostarševski družini živi z mamo	Otrok v enostarevski družini živi z očetom	Otrok v zunaj-zakonski skupnosti	Otrok v istospolni partnerski zvezi	Vse druge oblike - otroci niso člani družinskih gospodinjstev	Vsi otroci
Število otrok 0 do 4 leta	46354	22166	6491	33013	10	1280	109314
Št. Otrok do 24 let	263339	94615	20419	91794	20	20564	490751
Delež (%) otrok od vseh otrok							
0 do 4 leta	42,4%	20,3%	5,9%	30,2%	0,0%	1,2%	100,0%
0 do 24 let	53,7%	19,3%	4,2%	18,7%	0,0%	4,2%	100,0%
Deleži po tipih družin							
	Dvo-starševske družine		Enostarševske družine		Druge oblike		
0 do 4 leta		72,6%		26,2%		1,2%	
0 do 24 let		72,4%		23,4%		4,2%	

Deleži otrok, ki živijo v dvostarševskih družinah se morda zdijo zelo veliki, saj se v Sloveniji že veliko let okoli 60% otrok rodi zunaj sklenjene zakonske skupnosti. Vendar ni težko najti pojasnila. Zdi se, da delež otrok, ki živijo v enostarševskih družinah, ni tako velik, ker imata oba starša odgovoren in skrben odnos do otrok in otrok v veliki večini (ocenjujemo na več kot 70%, če upoštevamo tudi vzpostavljene družine). Čeprav se ne poročita, kmalu živijo skupaj. Z drugimi besedami, za pare je veliko »lažja« naloga, da skupaj skrbijo za otroke, kot pa da bi se poročili.

3 Opomba glede dveh tipov definicije družine

Potrebno je opozoriti tudi na napake, ki so posledica neupoštevanja dejstva, da se podatki zbirajo glede na dve različni definiciji družine – žal pa le redko najdemo opozorila na to, da so podatki zbrani po določeni definiciji in jih je zato treba interpretirati po tisti definiciji. V čem je težava? Antropološka, sociološka, pravna in definicija »običajnega človeka«, pa tudi religiozna (npr. krščanska) družino razume kot najmanj dvogeneracijsko skupnost. Zakonska skupnost v tem pomenu ni družina, ampak je eden njenih temeljnih namenov zasnovanje družine. Vemo, da vsi pari ne morejo imeti otrok. Statistična definicija je, če jo beremo ohlapno, širša: družina so tudi zakonske in zunajzakonske skupnosti brez otrok. Vendar ni tako preprosto. Opredelitev definicija statističnega urada R Slovenije (statistična definicija) se začenja takole: "Družina je življenjska skupnost oseb v okviru zasebnega gospodinjstva.« Antropološka definicija nasprotno poudarja, da večinoma člani družine res

Različnost razumevanja se jasno vidi v primerih ko v gospodinjstvu živijo tri generacije ali je gospodinjstvo enočlansko (tako gospodinjstvo ne more biti družinsko). Dolenc [2, str. 11] opisuje primer:

" V stanovanju št. 1 živi gospa Marija, ki je stara 78 let. Odkar ji je umrl mož, […] živi sama. Vsi trije otroci so se odselili že prej in živijo v lastnih gospodinjstvih. Tako kot gospa Marija tudi 40% žensk njene starosti živi samih. […] Gospa Marija je seveda tudi že babica, saj ima 3 vnuke in 2 vnukinji. Čeprav je mama in babica, v statističnem smislu ni družina ampak enočlansko gospodinjstvo."

Pomembno je dodati: tudi če bi v istem gospodinjstvu živela poročen sin ali hči (ali sin ali hči z vsaj enim otrokom), ovdovela babica in mama po statistični definiciji ni član (osnovne) družine. Večina razširjenih družinskih gospodinjstev (okoli 60%) je sestavljeno iz treh generacij.

»V veliki večini teh gospodinjstev (94 %) samo en član ni pripadal nobeni družini, najpogosteje je bil to eden od ovdovelih staršev (pretežno mati) ali pa neporočen brat/sestra enega od družinskih članov, zato so v teh gospodinjstvih med nedružinskimi člani prevladovale ženske […]. Vsak četrti član razširjenega družinskega gospodinjstva je bil vnuk.« (ibid. 7)

Z drugimi besedami, čeprav vsakdanje razumevanje ovdovele babice in dedke šteje med člane družine (trigeneracijske), jih statistična definicija opredeljuje drugače. Podobno je z statistično opredeljenimi poročenimi ali zunajzakonskimi pari brez otrok, ki je vse pogostejši tip statistične opredelitve družine. Nekateri teh parov otrok (še) nimajo, drugi pa otroke imajo, a so oblikovali svoje družine ali zapustili skupno gospodinjstvo. Brez upoštevanje teh vidikov statistične opredelitve družin lahko napačno sklepamo vrsto stvari. Podajmo samo en primer: povprečno število otrok v statistično opredeljenih družinah ni

povprečno število otrok na mati ali družino, ampak povprečno število otrok, ki živi v družinskih gospodinjstvih.

4 Sklep

V prispevku smo pokazali na nekaj dilem pravilnega branja podatkov empiričnih anketnih raziskovanj in statističnih podatkov o družini. Omenili smo tudi na nekaj napačnih interpretacij, ki jih lahko najdemo tudi v strokovni literaturi. Zdi se, da je treba biti pozoren predvsem na sledeče vidike:

1) Ko uporabljamo podatke zbrane po obeh definicijah družine, je potrebno jasno poudariti za katero definicijo v katerem primeru gre.

2) Za mnoge podatke posameznih anketnih vprašanj in podatki statističnega urada lahko rečemo, da so veljavni znotraj nekih »meja«. Ne smemo jih uporabljati preko njih. Zgoraj smo podali nekaj konkretnih primerov, ki kažejo na potrebno previdnost. Eden izmed načinov, da razrešimo dileme, ki nastanejo v primerih, je ta, da ima anketni vprašalnik več vprašanj, ki vprašajo o »istem«, a nekoliko drugače. V raziskavi Aufbruh so tako za vsako izmed treh načinov izražanja (ne)solidarnosti (medosebna, družbeno-sistemska, individualizem) uporabili tri vprašanja [4]. Na ta način lahko tudi precej dobro preverimo, ali ljudje odgovarjajo koherentno.

3) Zlasti pri delikatnih anketnih vprašanjih je treba biti pozoren na to, da ljudje ne bi odgovarjali tako, kot menijo da je »družbeno« pravilen odgovor in ne kot oni sami menijo. Zato je zelo pomembno kako je vprašanje zastavljeno. Pri interpretaciji odgovorov na vprašanja, ki imajo velik »vrednostni naboj«, pa je potrebna dvojna previdnost. Ne preseneča, da so mnogi vprašani pri vprašanju ali odobravajo, da bi žena imela otroka tudi če si ne želi stalnega odnosa z moškim, v ospredju videli pravico žensk – in so tako odgovorili. Podobno so pri vprašanju ali je za otrokovo odraščanje bolje, da živi v domu obeh staršev, videli dobro otroka. Čeprav sta vprašanji vsebinsko povezani, sta zastavljeni tako, da v ospredje postavita različne akterje – mnogi vprašani zato niso prepoznali njune povezanosti in so na vsako vprašanje odgovarjali kot oni mislijo ali kot je »družbeno najbolj primerno« - ne pa tako, da bi pri obeh vprašanjih upoštevali dobro vseh vpletenih akterjev (obeh staršev in otrok).

REFERENCE

[1] Dolenc, Danilo. 2011. "Gospodinjstva in družine, Slovenija, 1. januar 2011 - končni podatki" (SURS), (Prva objava : 30. junij 2011) http://www.stat.si/novica_prikazi.aspx?id=4029, dostop 1.2.2012..

[2] Dolenc, Danilo. 2016. *Ata, mama, babi, dedi… Gospodinjstva in družine v Sloveniji*. Ljubljana: Statistični urad Republike Slovenije. http://www.stat.si/StatWeb/File/DocSysFile/8914/ata-mama-dedi-babi.pdf (dostop 20. januar 2018).

[3] Ember, Carol R. in Melvin Ember. 1988., *Antropology,* New Jersey: Prentice Hall.

[4] Zulehner, Paul M.; Tomka, Miklós. 2008. *Religionen und Kirchen in Ost(Mittel)Europa : Entwicklungen nach der Wende*. Ostfildern : Schwabenverlag, cop.

VIRI

Evropska raziskava vrednot, podatki iz Arhiva družboslovnih podatkov za raziskave EVS 1992, EVS 1999, EVS 2008 in EVS 2017. https://nesstar2.adp.fdv.uni-lj.si/webview/?language=sl (dostop 2015 do 2022).

DEMOGRAPHIC DEVELOPMENTS IN KOSOVO IN TWO DECADES OF THE CENTURY XXI

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Abstract:
Demographic processes do not develop isolated from outside of social flows but in mutual dependence on biological, economic, social, political, historical, psychological, spatial, and other factors. The influence of these factors is different in space and time, thus causing significant differences in demographic development.
Kosovo after the 80s and especially after the 90s of the last century is characterized by the deterioration of the general economic, political, security, and other situation, which escalated into open war at the end of the 90s, and it was accompanied by great consequences in the demographic sphere as well.
As a result, today Kosovo is at the beginning of a demographic crisis, which is deepening day by day and the emigration of the population has an extraordinary contribution.
From the analysis of the current trends and future demographic developments in Kosovo, it can be concluded that if no concrete population policy measures are taken, the demographic trends will worsen further with the deepening of the depopulation process, demographic aging, and deterioration of all demographic structures and socio-economic of the population, which would jeopardize not only the stable demographic development but also the general stability in Kosovo, since, for the sustainable development of countries, it is necessary to ensure demographic stability in the first place.
Ignoring the demographic processes or their unconstrained (spontaneous) development will undoubtedly lead to a further deepening of the demographic, economic and social crisis, which poses a threat to sustainable development and the fulfillment of the Sustainable Development Goals - Agenda 2030.

Keywords*: demographic developments, population, fertility, natural increase, structure by age, emigration Kosovo, etc.*

1. INTRODUCTION

Resources and demographic potential are the most important component of the human development of a country, including the qualitative and quantitative characteristics and the social and biological potential of the population.
Kosovo is characterized by specific demographic development compared to other countries and other populations in the region and Europe in general. Such a development was primarily a consequence of the low and late level of economic development (industrialization), urbanization of life as well as the very one-sided and unfavorable economic structure (extractive industry). Thus, Kosovo was delayed in the stages of demographic transition, presenting the last demographic transition in Europe.
However, the demographic situation in Kosovo in the last three decades is unfavorable and has worsened significantly, which can also be defined as a demographic crisis. The main contributor to the disadvantages of demographic trends during these three decades is undoubtedly emigration.
If there won`t be actions taken, the demographic trends will worsen even more, therefore population policies have become necessary in order to reduce the consequences of negative developments that are transmitted in all segments of life.

2. DEMOGRAPHIC DEVELOPMENTS

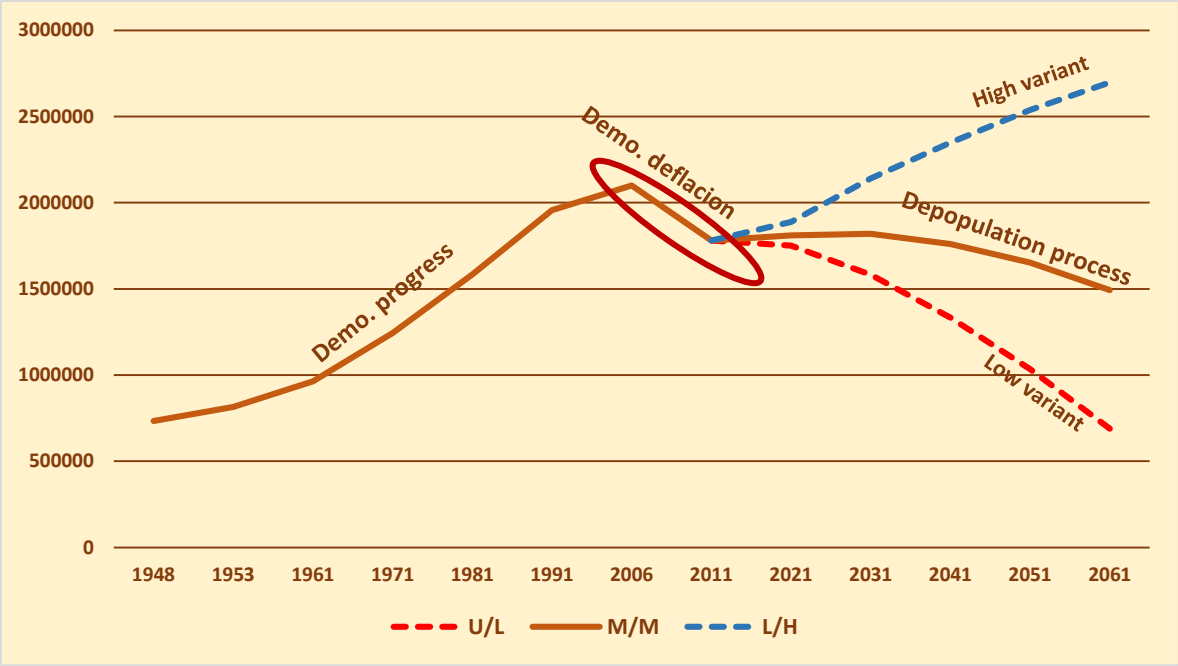
2.1. Dynamics in the total population

The movement of the general population of Kosovo shows that many times that Kosovo went through peaceful phases of development, there

was an increase in the population, while in periods of political, and economic crises and wars, there was a decrease in the population with the loss of people or emigration.

After the Second World War, with the improvement of socio-economic and sanitary conditions, the total number of the population has been constantly increasing (until the beginning of the XXI century), even though emigration continued with different intensity throughout the period to reach a peak in the last 10 years of the 20th century, when it is estimated that 30-35% of the total population of Kosovo emigrated. As a consequence of mass emigration and losses in the war of 1999, the population of Kosovo for the first time in the period 1991-2011 is characterized by a tendency to decrease the total population.

In the first two decades of the XXI century, the population is characterized by an accelerated trend of decline. Compared to the year 2000, when Kosovo was estimated to have 2,304,000 **(1)** (KAS estimate since there was no population register), at the end of 2020 the number of inhabitants decreased to 1,798,186, which represents a decrease of -505,814 inhabitants, or - 21.9%. During this period, Kosovo lost more than 1/5 of its population.



*Graph 1. Dynamics in the total number and projections of the population in Kosovo 1948-2061(**2 and 3**)*

After the XX century, when the population of Kosovo increased by 139.6% (1948-1991). In the first half of the century XXI, the first phase will be characterized by stagnation or slow population growth of 2.1% (2011-2031), while the second phase (2031-2061) will be the phase of the depopulation process with negative growth of -17.9%. Until the end of the century, the process of depopulation will deepen even more, understandably, if no unexpected positive or negative developments occur.

2.2. Indicators of natural increase in Kosovo 2000- 2020

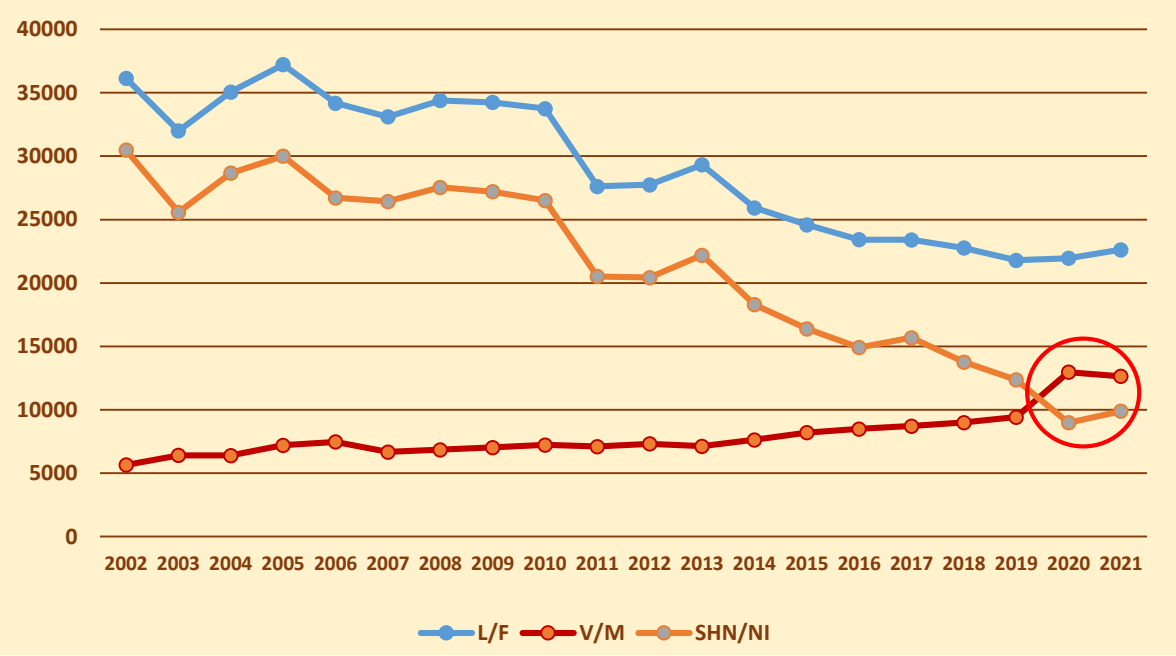
As a long-term (historical) process, the characteristics of the natural movement are a consequence of the early socio-economic and demographic development, while the later trends will be a reflection of today's socio-economic, cultural, and demographic situation, as well as the natural dynamics of the population **(4)**.

Fertility trends in -2019, 2020, and 2021, were recorded as the lowest number of births in Kosovo since 1920 and 1939 respectively. The

number of births in Kosovo in the period 2000-2020 has decreased from 38,687 (2000, births only in Kosovo), to 21,952 (2020) and 22,630 (2021) **(5),** which means almost half of births (-43.2% and -41.5%, respectively).

Mortality trends - mortality is the only component of the natural movement of the population that is characterized by growth trends in the observed period. Thus in the year 2000 when Kosovo had registered 8624 deaths in 2021, the number reaches 12,641**(5)** deaths, which shows an increase of 46.6%.

Natural increase- is characterized by the trend of falling even faster than the birth rate. Thus, compared to the year 2000, when the natural increase was 30,063 people, in 2021 it decreases to 9,989, which represents a decrease of 20,074 people, or a decrease of almost 3 times. The natural increase in 2021 is almost similar to the second half of the XXs of the last century.



Graph 2. The trend of fertility, mortality and natural increase in Kosovo 2002-2021[1]

As can be seen from graph 2, the Covid 19 pandemic effects were high, in Kosovo for the first time the number of deaths was higher than the natural increase of the population which as a phenomenon (since the end of the second world war) from the vital statistics in Kosovo was registered himself in 1951 **(6).**

The pandemic has accelerated the deterioration (of the ratios) of the natural movement of the population in 2020 for:

- 10.4 years in terms of mortality and
- 8.3 years in terms of natural increase.

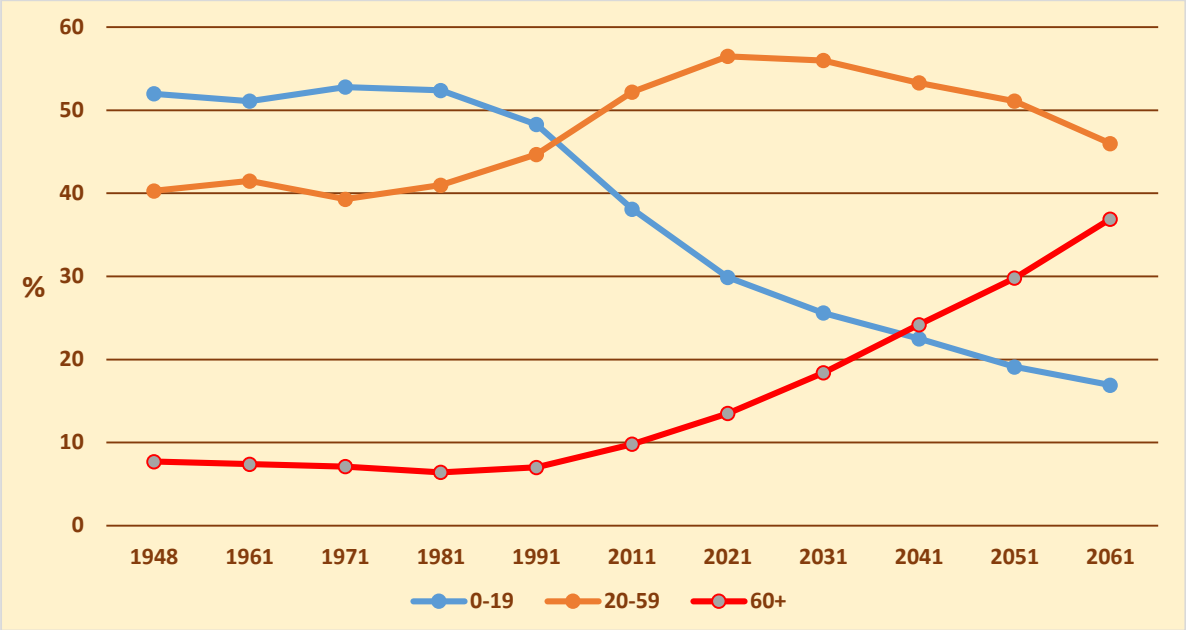
2.3. Population structure by age - demographic aging 2000-2021

In Kosovo, the process of demographic aging appears as a phenomenon from the 70s of the last century (the period when the participation of young age groups in the general population begins to decrease).

Important (negative) changes in this aspect occur in the last decade of the XXth century, when for the first time this participation decreases below 50%, even though the young age group made up the majority of the population. It should be noted that although the participation of the young age

[1] Explanation: The data of 2021 were used by the ASKDATA platform, since in the publication Statistics of Births, Deaths, Marriages and Divorces, the data also includes births, deaths, marriages and divorces from outside Kosovo.

group has decreased since the 70s, the overall number has increased until the beginning of the 90s. The situation of the 90s, in addition to the demographic and socio-economic sphere, as a result of the war and selective emigration, was also negatively manifested in the structure of the population according to age, affecting the increase in the participation of the older age group.



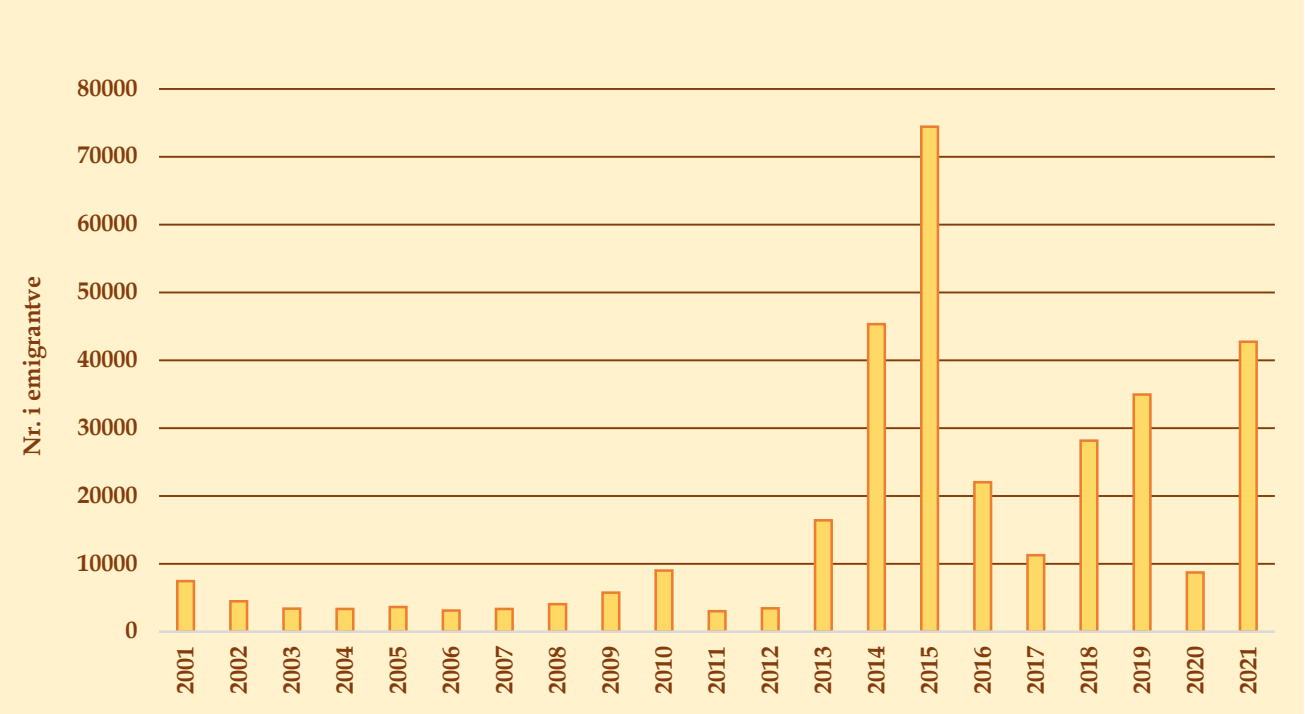
Graph 3. Participation of age groups in the population of Kosovo 1948-2061

The very rapid decline of natural increase and selective emigration (age groups of 20-39 compose nearly half of emigrants) have accelerated the aging process of the population. Thus, until 2011, the age group over 60 constituted 9.6% of the population, in 2021 this participation has increased to 13.5%. At the same time, the 0-19 age group showed a tendency to decrease participation from 38.1% to 32.3% **(7).** Population aging as a phenomenon is accompanied by negative consequences for demographic, economic, social, and other developments.

2.4. Emigration trends 2000-2021

Population emigration from Kosovo to European countries is not a new phenomenon. Throughout the XXth century and the beginning of the XXIst century, Kosovo was and remained a typical emigrant territory. The main causes that forced the population to emigrate were and remain still: the low level of economic development, the destruction caused by wars, as well as the unfavorable political situation, and other related factors. Other reasons are related to emigration, such as the dissatisfaction of the citizens of Kosovo with the current state of the socio-economic perspective and the general level of well-being, manifested by a high rate of unemployment, especially among young people, and the high percentage of people living in poverty.

In the period 2000-2021, 422,761 inhabitants have left Kosovo (according to KAS statistics), with an average of over 21,000 inhabitants per year, even though there was previously the belief that with freedom and independence, Kosovo would also recover from this centuries-old wound.



Graph 4. Emigration trends in Kosovo 2000-2021

Even more inconvenient is the fact that based on various surveys carried out in the country, about 60% of the respondents have expressed the desire to leave Kosovo, mainly the new generations (20 to 40 years old) who make up the main demographic and birth cohort, the main group of work, security, causing a decline in "human capital", as the main carrier of socio-economic development.

Given the current progress but also what is expected in economic development, employment opportunities, and other unfavorable circumstances, migratory movements of the population with undiminished intensity should be expected for a while. Unfortunately, Kosovo's institutions have not done much to address the factors driving emigration, such as economic development, unemployment, and prospects for a safe, better, more dignified life.

The situation regarding emigration could worsen even more in the case of visa liberalization and the union of Kosovo with the EU, which could stimulate a massive wave of emigration, given the fact that Kosovo lags behind the EU countries in the socio-economic sphere since one of the main factors of migration is the difference in income between the countries of origin and host.

3. CONCLUSION

Today, Kosovo is facing radical changes in its demographic profile. This is best argued by the fact that: on the one hand, we have a drastic reduction in the number of births and a natural increase, while on the other hand, as a result of selective emigration, the population is aging with accelerated trends. The situation is so unfavorable that it can be defined as a demographic crisis.

The demographic problems that Kosovo will face during the two decades of the XXI century can be prevented or mitigated through population policies.

Since emigration is the most important factor in the decline or stagnation of the population of Kosovo, the state must act to influence the reduction of the causes that encourage emigration. Establishing better conditions for people, especially the youth, to have confidence in building a future in their country is the key to stopping the emigration and the demographic crisis in Kosovo.

If the causes driving the population to emigrate are not addressed, other provisions aimed at

increasing fertility may simply result in more people leaving the country.

Demographic developments and the consequences of these developments, both the current ones and those that the Kosovar society will face in the future, do not allow the indifferent attitude of the society and the state to these developments, but immediate population policy measures must be taken with the aim of sustainable demographic development, which is a condition for overall sustainable development and the fulfillment of the Sustainable Development Goals - Agenda 2030

4. LITERATURE

1) "Kosovo Vital Statistics, 2002/2003 ", Kosovo Agency of Statistics. Prishtina 2004, pg 6. in English available at https://ask.rks-gov.net/media/1822/kosovo-vital-statistics-2002-2003.pdf
"Statistikat vitale të Kosovës", Agjencia e Statistikave të Kosovës, Buletini nr.4, Prishtinë 2005, fq. 6 in Albanian available :https://ask.rks-gov.net/media/1823/statistikat-vitale-te-kosoves-2004.pdf
2) "Kosovo population projection 2017 – 2061. Kosovo Agency of Statistics. Prishtina 2017, fq21, in English available https://ask.rks-gov.net/media/6287/kosovo-population-2010-2061.pdf
3) " Demographic changes of the population of Kosovo in the period 1948-2006 ", Kosovo Agency of Statistics, Pr. 2008. fq7, in Albanian available at https://ask.rks-gov.net/media/1834/ndryshimet-demografike-te-popullsise-se-kosoves-ne-periudhen-1948-2006.pdf
4) Islami H.(1981). "Popullsia e Kosovës". Studim demografik. Enti i Teksteve dhe Mjeteve Mësimore., Prishtinë fq 39
5) Preliminary data, available at: http://askdata.rks gov.net/pxweb/sq/ASKdata/ASKdata__Population__Demography%20and%20Migration/
6) Behrami S., Bajraktari F., Zogaj N., (2021) "The impact of the Covid 19 pandemic on demographic development in Kosovo"., International Conference- "Geographical changes during the Covid-19 pandemic"., University of Tirana, Faculty of History and Philology, Department of Geography, Tirana 2021.
7) Behrami S., "The demographic crisis of Kosovo in the two decades of the century XXI", in Albanian available at https://www.albinfo.ch/kriza-demografike-ne-kosoves-ne-dy-dekadat-e-shek-xxi/)

Politična korektnost in spoštovanje teles umrlih

Political correctness and the respect of human body after death

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POVZETEK

Članek opozarja na neverjetno hitro in temeljito spremembo tisočletja stare kulture pokopavanja in spoštovanja teles umrlih v Sloveniji. V nekaj desetletjih je delež sežigov poskočil od 0 do 84%, ponekod tudi preko 97%. Z analizo možnih vzrokov kot so prostorska stiska, ekonomski, ekološki, etični in verski razlogi, ne pridemo do razlage tega fenomena. Nasprotno, podatki kažejo, da bi se bilo treba upepeljevanju izogibati. Vendar nas mediji s temi podatki ne seznanjajo, kot da bi se pokoravali neki politični "korektnosti". Ostaja vprašanje, kdo podpira tak razvoj in zakaj.

KLJUČNE BESEDE

družina, pokopavanje, politična korektnost, spoštovanje človeškega telesa, upepelitev, pokop v krsti, ekologija, etika, verska svoboda, prostorska stiska

ABSTRACT

This paper warns of unbelievably rapid and thorough change of thousands of years old culture of burying and respecting the body of the death in Slovenia. In some decades the share of cremations jumped from 0 to 84%, in some locations also 97%. The analysis of possible causes such as lack of space, economic, ecological, ethical and religious reasons does not give a satisfactory explanation of this phenomenon. On the contrary, the data shows, that cremation should be avoided. However, media do not inform us about these data, like being obedient to a political "correctness". The question, who supports such a trend and why, remains unanswered.

KEYWORDS

family, burying, political correctness, respect of human body, cremation, burial in a coffin, ecology, ethics, religious freedom, lack of space.

1 UVOD

Spoštovanje človeškega dostojanstva pred rojstvom, po rojstvu in tudi po smrti ter varno okolje trdne družine sta močno povezana s pogumom za sprejemanje novih življenj. Zato je treba opozoriti na neverjetno hitro in temeljito spreminjanje tisočletja stare kulture pokopavanja in spoštovanja teles umrlih. Pokop telesa vzpodbuja trajno povezanost družine, stik z lastnimi koreninami in narodnim izročilom, ki nam govori o pomenu družine.

To hitro spremembo bomo ilustrirali z nekaj dejstvi in se vprašali, ali bi morebiti lahko bila posledica prostorske stiske, ekonomskih, ekoloških, etičnih ali verskih razlogov.

2 Neverjetno povečanje upepelitev

»Slovenija je fenomen od fenomenov, ker je tako visok odstotek upepelitve. ….Mi smo v 30 letih prišli iz 0 na 97 %,« je povedal gospod Domen Kokalj s pogrebnega podjetja Žale [1] , Jože Homar, direktor podjetja Menina pa: »Trenutno jih je blizu 75 odstotkov, kar nas umešča v evropski vrh, skupaj z Veliko Britanijo. Najbolj osupljivo pri tem je, da smo mi ta odstotek, za razliko od Britancev, dosegli v zelo kratkem času, v zadnjih petnajstih letih, in da ta odstotek še narašča. V tem pogledu smo Slovenci edinstveni v evropskem prostoru" [2] . Po besedah mag. Lidije Pliberšek, direktorice Pogrebnega podjetja Maribor je porast upepelitev v Sloveniji "naravnost osupljiva".

Leta 2020 smo sežgali 83.84% pokojnikov. Med članicami EU sta nas takrat prekašali le Češka 84,08% in Danska 85,84%.[3] Marsikje v Sloveniji je odstotek upepelitev krepko nad 90. V Večeru 4. 12. 2021 [4] na primer beremo, da so v Slovenj Gradcu leta 2021 do sredine novembra imeli 4,5 odstotkov klasičnih pokopov, v Mežici 10 odstotkov, na območju JKP Log (občine Ravne, Prevalje in Črna) v letu 2020 pa 4 odstotke. Je tako zaradi prostorske stiske, ekonomskih, ekoloških, etičnih ali verskih razlogov?

3 Prostorske stiske

posameznik, ki se odloča za vrsto pogreba, ne čuti. Varčno gospodarjenje s prostorom je lahko tema razmisleka za občinske urbaniste, svetnike in župane. Za površine vsake občine, posebej mestne, tekmujejo različni nameni. Tudi avtomobili in grobovi. Vsak avtomobil, tudi če nima garaže v hiši, potrebuje in dobi vsaj tri parkirna mesta (blizu mesta bivanja lastnika, pri njegovem delovnem mestu ter pred uradi, nakupovalnimi središči, …). Če je parkirni prostor velik za štiri klasične grobove, torej avtomobilu namenimo površino 12 grobov. Pri mirovalni dobi groba 10 let v isti grob v človekovi življenjski dobi zaporedoma pokopljemo na primer 4 svojce: prostor za klasičen pokop enega človeka tako predstavlja približno 2 odstotka prostora za en avtomobil.

Žarni grob res zavzema dober kvadratni meter manj površine kot klasični, vendar v Sloveniji ni občine, tudi mestne ne, ki bi ji za žarne ali klasične grobove zmanjkalo prostora. Toliko spoštovanja do svojih pokojnikov, da bomo za grobove zagotovili potrebne površine, bomo vedno premogli. Dežela, katere polja in travnike preraščajo gozdovi, ki jih je več kot 60

odstotkov, in bi jih bilo še več, če država ne bi plačevala kmetom košnje travnikov ob njih, lahko zagotovi svojim prebivalcem prostor za zadnji počitek v slovenski zemlji. Če bi bilo pomanjkanje prostora razlog, da bi oblasti podpirale sežiganje umrlih, bi ga morala najbolj podpirati tista članica EU, ki ima med vsemi članicami največjo gostoto prebivalstva. To je Malta, katere gostota prebivalstva je petnajstkrat večja od slovenske. Vendar Malta do leta 2019 sežiga ni dovoljevala, sedaj ga dopušča, vendar krematorija na Malti ni in ga še nekaj let ne bo. [5]

4 Ekonomski razlogi

so lahko cena pokopa, ki je v Ljubljani 647 evrov za osnovni pogreb v krsti in 482 za pogreb v žari (če upoštevamo tudi 85 evrov za upepelitev), ter najemnina groba (v Ljubljani 38 evrov za klasični in 23 evrov za žarni grob). [6]

Cene pogrebov so v različnih slovenskih občinah različne, posebej se razlikujejo cene pogrebov z upepelitvijo, saj mora naročnik, ki ni iz Ljubljane ali Maribora, pokriti prevoz pokojnika v Ljubljano ali Maribor in potem prevoz žare nazaj, kar lahko znese tudi nekaj sto evrov. V Mežici je žarni pogreb za 50 evrov dražji od klasičnega, v Dravogradu za 136 evrov, na Ptuju pa za 186 evrov. V Mariboru je pogreb s krsto za 21 evrov dražji od žarnega, v Kranju sta ceni približno enaki.

Celo v Ljubljani in Mariboru tako množičnega odločanja za upepeljevanje ne moremo pripisati razliki v ceni pogrebov, posebno pa ne v drugih krajih, kjer je cena pogreba z žaro višja kot cena pogreba v krsti – tudi tam so namreč odstotki pogrebov v krsti prav tako nizki ali še nižji kot v obeh mestih s krematoriji. Poglejmo še grobnine oziroma cene letnega najema grobov. V Ljubljani nas enojni grob stane 38 evrov na leto, žarni pa 60 odstotkov tega zneska, torej 22.80 evrov, v Mariboru 30 in 21,5, v Kopru 31 in 22, v Kranju 27 in 24, v Velenju 34 in 23, Slovenj Gradec 28 in 23, v Radljah 30 in 24; v Mežici in Dravogradu sta obe ceni enaki. Razlike v letnem strošku se torej gibljejo od 15 evrov v Ljubljani, 11 v Kopru in Velenju 8,5 v Mariboru, 6 v Radljah, 5 v Slovenj Gradcu, 3 v Kranju, do nič v Mežici in Dravogradu. Na Blokah nimajo žarnih grobov in žare pokopavajo v enojne ali večje grobove. S tako majhnimi razlikami ni mogoče obrazložiti tako hude rasti sežigov posebej tudi, ker kraji z manjšo razliko v grobninah ne kažejo manjših odstotkov žarnih pokopov. V Mežici in Dravogradu sta ceni letne najemnine žarnega in klasičnega groba enaki, cena žarnega pokopa je višja od cene klasičnega, kljub temu pa so v krste položili v Mežici le 10, v Dravogradu pa le 7 odstotkov pokojnikov, kar je celo manj kot v Ljubljani. Tako niti cene pogrebov, niti cene grobnin, niti obojne skupaj ne morejo pojasniti trendov zadnjih desetletij.

5 Ekološki razlogi.

Človeško telo pri sežigu gori poldrugo uro pri temperaturi okrog 1000 stopinj, v peči, ki se kuri z zemeljskim plinom. Pri tem gredo v zrak prašni delci, strupeni ogljikov monoksid. Med upepelitvijo človeškega telesa nastane 160, po nekaterih virih pa celo več kg tega toplogrednega ogljikovega dioksida. Tu je upoštevan tudi CO2, ki nastane pri zgorevanju plina, ki segreva peč. Sproščajo se vodikov klorid, zelo nevarni dioksini in furani, živo srebro (vse iz amalgamskih zalivk se sprosti v okolje; emisije živega srebra iz upepeljevalnic so pomemben vir onesnaženja okolja) ter druge kovine. [7]

V Sloveniji s sežiganjem mrtvih obogatimo zrak s tri tisoč tonami CO2 letno, pokurimo skoraj sto tisoč kubikov vedno bolj dragocenega plina (za vsakega pokojnika, po podatkih podjetja Žale, 5 kubikov), obenem pa učimo otroke prihraniti kakšno kalorijo in hvalimo dobavitelje zelene elektrike. Na Konferenci ZN o podnebnih spremembah v Glasgowu si je nekaj sto predstavnikov in voditeljev 197 držav novembra 2021 dva tedna belilo glavo, kako zmanjšati izpuste CO2. Zaradi okoljskih razlogov je Civilni iniciativi Aljažev hrib pred leti uspelo preprečiti zgraditev krematorija v Celju. V časopisih beremo članke, kot na primer »Energetska ura resnice za evropsko politiko« [8] , mediji pozivajo k ukrepom za (tudi še tako majhno) znižanje porabe plina.

A. Mernik med težavami, ki jih je imel z zbiranjem podatkov navaja tudi raziskavo [9] , v kateri avtorja ugotavljata, da je število raziskav o emisijah iz upepeljevalnic v primerjavi z nekaterimi drugimi raziskavami, predvsem tistimi, ki obravnavajo emisije iz sežigalnic odpadkov, zelo omejeno in to kljub dejstvu, da število upepeljevalnic po svetu ni majhno in da še narašča.

6 Etični razlogi.

Bogomir Štefanič [10] je navedel naslednjo misel velikega človeka in pravnika dr. Lovra Šturma:« Človeško dostojanstvo je čisto posebna temeljna človekova pravica, ki za razliko od drugih pravic, ni priznana samo živim osebam, temveč tudi pokojnim.« Poglejmo kakšno je dostojanstvo pokojnika v nadaljevanju postopka upepelitve.

»Po sežigu se pepel pograbi v posebno posodo. Kosti, ki ostanejo po sežigu, kot so lobanja, prsni koš, kolki in kolena, se zmeljejo v mlinu«. [11]

Lobanja, prsni koš, kolki in kolena, gredo torej v drobilec - krogelni mlin, kjer pokojniku polomijo in strejo vse kosti. V zapisih se mnogi izogibajo besedam drobilec, mlin, mletje, drobljenje, ampak zapišejo, da se kostem »zmanjša prostornina«. Kdor je bil priča temu manjšanju prostornine in je poslušal pokanje in hreščanje ob lomljenju in trenju kosti pokojnika, se bo iz spoštovanja do svojega ali sorodnikovega telesa odločil za pokop v krsti. »Postopek kremiranja je precej zastrašujoč, predvsem mletje ostanka kosti…« [12]

7 Verski razlogi.

Ali epidemijo žarnih pokopov lahko pojasnimo z vplivom vere?

Zakonik cerkvenega prava [13] določa, da »Cerkev zelo priporoča, naj se ohrani pobožna navada pokopavanja teles rajnih, vendar ne prepoveduje sežiganja, razen če je bilo izbrano iz razlogov, ki so nasprotni krščanskemu nauku«. Katoliški duhovniki opravijo pogrebni obred in iz mrliške vežice do groba pospremijo tudi žaro s pepelom pokojnika, vendar pa cerkveni dokumenti zelo priporočajo pogreb telesa.

Muslimani, pravoslavni, evangeličani in Jehovove priče so mi svoja stališča povedali po telefonu ali sporočili po elektronski pošti. Muslimani, pravoslavni kristjani in judje odločno podpirajo pokop telesa. Pri zavračanju sežiga so najstrožji muslimani, ki ne dovolijo svojim imamom opraviti verskega pogreba, če je telo upepeljeno. Povedna je utemeljitev Islamske skupnosti v RS, da se telesa ne sme poškodovati - ima »svojo svetost in po islamskem nauku je lomljenje kosti umrle osebe kot lomljenje kosti žive osebe«. »Tako je«, sem pomislil. Pa ni samo tako, ampak še bolj tako: nasilje nad truplom je še bolj nesprejemljivo kot nasilje nad živim; da živega udariš ali poškoduješ, se v skrajnih primerih še da opravičiti, kaj takega narediti mrtvemu, pa ni predstavljivo, niti opravičljivo. In zelo težko oprostimo tistim, ki so kaj takega naredili našim pokojnim. Pravoslavni ne dovoljujejo duhovnika pri pokopu žare. Opozarjajo, da s pokojnikom sežgemo relikvije morebitnega svetnika. Odločno pokop telesa podpirajo tudi judje. Evangeličanska cerkev AV v RS je do načina pokopa nevtralna. Nevtralne so tudi Jehovove priče. Ni pa nobene vere, katere število vernikov bi se približalo odstotku prebivalstva, in bi se zavzemala ali zahtevala sežig pokojnikov. Vera bi torej vplivala kvečjemu v nasprotno smer: več pogrebov v krstah.

Je pa ob omembi vere prav omeniti še svobodo vere. Veram je način pokopa zelo pomemben. S ceno pokopov, najemov grobov in drugimi ukrepi lahko država ali občina vodi politiko pospeševanja enega ali drugega načina pokopa in s tem širi ali oži prostor verske svobode. Posebej pri verah, ki vernikom zelo jasno določajo način pokopavanja, bi favoriziranje enega načina (na primer: odrekanje prostora za klasični grob; odločitev občine, da pogrebi, ki gredo na občinske stroške, ne morejo biti klasični; predpis, da se v tujini umrli domačini lahko pokopljejo doma, vendar samo, če so v žari, …) lahko predstavljalo diskriminacijo na osnovi vere in kršitev pravice do verske svobode.

Ko smo že pri pravicah. Pred nedavnim sem izvedel za primer, ko se je desetletja pred osamosvojitvijo po smrti neke osebe pojavil sum na umor in so sum potrdili na osnovi rezultatov naknadne obdukcije. Telo človeka je tudi bogat in dragocen arhiv podatkov. Ob množičnem sprotnem sežiganju teh arhivov marsikdo ne bo mogel do pravice in pravica do marsikoga ne.

8 Sklep.

Med različnimi možnimi vzroki torej nismo našli takega, da bi z njim lahko pojasnili tako globoko in tako hitro spremembo večinske kulture. Nasprotno, podatki govorijo bolj v prid klasičnemu pokopu telesa v krsti.

Vendar se o prikazanih podatkih ne ve dosti. V medijih ne boste našli tega področja med možnostmi za izboljšanje okolja ali energetsko varčevanje, posebej s plinom. Niti o lomljenju kosti ne boste brali. Raziskav je, kot smo videli, malo. Politična korektnost, proti kateri s tem zapisom grešimo?

Iz tega zapisa ne izvemo za prave vzroke, niti za skupine ali osebe, ki stojijo za njimi. Ne glede nanje pa privoščimo sebi in svojim, kar je Prešeren privoščil prijatelju Andreju, namreč v zemlji domači, da truplo leži!

Drago Čepar

Zahvaljujem se pogrebnim in komunalnim podjetjem, občinam, veleposlaništvom, cerkvam in drugim verskim skupnostim, uradu evropskega poslanca F. Bogoviča in drugim , ki so mi prijazno posredovali vire, podatke in pojasnila; pa tistim, ki so mi dostop do podatkov omogočili z objavo na spletu

LITERATURA IN VIRI

[1] T. Arzenšek, N. Šardi, Pogled ljudi na vrsto pokopa umrlega, Raziskovalna naloga, Srednja zdravstvena šola CELJE, 2015 str. 48).
[2] Prav tam, str. 54
[3] https://www.effs.eu/info-corner.html
[4] J. Detela, Klasični pokopi so vse bolj preteklost
[5] https://www.camillerifuneraldirectors.com/cremation-in-malta/
[6] Podatki so s spletne strani podjetja Žale. Tudi drugi podatki v tem razdelku so iz spletnih strani posameznih podjetij in občin, iz že omenjenega članka J. Detele v Večeru, telefonskih pogovorov in spletnega dopisovanja avtorja s posameznimi podjetji in občinami.
[7] Zobavnik, M. Pristavec Đogić, Upepeljevanje pokojnikov in sežiganje biološkega materiala, DZRS, 2016 in A. Mernik, Družbeno ekonomski vidiki delovanja upepeljevalnic, Univerza v Mariboru, 2010
[8] Peter Žerjavič, Delo, 9.9. 2022
[9] Mari Montse, Domingo José L. Toxic emissions from crematories: A review. Environmental International, 36/2010, str. 131.
[10] In memoriam dr. Lovro Šturm (1938-2021), Družina, 12. decembra 2021.
[11] A. Bedek, Za zidovi krematorija v Mariboru, 28. 2. 2020, https://vestnik.si/clanek/aktualno/foto-za-zidovi-krematorija-v-mariboru-kjer-so-edinega-kitajca-za-zdaj-upepelili-z-denarjem-vred-761231
[12] N.J., Ni za občutljive, https://www.moskisvet.com/zanimivo/ni-za-obcutljive-tako-je-videti-upepeljevanje.html
[13] Kan.1176, § 3

Nekaj primerov demografskega zmanjševanja

Examples of demographic schrinking

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POVZETEK

Predstavljenih je nekaj primerov zmanjševanj prebivalstva v Južni Koreji, na Japonskem, v Sloveniji itd. v primerjavi z rastjo svetovnega prebivalstva. Vzorec je znan: ob premajhni rodnosti in eksponentni naravi demografskih gibanj se število prebivalstva eksponentno zmanjšuje. Prav tako je znano, kaj vpliva na večjo ali manjšo rodnost ali dogajanja ob večji rodnosti. V zgodovini človeštva pa še nismo imeli zabeleženega široko razširjenega pojava prostovoljnega zmanjševanja prebivalstva, nekateri viri celo govorijo o nevarnostih za izumrtje, brisanje genetskih podskupin, kultur, jezikov in v skrajni meri človeštva. Kaj torej lahko ugotovimo z analizo pojava in napovedjo za naprej?

KLJUČNE BESEDE

Demografski trendi, zmanjševanje prebivalstva, analiza demografskih posledic

ABSTRACT

Demographic events and its consequences are presented for a couple of countries with under-sustainable birth rate, such as South Korea, Japan, Slovenia, etc., compared to the world population growth. Several patterns are established: when the birth rate is too low, the number of inhabitants decreases exponentially. Also, the reasons and mechanisms influencing the birth rate are to a certain extend known. However, there is no report about a country free-willingly decreasing its population and the consequences; there are even dire predictions about potential extinctions of nations, genetic subgroups, cultures and in the worst case even the humanity. Hence, what can be analysed and predicted in this period of time?

KEYWORDS

Life achievements, science, industry, dictionaries, relevancy

writing in Slovene, add English keywords below the Slovene ones, keyword, keyword, keyword

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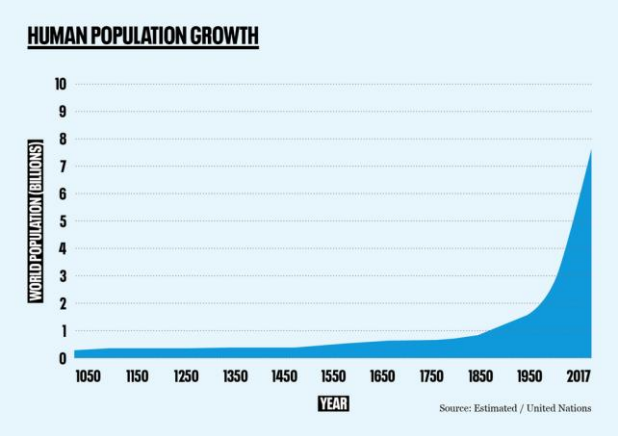
1 UVOD

V tem prispevku se ukvarjamo z analizo držav z nizko rodnostjo – kakšne so nekatere značilne oziroma odmevne projekcije. Najprej si bomo ogledali svet in nato Južno Korejo [1](23). Vsakič bomo poleg projekcije dodali še analizo stanja in perspektiv. Pomembno je razumeti, da gre za eksponentno upadanje prebivalstva v mirnem stanju, praktično blagostanju, podobno kot gre pri več kot 2.1 otroka na žensko za eksponentno rast, kar je ugotovil že Malthus. Podobno kot v demografiji oz. v živalskem svetu je problem tudi rast obremenitev planeta, ki ni vzdržna, zato je nujna preusmeritev v trajnostno rast [2,3,4]((Meadows 1972, 14, 15, 24). Glede demografije pa - zgodovinsko gledano strokovnjaki zelo dolgoletne negativne rasti še niso mogli empirično obsežno analizirati, ker takih primerov še ni bilo v moderni človeški zgodovini.

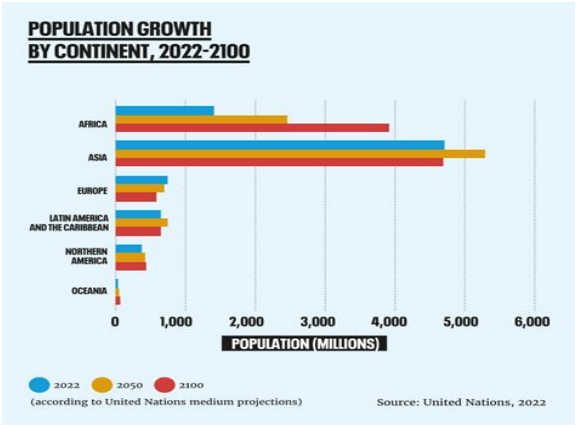
2 SVETOVNA POPULACIJA



Slika 1: Gibanje svetovnega prebivalstva od leta 1000 dalje. Vir: Populationmatters.org.

Slika 1 kaže dolgoročno gibanje svetovnega prebivalstva in kaže značilnosti eksponentne rasti. Predvideno gibanje svetovnega prebivalstva je povzeto po: "World Population Prospects: The 2022 Revision", objavljeno pri Združenih narodih [5]((27). Iz grafa na Sliki 1 je očitna osnovna zakonitost - eksponentna rast prebivalstva v zadnjih 100 letih. Taka rast bi slej ko prej preplavila planet in uničila okolje, rastlinstvo in živalstvo, planet in človeško civilizacijo. Primer: pri rodnosti 5, kot je bila na svetu v letih 1950-55, bi v 10 generacijah na našem planetu živelo 40.000 milijard ljudi, pri rodnosti 2.5 bi v 13 generacijah

prišli na gostoto 1 človeka na m2, pri 40 generacijah pa na 1 človeka na kg Zemlje. Pri rodnosti 2.5 pa bi v 10 generacijah prišli »le« na 40 milijard, in pri 13 generacijah 10x več kot vzačetka [6]((20).



Slika 2: Projekcije števila prebivalcev po kontinentih v letih 2022, 2050 in 2100. Vir: Populationmatters.org.

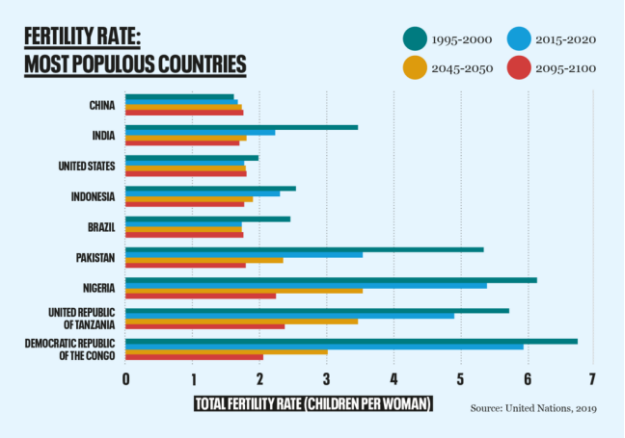
Slika 3: Prebivalstvene piramide za Kitajsko, Italijo in Afriko – zaporedoma. Pri tem je levi grafikon za leto 2019 za Kitajsko in Italijo, spodnji za Afriko pa 1950. Desno je vedno projekcija za 2100. Vir: https://www.populationpyramid.net/.

Slika 2 prikazuje velikost populacije po kontinentih v letih 2022, 2050, 2100. Daleč izstopa Afrika, ki bo skupaj z Azijo predstavljala skoraj polovico celotnega svetovnega prebivalstva leta 2100.

Slika 3 prikazuje demografske piramide za Kitajsko, Italijo in Afriko. Pomembno je opaziti iz slik 2 in 3, da se prebivalstvo hitro povečuje le v Afriki, vse ostale celine v povprečju nazadujejo. Nekaj zanimivih prebivalstvenih piramid si je možno ogledati tudi na »The World's Craziest Population Pyramids« (https://www.youtube.com/watch?v=keUaC-oyXWU).

Slika 4 kaže spremembe rodnosti v nekaj največjih državah sveta do 2100. V vseh prikazanih državah je očiten trend velikega padca rodnosti. Na »The Countries With the Lowest Birth Rate in the World« (https://youtu.be/4QwHGBBZB6w) si je možno ogledati najnižje rodnosti držav po svetu v letih. Okoli leta 2002 je med njimi tudi Slovenija z malo nad 1.2. Po tem obdobju je ta demografska konferenca organizirala nekaj dogodkov in obiskov pri najpomembnejših nacionalnih voditeljih in rodnost se je dvignila nad 1.5, kar daje misliti, da je možno povečati rodnost s primernimi ukrepi in pozornostjo vodilnih. Obsežnejše in kvalitetnejše analize avtorja in sodelavcev z metodami umetne inteligence pa so prišle nekaj kasneje [7,8,9](2,4,5) in nato pripeljale do hipotez o nevarnosti izumiranja malih narodov [10,11,12]((1, 8, 9).

Če vse države kažejo na padec rodnosti, zakaj število prebivalstev po svetu narašča? Precej ima s tem opraviti časovni zamik med rodnostjo in dejanskim številom prebivalcev. A na daljše obdobje je ključno, koliko se jih rodi in koliko jih umre.



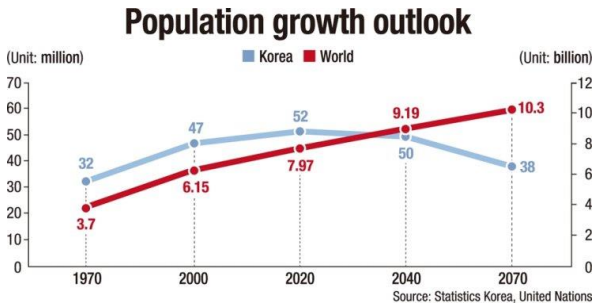
Slika 4: Rodnost v najštevilčnejših državah sveta v 5-letnih obdobjih do 2000, 2020, 2050, 2100. Trajna rodnost je pri 2.1. Vir: Populationmatters.org.

Prevelika rast prebivalstva v bližnji zgodovini je sprožila odzive v večini držav sveta. Recimo Kitajska je kar predpisala dovoljeno maksimalno število otrok, enega v mestih in nekaj dodatnih pravil recimo na podeželju, če prvi otrok ni moški, nato dvignila na 2 in 3. Zahodna civilizacija, kamor štejemo ZDA, Kanado, Evropo, Avstralijo in Novo Zelandijo pa nima možnosti predpisati kaj podobnega, saj v demokraciji formalna omejitev otrok ni izvedljiva. Zato so začeli razširjati miselnost in vrednote preko spletnih omrežij in večinskih medijev, ki so ljudi prepričevali, da svojo pozornost usmerjajo v druge smeri, recimo kariero, pridobivanje kapitala, egoistično potrošništvo in podobno, pa tudi razkroj družine, ki najbolj učinkovito okolje za

dosegati večjo rodnost. Posledično je padlo število porok [13]((26), porastle so druge oblike recimo istospolnih porok, ki imajo statistično gledano bistveno nižjo rodnost. Propagiranje združenj kot LGBT [14]((3) je skozi demografski pogled propagiranje nižje rodnosti. Osnovno zniževanje rodnosti pa pride preko destrukcije patriarhalne ali verske družine, kjer je vloga ženske tudi vloga matere, katera poglavitna skrb je imeti in skrbeti za otroke in ne odloča o številu otrok. Način prepričevanja za oba nivoja destrukcije družine ni točno znan, to je, koliko gre za spontano / emergentno dogajanje in v kolikšni meri za dirigirano s strani svetovnih elit, ki jih skrbi za prihodnost človeštva. Morda so v zvezi s tem zanimive izjave Billa Gatesa ali Davida Attenborougha »The planet can't cope with overpopulation« (https://www.weforum.org/agenda/2018/10/david-attenborough-warns-planet-cant-cope-with-overpopulation/). Posledice prevelike rodnosti so nesporne, saj bi z rodnostjo dejansko preplavili planet, kot opisano malo prej, zato se zdi zniževanje prevelike rodnosti bolj nuja kot možnost za cel planet in za države z veliko rodnostjo.

3 JUŽNA KOREJA

Južna Koreja se je v 2022 nekajkrat znašla med svetovnimi novicami. Osnovni razlog je razviden s Slike 5: projekcija neverjetno hitrega upadanja prebivalstva [1]((23). The Korea Times je objavil, da bo leta 2070 v Južni Koreji le 38 milijonov prebivalcev (NIKKEIAsia; https://asia.nikkei.com/Economy/South-Korean-population-on-cusp-of-steep-decline). Medtem ko bo svetovna populacija rastla, se bo v Južni Koreji število prebivalstev začelo eksponentno zmanjševati.



Slika 5: Druga projekcija prebivalstva Južne Koreje in primerjava s svetovnim prebivalstvom. Vir: (https://www.koreatimes.co.kr/www/biz/2022/09/602_335593.html).

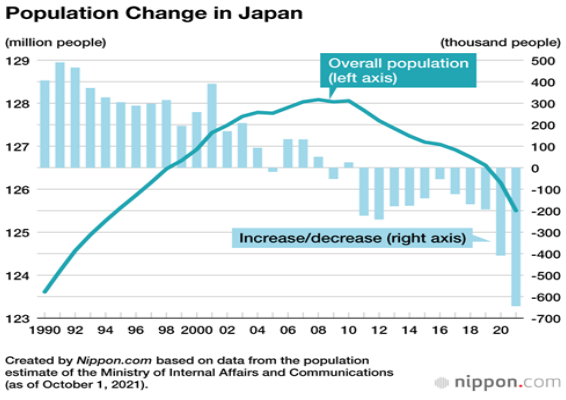
Podobne projekcije najdemo v raznih virih, zato ni veliko dvomov, da gre demografsko dogajanje v tej smeri (slika 5). Seveda so možne spremembe v eni ali drugi smeri, recimo jedrska vojna s hitrejšim zmanjševanjem in emigracija, ki bi pokrila primanjkljaj, a potrebno se je zavedati, da bo posebej drugo pomenili zmanjševanje in izginotje korejske genetske podskupine. Morda velja ob tem omeniti, da je Južna Koreja ena izmed tehnološko najbolj razvitih držav sveta in bi izostanek znanosti in razvoja v Južni Koreji pomembno vplival na razvoj celotnega sveta. Torej ne gre le za lokalna dogajanja, ampak zaskrbljujoč svetovni pojav: upadanje prebivalstva! Posledice zmanjševanja prebivalstva v Južni Koreji pa so vse prej kot enostavne.

Po projekcijah bo leta 2065 polovica prebivalcev veljala za »starejšo«, ker bo delež mladih tako upadel. Leta 2017 je bilo le 14% starejših kot 65 let. Tudi drugi pokazatelji so problematični: 58% moških se ne poroči do 44. leta. Padanje kvalitete življenja in gospodarstva zaradi prenizke rodnosti je empirično pokazana [15]((Sambt 2014 =21). Med leti 2016 in 2018 je država namenila preko 100 milijard dolarjev za povečanje stopnje rodnosti, a se je padanje nadaljevalo pod magično številko 1 (https://asia.nikkei.com/Economy/South-Korea-fertility-rate-at-new-lows-dipping-below-1.0-threshold) in je sedaj pod 0.9, kar je absolutni rekord v mirnodobnem času.

Južno Korejo in razviti svet čakajo težki časi, morda pa tudi človeško civilizacijo, če se bo tovrstni trend nadaljeval. V Thestreet (https://www.thestreet.com/technology/elon-musk-sounds-a-new-alarm-on-south-korea) Elon Musk opozarja na demografske probleme. Južna Koreja je skupaj z Japonsko ena izmed nosilcev tehnološkega svetovnega napredka. Podjetja kot Samsung, Hyundai in LG so globalni velikani. V tvitu je sporočil: »Important. South Korea is currently tracking to lose about half its population roughly every generation. Long lifespan hides the dire nature of the problem." 5.9.2022. V prevodu: Južna Koreja bo v eni generaciji izgubila polovico prebivalcev, kar zamegljuje dolga življenjska doba.

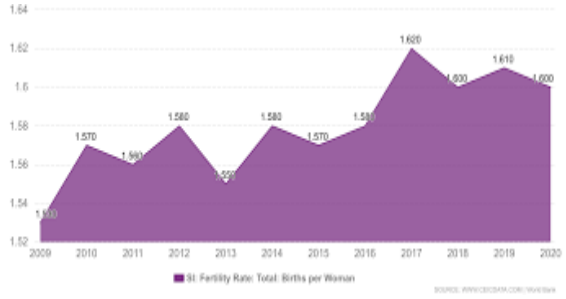
4 JAPONSKA IN SLOVENIJA

7. maja 2022 je Musk tvitnil, da bo s sedanjo rodnostjo Japonska populacija enostavno nehala obstajati in da bo to ogromna škoda za cel svet. Japonska doživlja podobne probleme »Elon Musk Sounds The Alarm About Japan« (https://www.thestreet.com/technology/elon-musk-sounds-the-alarm-about-japan?dicbo=v2-6a3286b833840b4355954162bb674199). Po Musku je japonska populacija v 2021 upadla za 644,000 na 125.5 mil. CNN je podobno objavil »Number of children in Japan shrinks to new record low« (https://edition.cnn.com/2018/05/07/health/japan-child-population-record-low-intl/index.html), saj je število otrok upadlo 37 let zaporedoma.



Slika 6: Demografske projekcije za Japonsko. Vir: https://www.nippon.com/en/japan-data/h01310/

Slika 6 prikazuje podobne razmere in perspektive za Japonsko. Tako Japonska kot Južna Koreja se zavedata problema in za rešitev so predlagali precejšnje finančne spodbude. Te spodbude so imele dokaj omejene učinke v drugih državah, zato so bili nekateri, skupaj z avtorjem tega članka, skeptični. Če si pogledate osnovne mehanizme za zmanjševanje populacije, ki so se izkazali za izredno empirično učinkovite, je dokaj verjetno, da finančne spodbude ob uveljavljenih načelih razkroja družine itd. ne bodo prinesle ključnih rezultatov.



Slika 7: Slovenska rodnost se zadna leta giblje okoli 1.5 oziroma 1.6, kar je še vedno precej premalo oz. pelje v eksponentno izginevanje domorodnih skupin. Vir: https://www.ceicdata.com/en/slovenia/health-statistics/si-fertility-rate-total-births-per-woman.

V Sloveniji na videz rodnost ni tako grozljivo slaba kot v Južni Koreji, saj je rodnost 1.5 precej večja kot 0.8. A vse pod 2.1 vodi v eksponentno upadanje in med demografi velja 1.8 za spodnjo mejo brez hudih posledic. Hitrost krčenja domorodne populacije se da prikazati tudi takole: na leto je 10.000 otrok premalo za trajnostno rast, hkrati se v Sloveniji priseli okoli 10.000 tujcev, kar pri populaciji nekaj nad 2 milijona pomeni zamenjavo populacije oz. izumrtje domorodnih skupin v 200 letih.

5 ZAKLJUČEK

Pomembno je, da se zavedamo, da je demografski problem oz. zmanjševanje populacije v večini držav in celin daleč najhujši od vseh problemov, saj prinaša ne samo zmanjšanje kvalitete življenja, ampak stagnacijo in morda nazadovanje človeške civilizacije. Ključno je, da pustimo stroki akademsko svobodo pri analizi problemov in da ne vnašamo ideologije in dogem. V Sloveniji so bila leta 2018 znanstvena dognanja o demografiji napadana z ideološko-političnega stališča [6,16,17]((19,20,22). Te spletne in medijske napade je možno pojasniti tudi s stanjem duha: ko so ljudje prepričani, zavestno (s strani dirigiranega vpliva medijev in spleta) ali podzavestno ma nivoju množic (možgani množic, emergentno), da je potrebno zmanjšati prebivalstvo nasploh, tako po svetu kot po Sloveniji, potem je razkritje škodljivosti tovrstnih trendov v Sloveniji »blasfemično« in ga je potrebno zatreti. A znanost temelji na tem, da odkriva dejanske zakonitosti in opozarja na probleme, da se jih lahko pravočasno izognemo. Na svetovnem nivoju se je veliki premik zgodil šele z Elonom Muskom, ko je začel omenjati demografske svetovne probleme. Njega se ni dalo »raztrgati« po spletnih omrežjih. Poleg tega je Elon Musk najbolj vplivna svetovna osebnost, ki ji ljudje načeloma prisluhnejo precej bolj kot politikom, ki so začeli širiti ideološke in seksualne konflikte z zahtevami, da se moški lahko brez vsakega testa proglasijo za moške, da so ženske »osebe, ki lahko rodijo«, uničevanjem otroštva [18]((12) in podobno. Večina prebivalstva kljub pritiskom preko spleta in medijev tovrstne pojave še vedno vidi kot nekaj za lase privlečenega in ne vidijo, zakaj se pojavljajo: za krotenje rasti prebivalstva. Vseeno se velik del prebivalstva da naivno prepričati v tovrstne anti-demografske teze. A vseeno Muskove misli dosežejo precej večji učinek kot od kateregakoli politika. Med drugim ima okoli 100 milijonov sledilcev na Twiterju. Druga pomembna sprememba je, da se tudi svetovne elite počasi začenjajo zavedati, da proces ustavljanja rodnosti po svetu prinaša zelo negativne posledice v precejšnjem delu sveta. Seveda pa je potrebno rast v Afriki še na nek način ustaviti in očitno ti sistemi anti-družinskih vrednost ne dosežejo pravega učinka v Afriki.

Ključna meja rodnosti je 2.1, a v 38 razvitih državah članicah OECD je rodnost v povprečju 1.59, kar pomeni izginotje v nekaj sto letih v povprečju. Nekateri strokovnjaki opozarjajo, da bo s tako rodnostjo vrsta držav doživela tako imenovani »age quake«, kar bi lahko prevedli kot starostni ali demografski potres [9,20]((16, 18).

REFERENCES

[1] Choi, Y. 2022. A decomposition of declining crude birth rate in South Korea, Journal of Population Research volume 39, pages373–389 (2022)

[2] Meadows, Donella H; Meadows, Dennis L; Randers, Jørgen; Behrens III, William W (1972). The Limits to Growth; A Report for the Club of Rome's Project on the Predicament of Mankind (PDF). New York: Universe Books. ISBN 0876631650.

[3] Meadows, D., Randers, J., and Meadows, D. A Synopsis: Limits to Growth: The 30-Year Update http://donellameadows.org/archives/a-synopsis-limits-to-growth-the-30-year-update/

[4] PhilipCafaroaPernillaHanssonbFrankGötmarkb. 2022. Overpopulation is a major cause of biodiversity loss and smaller human populations are necessary to preserve what is left, Biological Conservation, Volume 272, August 2022, 109646,

[5] World Population Prospects 2022: Data Portal, UN DESA, copied to Harvard University: https://repository.gheli.harvard.edu/repository/12496/

[6] Gams, M. 2018. Predstavitev na posvetu v Državnem svetu o demografiji. 2018, https://www.youtube.com/watch?v=A4rai9zoNg0

[7] Gams. M., Krivec. J. 2008. Demographic analysis of fertility using data mining tools. Informatica : an international journal of computing and informatics, 2008, vol. 32, no. 2, str. 147-156.

[8] Vidulin, V., Gams, M. 2012. Slovenske demografske projekcije in analize. V: MALAČIČ, Janez (ur.), GAMS, Matjaž (ur.). Soočanje z demografskimi izzivi : zbornik 15. mednarodne multikonference Informacijska družba - IS 2012, str. 14-18.

[9] Gams, M., Krivec, J. 2011. Slovenske demografske projekcije in analize. V: MALAČIČ, Janez (ur.), GAMS, Matjaž (ur.). Soočanje z demografskimi izzivi v Evropi : zbornik 14. mednarodne multikonference Informacijska družba - IS 2011, str. 14-18.

[10] Gams, M. 2017. Globalizem in prednosti superinteligence za Republiko Slovenijo, Prenova Evrope, Posvetovanje Prispevki za slovenski nacionalni program II, urednik Tine Hribar, Slovenska akademija znanosti in umetnosti. str. 118-128.

[11] Gams, M. 2007. Ekonomski in demografski samomor Slovenije. Finance, ISSN 1318-1548, 9.03.2007, št. 47, 12.

[12] Gams, M. 2007. Trije otroci bi nas rešili : demografska gibanja Slovencev. Znanost : štirinajstdnevna znanstvena priloga časnika Delo, 04.10.2007, letn. 49, št. 229, str. 19.

[13] Melissa S. K., Phillip B. Levine, P. B., and Luke Pardue. 2022. "The Puzzle of Falling US Birth Rates since the Great Recession." Journal of Economic Perspectives, 36 (1): 151-76. Spremenjene vrednote in način življenja krivi za padce rodnosti v ZDA

[14] Gams, M., Grabnar, J., Vidulin, V. 2013. Vpliv pravic istospolno usmerjenih na stopnjo rodnosti. V: MALAČIČ, Janez (ur.), GAMS, Matjaž (ur.). Soočanje z demografskimi izzivi : zbornik 16. mednarodne multikonference Informacijska družba - IS 2013, 7.-8. oktober 2013, Ljubljana, str. 13-17.

[15] Lee, R., Sambt, J., et al. 2014. Is low fertility really a problem?: population aging, dependency, and consumption. Science, ISSN 0036-8075, 10. Oct. 2014, vol. 346, iss. 6206, str. 229-234, doi: 10.1126/science.1250542.
[16] Gams, M., J. Malačič, J. (ur.). 2019. Bela knjiga slovenske demografije. http://library.ijs.si/Stacks/Literature/Bela%20knjiga%20demografije%20DS%202018.pdf
[17] Delo 2018, Jozef Stefan Institute does not support scientific theses of Matjaz Gams, in Slovene, https://www.delo.si/novice/slovenija/institut-jozef-stefan-ne-podpira-stalisc-matjaza-gamsa-55676.html
[18] Postman, M. 1994. The Disappearance of Childhood, First vintage book edition.
[19] Pearce, F. 2008. Peoplequake, Mass Migration, Ageing Nations and the Coming Population Crash, Transworld Publishers.
[20] Bricker, D., Ibbitson, J. Empty Planet. 2019. Robintson, UK.

Obremenjujoče izkušnje v otroštvu: primerjalna študija med odraslimi otroci alkoholikov in nealkoholikov

Adverse Childhood Experiences: A Comparison Study of Adult Children of Alcoholics and Non-Adult Children of Alcoholics

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POVZETEK*

Alkohol je v Sloveniji najbolj zlorabljena droga in poleg zdravstvenih in ekonomskih težav močno zaznamuje medosebne odnose. V družinah s prisotnim alkoholom najbolj trpijo otroci, katere posledice spremljajo v odraslo dobo. V klinični praksi se prepogosto srečujemo z odraslimi otroki alkoholikov, ki so doživeli različne obremenjujoče izkušnje v otroštvu in se spopadajo s posledicami na individualni in sistemski ravni. Temeljni cilj raziskave je bil ugotoviti razlike v doživetih obremenjujočih izkušnjah v otroštvu med odraslimi otroci alkoholikov in odraslimi otroci nealkoholikov Rezultati raziskave so pokazali statistično pomembne razlike na vseh postavkah lestvice o obremenjujočih izkušnjah v otroštvu (ACE-IQ). Informacija o doživetih obremenjujočih izkušnjah v otroštvu pri klientih in poznavanje le-teh je še posebno pomembno za psihoterapevte. Vprašalnik o obremenjujočih izkušnjah v otroštvu bi bilo potrebno vključiti v anamnezo, ne samo odraslih otrok alkoholikov, temveč tudi odraslih otrok nealkoholikov oz. vseh klientov.

KLJUČNE BESEDE

Obremenjujoče izkušnje v otroštvu, alkohol, odrasli otroci alkoholikov, odrasli otroci nealkoholikov, zasvojenost

ABSTRACT

Alcohol is the most abused drug in Slovenia and, in addition to health and economic problems, strongly affects interpersonal relationships. In families struggling with alcohol abuse, children are those who suffer the most, the consequences of which follow them into adulthood. In clinical practice, we too often encounter adult children of alcoholics who have experienced various troublesome events in childhood and are struggling with the consequences on an individual and systemic level. The primary goal of the research was to determine differences in adverse childhood experiences between adult children of alcoholics (and adult children of non-alcoholics. The results of the survey showed statistically significant differences on all items of the adverse childhood experiences scale (ACE-IQ). Information about adverse childhood experiences by clients and knowledge of them is particularly important for psychotherapists. A questionnaire about adverse experiences in childhood should be included in the medical history, not only of adult children of alcoholics but also adult children of non-alcoholics or of all clients.

KEYWORDS

Adverse childhood experiences, alcohol, adult children of alcoholics, adult children of non-alcoholics, addiction

1 UVOD

Alkohol je v Sloveniji najbolj zlorabljena droga, obenem pa je Slovenija po zdravstvenih posledicah zaradi alkohola nad povprečjem Evropske unije. Poleg zdravstvenih in ekonomskih težav alkohol močno zaznamuje medosebne in družinske odnose [1, 2]. Otroci, ki odraščajo v družinah s prisotnim alkoholom, se spopadajo s številnimi dolgoročnimi posledicami, ki jih spremljajo v odraslo dobo in odnose, ki jih ustvarjajo [3]. Za tiste posameznike, ki so odraščali v nefunkcionalni družini, kjer je bil prisoten alkohol, se v strokovni literaturi uporablja izraz odrasli otroci alkoholikov [4]. Vsi odrasli otroci alkoholikov ne doživljajo enakih težav, imajo pa mnogo skupnih značilnosti. Te se ne nanašajo samo na odnos do alkohola, temveč tudi na doživljanje, izražanje in reguliranje čustev [5]. Številne raziskave so pokazale statistično pomembne razlike med odraslimi otroci alkoholikov in odraslimi otroci nealkoholikov na področjih težav v odnosih [6] zlorabe substanc [7] in zanikanja [8]. Odrasli otroci alkoholikov so bolj izpostavljeni ranljivosti pred stresorji in imajo večje prilagoditvene težave [9]. Prisotne je tudi več psihopatologije [10] in slabe samopodobe za razliko od odraslih otrok nealkoholikov [11]. Kot otroci so se ob nekontroliranem pitju staršev počutili nemočne ali prestrašene. S skrbjo za starše pa so si pridobili občutek nadzora v sicer neobvladljivi situaciji, katere ni bilo možno nadzirati [12]. Ko odrastejo se to kaže v njihovi potrebi po nadzoru nad drugimi, spopadanju z zavrženostjo in zapuščenostjo, ki rezultira

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v močnih občutkih sramu. Skušajo nadzirati tisto, česar se dejansko ne da, druge osebe, obenem pa se veliko ukvarjajo s tem kaj si bodo drugi mislili o njih. Zaradi občutka nepripadnosti se počutijo manjvredne, kar lahko prikrivajo z mnogimi vlogami kot je pretirano odgovorna oseba ali perfekcionist. V partnerske odnose lahko vstopajo z osebami, za katere imajo občutek, da jim lahko pomagajo, saj zamenjujejo ljubezen z usmiljenjem [13]. V strokovni literaturi se v povezavi z zasvojenostjo enega izmed staršev, kjer je drug starš s svojimi vedenji zavedno in nezavedno podpiral partnerjevo zasvojenost, uporablja izraz »soodvisnost« (ang. Codependency). Kaže se v čustvenem in vedenjskem vzorcu interaktivnega obvladovanja, kar izhaja iz dolgotrajne izpostavljenosti omejevalnemu okolju, ki ne dovoljuje odkritega ali neposrednega izražanja čustev do sebe ali drugih družinskih članov [14]. Otrok je med staršema vzpostavljal most komunikacije in odigraval vlogo čustvenega starša, navadno nezasvojenemu staršu oz. s svojo skrbjo za oba starša ohranjal čustveno ravnovesje v družini. Empirična raziskava s sistemske perspektive je pokazala, da so bili udeleženci iz skupine z višjo stopnjo soodvisnosti, v otroštvu priče zlorabljanju alkohola s strani staršev, v odraslem odnosu pa so se osebe z izraženo višjo stopnjo soodvistnosti, pogosteje znašle v odraslem intimnem odnosu z zasvojenim partnerjem [15]. V klinični praksi se je pokazalo, da pari, od katerih je eden izmed partnerjev odrasel otrok alkoholika, pogosto poiščejo terapevtsko pomoč prav zaradi tovrstnih zapletov v partnerskem odnosu.

Odraščanje v družini, kjer je bil eden izmed staršev ali morda celo oba zasvojena z alkoholom, pa povečuje tveganje za različne obremenjujoče izkušnje v otroštvu [16]. Obremenjujoče izkušnje so med drugim opredeljene kot različne vrste nasilja in sicer spolno, fizično in psihično nasilje ter izpostavljenost nefunkcionalnemu družinskemu okolju [17]. Poleg presejalnega testa odraslih otrok alkoholikov smo se v raziskavi osredotočili na pet obremenjujočih izkušenj v otroštvu, katere opisujemo v nadaljevanju:

- čustveno zanemarjanje, ki se nanaša na neprepoznavanje in nezadovoljevanje čustvenih potreb otroka;
- fizično zanemarjanje, ki se nanaša na neprepoznavanje in nezadovoljevanje fizičnih potreb otroka (npr. potreba po hrani);
- čustveno zlorabo, ki se nanaša na verbalni vzorec zlorabe (npr. kričanje, žaljenje, poniževanje);
- fizično zlorabo, ki se nanaša na fizično nasilje nad otrokom (npr. klofutanje, brcanje, šeškanje, udarjanje s predmeti);
- spolno zlorabo, ki se nanaša na spolna dejanja nad otrokom (npr. prisilno občevanje, siljenje v občevanje, dotikanje)
- družinsko nasilje nad drugim članom družine [18].

V Sloveniji je bila prva reprezentativna raziskava o obremenjujočih izkušnjah v otroštvu izvedena leta 2019 na vzorcu 4940 odraslih oposameznikov. Med najpogostejšimi obremenjujočimi izkušnjami so navajali čustveno nasilje (55,4%) in telesno nasilje (42,7). 67% tistih, ki so poročali o čustvenem nasilju, pa je poročalo tudi o fizičnem nasilju. Čustveno zanemarjanje je doživelo 25% udeležencev, fizično zanemarjanje 24,2% udeležencev. Fizično nasilje med odraslimi člani gospodinjstva je doživelo 16,2% udeležencev. 6% anketirancev je doživelo spolno zlorabo, ob odraslem članu gospodinjstva, ki je bil zasvojen, pa je odraščalo 21,1% udeležencev. V raziskavi so poročali tudi o težavah v duševnem zdravju odraslega člana gospodinjstva, vključno s samomorom (13%), o kriminalnem dejanju odraslega člana gospodinjstva (3,3) in o izgubah/zapustitvah/razvezah staršev (30,4%) [19].

V navedeni raziskavi niso ugotavljali razlik med odraslimi otroci alkoholikov in nealkoholikov, zato se je pojavila potreba po nadaljnem raziskovanju. Z raziskavo smo želeli zapolniti vrzel in preveriti ali se pojavljajo razlike v doživetih obremenjujočih izkušnjah v otroštvu med odraslimi otroci alkoholikov in odraslimi otrodi nealkoholikov.

2 METODA

2.1 Udeleženci

V celotni raziskavi je sodelovalo 619 anketirank in anketriancev. V analizo je bil vključen ustrezen vzorec zato je pri posameznih vprašanjih lahko vzorec nekoliko nižji a še vedno ustrezen. Moških je bilo v vzorcu 27 odstokov, žensk 73 odstotkov (N=619). Večina anketirancev je starih med 21 in 30 let (34,4 %), sledijo stari med 31 in 40 let (18,2 %) ter stari med 41 in 50 let (18,0 %). Nad 51 let je starih 17,4 odstodka anketirancev. Pod 20 let pa 12,0 odstotkov anketirancev. Večina anketirancev je zaposlenih (42,7 %), sledijo študentje (35,4 %). Brezposelnih anketirancev je 8,0 odstokov, 11,0 odstotkov je upokojenih. Največ anketirancev je partnerski zvezi a so neporočeni (32,2 %). 30,1 odstokov je poročenih, sledijo samski (29,2 %). Velika večina anketirancev pripada katoliški veri (79,8 %). 14,3 odstotka anketirancev ne pripada nobeni veri. Večina anketirancev ni otrok alkoholika (57,5 %). Prav tako jih večina ni nikoli nevarno uporabljala alkohol (72,0 %) in pri njih ni prisotna odvisnost od alkohola (88,7 %). Nizko stopnjo ocene tveganja in škodljivo rabo odvisnosti dosega v obeh primerih 71,3 odstotka anketirancev. Večina anketirancev tudi ni iskala, trenutno ali v preteklosti, pomoči zaradi zasvojenosti (81,0 %). Med tistimi za katere anketiranci menijo, da je imel v družini težave je odgovor »le oče« dosegel 39,2 odstotka, mama (4,9 %) in oba starša (4,9 %). Da so živeli v skupnem gospodinjstvu živeli s članom, ki je bil problematičen pivec ali alkoholik oziroma uporabnik prepovedanih ali dovoljenih drog je odgovorili 62,9 odstodka anketirancev. 76,6 odstodka anketirancev je živelo v skupnem gospodinjstvu s članom, ki je bil depresiven, duševno bolan ali nagnjen k samomoru. Pri 27,1 odstotka anketiranih so se starši razvezali ali kdaj živeli ločeno. Pri 24,0 je mama, oče ali skrbnik umrl.

2.2 Pripomočki

Za namen raziskave je bil ustvarjen sklop vprašalnikov. Poleg demografskih vprašanj na začetku so udeleženci izpolnili še dva samoocenjevalna merska inštrumenta:

Presejalni test otrok alkoholikov (Children of Alcoholics Screening test CAST-6) [20, 21]. Sestavljen je iz šestih postavk, ki se navezujejo na posameznikove občutke, izkušnje in obnašanje, povezane s pitjem staršev in omogoča možnost odkrivanja ali je anketiranec otrok alkoholika.

Mednarodni vprašalnik o obremenjujočih izkušnjah v otroštvu (ang. Adverse Childhood Experiences International Questionnaire – ACE-IQ) vsebuje trditve, ki se navezujejo na obremenjujoče izkušnje iz otroštva. Vprašalnik identificira 13 kategorij obremenjujočih izkušenj v otroštvu, od katerih smo v našo raziskavo vključili šest naslednjih: čustveno zlorabo v družini, fizično zlorabo v družini, spolno zlorabo, doživljanje nasilja nad drugim družinskim članom, čustveno zanemarjanje, fizično zanemarjanje. Nižji rezultat pomeni večjo pogostost posamezne izkušnje v otroštvu [18]. Koeficient zanesljivosti (Cronbachov alfa) v naši raziskavi znaša za spolno zlorabo α=0,929; za čustveno zanemarjanje α=0,735; za fizično zanemarjanje α=0,591; za družinsko nasilje α=0,724; za psihično nasilje α=0,669; za fizično zlorabo α=0,677.

2.3 Postopek

Povezavo do vprašalnikov smo objavili na različnih spletnih straneh, forumih in spletnih omrežjih, anketiranci pa so vprašalnike izpolnjevali tudi v pisni obliki na eni izmed ustanov za zdravljenje odvisnosti od alkohola. Izpolnjevalnje vprašalnikov je potekalo

pomladi 2021 do pomladi 2022. Pridobljene statistične podatke smo obdelali s statističnim programom SPSS 20.

3 REZULTATI

Zanimalo nas je ali se pojavljajo razlike v zanemarjanju in nasilju ACE-IQ lestvice glede na to ali so anketiranci kot otroci odraščali z alkoholikom. Podatki niso bili normalno porazdeljeni zato smo analizo izvedli z neparametričnim testom Mann-Whitney, ki ga uporabimo kadar želimo ugotoviti razlike med dvema neodvisnima skupina. Rezultati analize so pokazali, da se statistično pomembne razlike pojavljajo pri vseh oblikah zanemarjanja (čustveno in fizično) in nasilja (družinsko, psihično, fizično, spolna zloraba). Statistična pomembnost je pri vseh dimenzijah pod 0,05. Povprečja rangov so prav tako višja pri vseh oblikah zanemarjanja in nasilja pri anketirancih, ki kot otroci niso odraščali ob alkoholiku.

Tabela 1: Razlike v obremenjujočih izkušnjah v otroštvu

otrok alkoholika		N	Povprečje ranga	Vsota ranga
čustveno_zanemarjanje	Ne	275	**283,15**	0,000
	Da	213	194,60	
	Skupaj	488		
fizično_zanemarjanje	Ne	272	**279,86**	0,000
	Da	209	190,42	
	Skupaj	481		
družinsko_nasilje	Ne	271	**290,95**	0,000
	Da	209	175,08	
	Skupaj	480		
psihično_nasilje	Ne	270	**281,99**	0,000
	Da	209	185,75	
	Skupaj	479		
fizična_zloraba	Ne	271	**271,54**	0,000
	Da	209	200,26	
	Skupaj	480		
spolna_zloraba	Ne	267	**247,70**	0,000
	Da	207	224,35	
	Skupaj	474		

4. RAZPRAVA IN SKLEP

Naši rezultati potrjujejo hipotezo v kateri smo predvidevali statistično pomembne razlike med odraslimi otroci alkoholikov in odraslimi otroci nealkoholikov v doživetih obremenjujočih izkušnjah v otroštvu. Nižji rezultat pri vseh oblikah zanemarjanja, fizičnega in spolnega nasilja pri odraslih otrocih alkoholikov, kaže na večjo pogostost posamezne izkušnje v otroštvu. Odrasli otroci alkoholikov so tako do dopolnjenega 18. leta starosti pogosteje poročali o čustveni in fizični zlorabi v družini, spolni zlorabi, doživljanju nasilja nad drugim družinskim članom, čustvenem in fizičnem zanemarjanju. Naši rezultati se skladajo z ugotovitvami tujih raziskav, kjer so odrasli otroci alkoholikov retrospektivno poročali o fizičnem in psihičnem zanemarjanju, družinskem nasilju, ki so ga doživeli med staršema in fizičnem nasilju nad njimi s strani staršev [22, 23]. Raziskave pa so pokazale tudi večjo verjetnost za spolno zlorabo [24, 25], saj je družinsko okolje pomemben dejavnik tveganja. Otroci kjer sta eden ali oba starša zasvojena z alkoholom, so prikrajšani za zdravo odraščanje, obenem pa so izpostavljeni večjemu tveganju za različne vrste zlorab. Raziskave so pokazale, da je pri spolnih zlorabah v otroštvu družinsko okolje pomemben dejavnik tveganja [26]. Pri posameznikih, ki so doživeli spolno zlorabo v otroštvu in njihovih intimnih partnerjih v odrasli dobi, obstaja statistično pomembna razlika v doživljanju fizične oz. spolne varnosti, za razliko od parov, kjer nihče v paru ni doživel spolne zlorabe [27]. Doživeta spolna zloraba v otroštvu tako predstavlja posledice za intimne odrasle partnerske odnose, kar se med drugim odraža tudi v spolni anoreksiji. [28]. Odpor do spolnosti in izogibanje spolnosti lahko povezujemo tudi z zmanjševanjem števila rojstev. V Slovenski raziskavi se je izkazalo tudi, da obremenjujoče izkušnje v otroštvu lahko prispevajo k poskusu samomora pri odraslih otrocih alkoholikov, ugotovljena pa je bila tudi pozitivna povezava med čustvenim zanemarjanjem in občutkom, da je oseba drugim v breme [29]. Teža posledic obremenjujočih izkušenj v otroštvu pa se povezuje tudi s slabšo delovno zmožnostjo. Udeleženci so poročali o težavah v službi, finančnih težavah in pogostim odhodom v bolniški stalež, prav tako so dosegali nizke rezultate na lestvici zdravja in dobrega počutja [30]. Slabo zdravstveno stanje bi lahko povezali z umrljivostjo, obenem pa slabša delovna zmožnost prispeva tudi k omejeni ponudbi delovne sile kar lahko postane omejitveni dejavnik gospodarske rasti. Na eni strani manjše število delovno aktivnih omejuje vire financiranja, na drugi strani pa podaljšani bolniški staleži povečujejo pritisk na javnofinačne izdatke [31], zaradi česar je potrebno ustezno pristopiti k demografskim spremembam in njihovim ekonomskim in zdravstvenim posledicam.

Prednost raziskave predstavlja raznolikost udeležencev, kot pomankljivost izpostavljamo vzorec, ki ni reprezentativen in ne ravno visoka zanesljivost za podlestvico fizičnega zanemarjanja.

V nadaljnih raziskavah bi bilo potrebno ne reprezentativnem vzorcu udeležence povprašati ali so doživeli incest oz. spolno zlorabo znotraj ali zunaj družinskega kroga in ugotoviti razlike pri odraslih otrocih alkoholikov in sicer glede na to kdo je imel težave z alkoholom – oče, mama ali oba starša in kako se tovrstve razlike kažejo tudi v ostalih obremenjujočih izkušnjah v otroštvu in v povezavi z razlikami glede na spol. Zgodnejše informacije o obremenjujočih izkušnjah v otroštvu bi koristile družinskim terapevtom pri načrtovanju terapevtske obravnave, predvsem pa bi lahko s čimprejšnim ustreznim zdravljenjem preprečili mnogotere težave v mladostništvu in odrasli dobi, predvsem na področju ekonomskih in zdravstvenih posledic. Vprašalnik o obremenjujočih izkušnjah v otroštvu bi bilo potrebno vključiti v anamnezo, ne samo odraslih otrok alkoholikov, temveč tudi odraslih otrok nealkoholikov oz. vseh klientov. Vsi strokovnjaki, ki se ukvarjajo z duševnim zdravjem oz. se pri svojem delu srečujejo z odraslimi otroci alkoholikov ali odraslimi, ki so v otroštvu doživeli obremenjujoče izkušnje, bi morali pridobiti ustrezno znanje s področja razumevanja dinamike družinskih odnosov in posledic odraščanja ob starših, zasvojenih z alkoholom.

REFERENCE

[1] Rehm, J., Shield, KD, Rehm, MX, Gmel, G., Frick, U. Alcohol consumption, alcohol dependence and attributable burden of disease in Europe: potential gains from effective interventions for alcoholdependence. Toronto: Centre for

Addiction and Mental Health; 2012 (http://www.zora.uzh.ch/64919/1/CAMH_Alcohol_Report_Europe_2012.pdf, %20accessed %202 %20May %202016).

[2] Sedlak, S., Zaletel, M., Kasesnik, K., Zorko, M. Ekonomske posledice tveganega in škodljivega pitja alkohola v Sloveniji [Economic impact of hazardous and harmful alcohol consumption in Slovenia]. Ljubljana: National Institute of Public Health; 2015 (http://www.nijz.si/sites/www.nijz.si/files/publikacije-datoteke/breme_alkohola_obl_02-2016.pdf).

[3] Rangarajan S., in Kelly L. (2006). Family communication patterns, family environment, and the impact of parental alcoholism on offspring self-esteem. *Journal of Social and Personal Relationships*, *23*(4), 655–671

[4] Pasternak, A., & Schier, K. (2012). The role reversal in the families of Adult Children of Alcoholics. *Archives of Psychiatry & Psychotherapy*, *14*(3).

[5] Hall, C. W., & Webster, R. E. (2002). Traumatic symptomatology characteristics of adult children of alcoholics. *Journal of Drug Education*, *32*(3), 195-211.

[6] Beesley, D., & Stoltenberg, C. D. (2002). Control, attachment style, and relationship satisfaction among adult children of alcoholics. *Journal of mental health counseling*, *24*(4).

[7] Christoffersen, M. N., Nielsen, A. M., Poulsen, H. D., & Soothill, K. (2004). The long-term consequences of parental alcohol abuse: a cohort study of children in Denmark in 1966. *Ugeskrift for laeger*, *166*(41), 3609-3613.

[8] Hart, K. E., & McAleer, M. (1997). Anger coping style in adult children of alcoholics. *Addiction Research*, *5*(6), 473-485.

[9] Hart, K. E., & McAleer, M. (1997). Anger coping style in adult children of alcoholics. *Addiction Research*, *5*(6), 473-485.

[10] Carpenter, D. R. (1995). Adult children of alcoholics: CAQ profiles. *Alcoholism Treatment Quarterly*, *13*(2), 63-70.

[11] Rodney, H. E. (1996). Inconsistencies in the literature on collegiate adult children of alcoholics: Factors to consider for African Americans. *Journal of American College Health*, *45*(1), 19-25.

[12] Kelley, M. L., French, A., Bountress, K., Keefe, H. A., Schroeder, V., Steer, K., ... & Gumienny, L. (2007). Parentification and family responsibility in the family of origin of adult children of alcoholics. *Addictive behaviors*, *32*(4), 675-685.

[13] Middelton-Moz, J., & Dwinell, L. (2010). *After the tears: Helping adult children of alcoholics heal their childhood trauma*. Health Communications, Inc..

[14] Fisher, G. L., & Harrison, T. C. (2012). *Substance abuse: Information for school counselors, social workers, therapists and counselors*. Pearson Higher Ed.

[15] Cullen, J., & Carr, A. (1999). Codependency: An empirical study from a systemic perspective. *Contemporary Family Therapy*, *21*(4), 505-526.

[16] Dube, S. R., Anda, R. F., Felitti, V. J., Chapman, D. P., Williamson, D. F., & Giles, W. H. (2001). Childhood abuse, household dysfunction, and the risk of attempted suicide throughout the life span: findings from the Adverse Childhood Experiences Study. *Jama*, *286*(24), 3089-3096.

[17] Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., Koss, M. P., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American Journal of Preventive Medicine, 14*(4), 245–258.

[18] World Health Organization. 2018. Adverse Childhood Experiences International Questionnaire. In Adverse Childhood Experiences International Questionnaire (ACE-IQ). [website]: Geneva: WHO, 2018. http://www.who.int/violence_injury_prevention/violence/activities/adverse_childhood_experiences/en/

[19] Kuhar, M., & Kocjan, G. Z. (2020). *Konglomerat travme: obremenjujoče izkušnje v otroštvu in njihovo socialno-demografsko ozadje*. Fakulteta za sociologijo, politične vede in novinarstvo Univerze v Ljubljani.

[20] Hart, K. E., Fiissel, D. L., in McAleer, M. (2003). Do adult offspring of alcoholics suffer from poor medical health? A three-group comparison controlling for self-report bias. *The Canadian Journal of Nursing Research*, *35*(1), 53–72.

[21] 21. Harter, S. L. (2000). Psychosocial adjustment of adult children of alcoholicss: A review of the recent empirical literature. *Clinical Psychology Review, 20*(3), 311–337.

[22] Burnett, G., Jones, R. A., Bliwise, N. G., in Ross, L. T. (2006). Family unpredictability, parental alcoholism, and the development of parentification.

[23] Johnson, P., & Stone, R. (2009). Parental alcoholism and family functioning: Effects on differentiation levels of young adults. *Alcoholism Treatment Quarterly*, *27*(1), 3-18.

[24] Jakubczyk, A., Klimkiewicz, A., Krasowska, A., Kopera, M., Sławińska-Ceran, A., Brower, K. J., & Wojnar, M. (2014). History of sexual abuse and suicide attempts in alcohol-dependent patients. *Child abuse & neglect*, *38*(9), 1560-1568.

[25] Walsh, C., MacMillan, H. L. in Jamieson, E. (2003). The relationship between parental substance abuse and child maltreatment: Findings from the Ontario Health Supplement. Child Abuse & Neglect, 27(12), 1409–1425.

[26] Jerebic, S. (2020). Družinsko okolje kot dejavnik tveganja za spolno zlorabo v otroštvu = Family environment as a risk factor for childhood sexual abuse. V: MERTIK, Matej (ur.). *Relevanca znanosti in izobraževanja : zbornik povzetkov = Relevance of science and education : book of abstracts*. 8. znanstvena konferenca z mednarodno udeležbo Za človeka gre = 8th Scientific Conference with International Participation All About People: Relevance of science and education, Maribor, 13. - 14. 3. 2020. 1. izd. Maribor: AMEU - ECM, Alma Mater Press, 2020. Str. 284. ISBN 978-961-6966-59-7. http://press.almamater.si/index.php/amp.

[27] Jerebic, D., & Jerebic, S. (2019). Are childhood sexual abuse and intimate safety in adult intimate relationships correlated?. *The Person and the Challenges. The Journal of Theology, Education, Canon Law and Social Studies Inspired by Pope John Paul II*, *9*(2), 193-206.

[28] Carnes, P., & Moriarity J. (1997). *Sexual anorexia : overcoming sexual self-hatred*. Center City, Minn.: Hazelden.

[29] Šrajner, M., Šedivy, N. Z., & Poštuvan, V. (2022) Travma iz otroštva kot dejavnik samomorilnega vedenja tekom življenja pri odraslih otrocih staršev s škodljivo rabo alkohola. Psihološka obzorja, 31, 8-21.

[30] Anda, R. F., Fleisher, V. I., Felitti, V. J., Edwards, V. J., Whitfield, C. L., Dube, S. R., & Williamson, D. F. (2004). Childhood abuse, household dysfunction, and indicators of impaired adult worker performance. *The permanente journal*, *8*(1), 30.

[31] Čelebič, T., Ferk, B. B., Zver, E., Pečar, J., & Perko, M. (2016). *Demografske spremembe ter njihove ekonomske in socialne posledice*. Urad RS za makroekonomske analize in razvoj.

Razlike v predpisovanju zdravil v obdobju pred in med pandemijo bolezni COVID-19

Differences in prescribing of medicines before and during the COVID-19 pandemic

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POVZETEK

Obsežne zdravstvene, ekonomske, socialne in demografske posledice so povezane s pandemijo koronavirusne bolezni 2019 (COVID-19), ki jo je Svetovna zdravstvena organizacija razglasila 11. marca 2020. Zdravstvene posledice bolezni se kažejo v preko 600 milijonov potrjenih primerih bolezni, zaradi posledic bolezni COVID-19 je v globalnem merilu umrlo že okrog 6,5 milijona oseb. Zaradi spremenjenih pogojev ter načina življenja in vedenja prebivalcev so bile pričakovane tudi razlike v predpisovanju zdravil na recept. Pregled podatkov za Slovenijo je pokazal, da se predpisovanje zdravil iz večine glavnih skupin anatomsko-terapevtsko-kemične (ATC) klasifikacije med letoma 2019 in 2020 ni bistveno spremenilo. V dveh letih pandemije se je glede na predhodni leti znatno zmanjšal obseg predpisovanja zdravil iz ATC skupine J, zdravil za sistemsko zdravljenje infekcij, kar se pripisuje vzdrževanju fizične razdalje in upoštevanju higienskih ukrepov.

KLJUČNE BESEDE

Predpisovanje zdravil, pandemija, COVID-19, ATC klasifikacija, cepiva, monoklonska protitelesa

ABSTRACT

Extensive health, economic, social and demographic implications have been related to the coronavirus disease 2019 (COVID-19) pandemic, declared by the World Health Organization on March 11, 2020. Health implications have been shown in over 600 million of confirmed disease cases, 6,5 million persons have died due to the impact of the COVID-19 globally. Because of the changed conditions and way of life and behaviour of the inhabitants also the differences in prescribing of medicines have been expected. Review of the Slovene data has shown that prescribing of medicines from a majority of the main groups of the Anatomical Therapeutic Chemical (ATC) classification hasn't changed essentially between 2019 and 2020. In two year pandemic periods, a scale of prescribing of medicines from the ATC group J with antiinfectives for systemic use has significantly decreased, in comparison with the previous two years, assigned to maintaining the physical distance and to a consideration of the hygienic measures.

KEYWORDS

Prescribing of medicines, pandemic, COVID-19, ATC classification, vaccines, monoclonal antibodies

1 UVOD

Pandemija koronavirusne bolezni 2019 (COVID-19) ima obsežne zdravstvene, ekonomske, socialne in demografske posledice v globalnem merilu. Razvidna je bila presežna umrljivost, zaradi pandemije so tudi v bodoče možne demografske spremembe. Raziskovalci [1] so ugotovili, da je lahko anksioznost, ki izhaja iz pandemije, v veliki meri odvisna od demografskih in zdravstvenih značilnosti. Predvsem starejši mladostniki in osebe z nižjimi prihodki so bili posebej zaskrbljeni zaradi dolgotrajnih posledic pandemije, osebe s kroničnimi boleznimi pa zaradi same bolezni. Zaradi številnih zdravstvenih obravnav oziroma hospitalizacij pacientov so bili obremenjeni celotni zdravstveni sistemi. Na osnovi zasedenosti določenih zdravstvenih ustanov je zagotovitev ustreznih zdravstvenih storitev za vse paciente predstavljala velik izziv.

Poleg številnih oseb z blažjim potekom bolezni je v obdobju pandemije določen delež oseb izkusil resen potek bolezni, tudi s smrtnim izzidom. Konec leta 2020 so bila uvedena cepiva, namenjena doseganju imunosti proti bolezni. Določena zdravila so namenjena zdravljenju simptomov bolezni COVID-19, posebej resnejših simptomov.

Ta prispevek je osredotočen na razlike v predpisovanju zdravil v letih pred pandemijo bolezni COVID-19 in v letih pandemije, glede na posamezne ATC skupine zdravil.

2. POVZROČITELJ, PREPREČEVANJE IN ZDRAVLJENJE BOLEZNI COVID-19

2.1 Osnovni podatki o zbolevnosti in umrljivosti zaradi bolezni COVID-19 ter o uporabljenih odmerkih cepiva

Povzročitelj bolezni COVID-19 je virus SARS-Cov-2 [1]. Kot vsi virusi se tudi virus SARS-Cov-2 tekom časa spreminja. Večina sprememb nima, ali ima le malo vpliva na lastnosti virusa. Določene spremembe pa lahko vplivajo na lastnost virusa in povezano širjenje okužbe, resnost poteka bolezni ter preventivne in druge zdravstvene in socialne ukrepe.

Novejši podatki (iz prve polovice septembra 2022) kažejo [3] skupno 603.711.760 potrjenih primerov bolezni COVID-19, umrlo je 6.484.136 oseb. Še vedno je razviden trend rasti, tako glede števila potrjenih primerov bolezni, kot tudi števila umrlih oseb. Glede na regije, opredeljene skladno s Svetovno zdravstveno organizacijo (SZO, *World Health Organization,*

WHO), je bilo primerjalno največ primerov zaznanih v Evropi (249.105.808), sledi področje Severne in Južne Amerike (176.342.137). V Sloveniji je bilo evidentiranih 1.136.236 primerov bolezni COVID-19 [4], 8.161 oseb je zaradi posledic bolezni umrlo.
Podatki [4] o številu oseb, ki so bile polno cepljene, kažejo vrednost 62,84 na 100 prebivalcev v globalnem merilu; celotno število odmerkov na 100 prebivalcev je bilo 160,88. V Sloveniji je bilo polno cepljenih 57,46 oseb na 100 prebivalcev, celotno število odmerkov cepiva na 100 prebivalcev pa je znašalo 141,3.

2.2 Preprečevanje in zdravljenje bolezni

2.2.1. Cepiva

Cepiva in specifični imunoglobulini so opredeljeni [5] kot visoko regulirani celostni biološki pripravki. Učinkovito in varno ustvarjajo zaščitni imunski odziv na okužbo pri cepljeni osebi. Tekom registracije regulatorne ustanove presojajo in izdajo dovoljenje po potrjeni varnosti in učinkovitosti cepiv. Tudi v času uporabe cepiv se spremljata učinkovitost in varnost cepiv.
Cepiva proti bolezni COVID-19 delujejo kot mRNK oziroma vektorska cepiva [6]. Vsebujejo navodila za celice organizma, kako naj tvorijo antigensko beljakovino. Navodila so v obliki molekule, ki se imenuje sporočilna ribonukleinska kislina (mRNK), oziroma v obliki genetskega zapisa v neškodljivem vektorskem oziroma prenašalnem virusu, ki je spremenjen tako, da ne povzroča bolezni. Določene celice cepljene osebe preberejo navodila in krajši čas proizvajajo antigensko beljakovino. Imunski sistem organizma proti antigenski beljakovini ustvarja protitelesa.

2.2.2. Monoklonska protitelesa

Za zdravljenje so bila uvedena zdravila proti bolezni COVID-19, ki olajšajo predvsem resen potek bolezni.
Monoklonska protitelesa se uporabljajo za spopad organizma z okužbo. Pomagajo lahko v primeru visokega tveganja za resne simptome ali hospitalizacijo [7]. Zdravljenje s protitelesi ne nadomesti potrebe po ustvarjanju imunosti, ki jo dajejo cepiva; a po dajanju cepiv traja določen čas, da se razvije dovolj protiteles proti virusu. Večje tveganje za razvoj bolezni COVID-19 obstaja pri starejših osebah oziroma pri osebah z zdravstvenimi stanji kot so kronična obstruktivna pljučna bolezen, bolezni srca oziroma oslabljen imunski sistem [8]. Cepljenje je učinkovit preventivni ukrep. Vendar nekaterim cepljenim osebam, posebej starejšim od 65 let oziroma osebam z drugimi dejavniki tveganja za razvoj resnega poteka bolezni, lahko koristi zdravljenje. O ustreznosti in načinu zdravljenja odloča zdravnik. V ZDA je Urad za hrano in zdravila (F*ood and Drug Administration, FDA*) odobril določena antivirusna zdravila oziroma monoklonska protitelesa za zdravljenje oseb, pri katerih je resen potek bolezni bolj verjeten. Cilj antivirusnega zdravljenja je zaustavitev razmnoževanja virusa v organizmu. Monoklonska protitelesa pomagajo imunskemu sistemu, da razpozna in bolj učinkovito odgovori na virus.
Tudi v Sloveniji so razpoložljiva nekatera zdravila za paciente s simptomi bolezni COVID-19, pri katerih je zdravljenje indicirano [9]. Uvedena je bila farmacevtska oblika s kombinacijo zdravilnih učinkovin kasirivimab in imdevimab, dveh monoklonskih protiteles, ki z vezavo na dve različni mesti na beljakovini bodice virusa SARS-CoV-2 virusu preprečita vstop v telesne celice. Učinkovine, ki jih vsebujejo zdravila za zdravljenje, oziroma za profilakso bolezni, so tudi tiksagevimab, sotrovimab, molnupiravir, remdesivir, regdanvimab.

3. RAZLIKE V PREDPISOVANJU ZDRAVIL V LETIH 2020 IN 2021, GLEDE NA 2018 in 2019

Na osnovi pregleda podatkov so izhajale ugotovitve o povečanju ali zmanjšanju predpisovanja zdravil iz več ATC skupin, med leti 2018 in 2021. V ATC klasifikacijskem sistemu so zdravila razvrščena v različne skupine [10]. Merilo za razvrščanje so mesto delovanja, terapevtske lastnosti in kemične lastnosti. Prva raven obsega 14 glavnih, anatomskih skupin. Sledijo skupine in podskupine glede na terapevtsko, farmakološko oziroma kemično razvrstitev. Zadnjo, peto raven predstavlja učinkovina (mednarodno nezaščiteno ime, *International Nonproprietary Name, INN*). Celotno ATC oznako vsakega zdravila sestavlja kombinacija sedmih številčnih in črkovnih znakov.

3.1 Metode

Pregled predpisovanja zdravil je temeljil na podatkih Zavoda za zdravstveno zavarovanje Slovenije (ZZZS), za leti pred pandemijo bolezni COVID-19 (2018 in 2019) in za leti 2020 in 2021, v času pandemije. SZO je razglasila izbruh bolezni kot javnozdravstvene izredne razmere v mednarodnem obsegu 30. januarja 2020 in pandemijo 11. marca 2020 [11].
Predpisovanje zdravil je prikazano glede na ATC klasifikacijo zdravil. Razlike v predpisovanju zdravil so razvidne glede na število škatel, število receptov in število definiranih dnevnih odmerkov (*Defined Daily Dose, DDD*). V uporabljeni tabeli 'Receptna lista' [12] so zajeti podatki o številu škatel, številu DDD, številu DID, številu predpisanih receptov, celotni vrednosti receptov, in vrednosti osnovnega zdravstvenega zavarovanja (OZZ) za posamezno zdravilo predpisano na recept v breme OZZ po ATC skupinah.

3.2 Rezultati

3.2.1. Razlike v predpisanih zdravilih v letu pred pandemijo in v letu začetka pandemije bolezni COVID-19

Pri primerjavi rezultatov o predpisovanju zdravil med leti 2019 in 2020 lahko ugotovimo, da se pri zdravilih iz večine glavnih ATC skupin predpisovanje zdravil, izraženo v številu škatel, v odsotnem deležu ni bistveno spremenilo [12]. Povečan obseg predpisovanja med 2019 in 2020 je razviden pri ATC skupinah A, B, H, L, N, V. V manjši meri pa so se v 2020, glede na 2019, predpisovala zdravila iz ATC skupin C, D, G, J, M, P, R, S (Tabela 1). Primerjalno največ škatel zdravil je bilo predpisanih v okviru zdravil za bolezni srca in ožilja, ki tvorijo ATC skupino C. Zdravila za bolezni srca in ožilja se v veliki meri kot kronično zdravljenje predpisujejo starejšim osebam. Čeprav v odstotnem

deležu zmanjšanje predpisovanja med 2019 in 2020 ni bilo veliko (1,92 %), pa v številu škatel to pomeni preko 233 tisoč.

Tabela 1: Število predpisanih škatel zdravil, po posameznih ATC skupinah, 2019 in 2020 (ZZZS, 2022 [12])

ATC klasifikacija zdravil: glavne skupine	Število predpisanih škatel zdravil, 2019	Število predpisanih škatel zdravil, 2020	Razlika v predpisanih škatlah zdravil, 2019 – 2020 (%; število škatel)
A – Zdravila za bolezni prebavil in presnove	5.697.001	5.706.633	+ 0,17 % (9.632)
B – Zdravila za bolezni krvi in krvotvornih organov	1.665.302	1.674.544	+ 0,55 % (9.242)
C – Zdravila za bolezni srca in ožilja	12.121.499	11.888.342	- 1,92 % (233.157)
D – Zdravila za bolezni kože in podkožnega tkiva	748.077	666.786	- 10,87 % (81.291)
G – Zdravila za bolezni sečil in spolovil ter spolni hormoni	1.929.503	1.886.508	- 2,23 % (42.995)
H – Hormonska zdravila za sistemsko zdravljenje – razen spolnih hormonov in insulinov	960.441	1.007.928	+ 4,94 % (47.487)
J – Zdravila za sistemsko zdravljenje infekcij	1.429.694	1.109.677	- 22,38 % (320.017)
L – Zdravila z delovanjem na novotvorbe in imunomodulatorji	393.292	406.286	+ 3,30 % (12.994)
M – Zdravila za bolezni mišično-skeletnega sistema	1.883.524	1.778.089	- 5,60 % (105.435)
N – Zdravila z delovanjem na živčevje	8.388.477	8.444.636	+ 0,67 % (56.159)
P – Antiparazitiki, insekticidi in repelenti	91.980	84.758	- 7,85 % (7.222)
R – Zdravila za bolezni dihal	1.929.627	1.876.975	- 2,73 % (52.652)
S – Zdravila za bolezni čutil	1.160.825	1.093.982	- 5,76 % (66.843)
V – Razna zdravila	479.568	507.169	+ 5,76 % (27.601)

Znatno odstotno zmanjšanje v številu škatel predpisanih zdravil je bilo med letoma 2019 in 2020 [12] razvidno pri ATC skupini D (za 10,87 %), predvsem pa pri ATC skupini J (za 22,38 %).

3.2.2. Zmanjšanje predpisovanja zdravil iz ATC skupine D in ATC skupine J, med leti 2018-2019 in 2020-2021

Tabela 2: Število škatel predpisanih zdravil in število receptov z zdravili iz ATC skupine D in J, 2018-2021

ATC skupini	Leto	Število škatel	Število Rp
D Zdravila za bolezni kože in podkožnega tkiva	2018	752.611	482.233
	2019	748.077	484.734
	2020	666.786	438.138
	2021	686.315	455.316
J Zdravila za sistemsko zdravljenje infekcij	2018	1.442.610	1.026.236
	2019	1.429.694	1.014.217
	2020	1.109.677	783.300
	2021	1.096.573	780.084

V okviru ATC skupine D, ki zajema zdravila za bolezni kože in podkožnega tkiva, je v 2018 in 2019 razviden podoben obseg predpisovanja zdravil [12]. Predpisovanje zdravil iz skupine D pa je bilo v 2020 in 2021 primerjalno manjše. Zmanjšanje predpisovanja zdravil je bilo razvidno pri upoštevanju števila škatel in števila receptov.

Prav tako je bilo predpisovanje zdravil za sistemsko zdravljenje infekcij, ki sodijo v ATC skupino J, v letih 2021 in 2020 manjše od predpisovanja zdravil v 2018 in 2019 [12], če upoštevamo število škatel, število receptov, oziroma število definiranih dnevnih odmerkov (DDD). V 2018 je bilo v ATC skupini J predpisanih 9.406.517 DDD, v 2019 pa 9.397.850 DDD, kar je več kot leta 2020 in leta 2021 (7.479.037 oziroma 7.398.997).

4. RAZPRAVA

Na letni ravni je v Sloveniji v 2020, letu razglasitve pandemije, glede na 2019 pri večini ATC skupinah zdravil razviden podoben obseg predpisovanja zdravil, z določenimi odstopanji. Pri določenih ATC skupinah je predpisovanje zdravil v dveh letih pandemije znatno odstopalo od predpisovanja v prejšnjih dveh letih oziroma pričakovanih vrednosti.

Raziskovalci [13] so opazovali podrobne razlike pri izdaji zdravil, ki sovpadajo z dogodki in ukrepi v prvi polovici leta 2020 na Švedskem. Razlike v obsegu izdaje predpisanih zdravil, glede na predviden vzorec izdaje zdravil, so opazili v delu meseca februarja in marca 2020, ko se je izdaja zdravil signifikantno povečala, v različnih starostnih skupinah, pri obeh spolih in v različnih okoljih. Prav tako se je v tem obdobju znatno povečala prodaja zdravil brez recepta. Največji obseg izdaje zdravil so opazili v tednu, ki se je začel 11. marca 2020, kar je skladno z objavo SZO o pandemiji. Kmalu nato je sledilo zmanjšanje izdaje zdravil, pa tudi prodaje zdravil brez recepta, kot posledica vladnih priporočil o omejitvi izdaje oziroma prodaje zdravil. Izdaja zdravil je v začetku aprila 2020 že sovpadala s predvidenimi ravnmi. Kot možni razlog za začetno

povečevanje zalog zdravil so poročali [13], da so se pacienti s kroničnimi boleznimi kot so sladkorna bolezen in bolezni srca in ožilja odločili za dodatne zaloge zdravil za primer morebitnega oteženega obiska lekarne, povezanega z ukrepi v pandemiji. Predvidoma so osebe z zdravstvenimi stanji, zaradi katerih veljajo tveganja za resnejše oblike koronavirusne bolezni 2019, dodatno kopičile zdravila. Ta pojav je bil razviden pri zdravilih za zdravljenje astme, saj je bila astma v začetku 2020 opredeljena kot možen dejavnik tveganja za resen potek bolezni COVID-19.
V Sloveniji je bilo v ATC skupini P, ki zajema antiparazitike, insekticide in repelente, med 2019 in 2020 razvidno nekoliko zmanjšano predpisovanje zdravil [12], za 7,85 %, izraženo v številu škatel zdravil. Raziskovalci na Švedskem [13] so v marcu 2020 opazili povečano uporabo zdravilnih učinkovin klorokin in hidroksiklorokin iz ATC skupine P. Sprva so učinkovinama pripisovali koristne učinke pri zdravljenju bolezni COVID-19; vendar kasnejše raziskave tovrstne učinkovitosti niso pokazale, skrb je veljala tudi možnim neželenim učinkom [13]. V Sloveniji se klorokin in hidroksiklorokin prav tako uporabljata za določene indikacije. Med 2019 in 2020 [12] se je predpisovanje hidroksiklorokina povečalo, ne pa tudi predpisovanje klorokina.
V Sloveniji je bilo glede na 2018 in 2019 v letih pandemije 2020 in 2021 razvidno zmanjšanje predpisovanja zdravil za sistemsko zdravljenje infekcij iz ATC skupine J [12]. To zmanjšanje je med 2019 in 2020 v številu škatel znašalo 22,38 %, v številu receptov 22,77 % in v številu DDD 20,42 %. Ti rezultati soglašajo z rezultati objavljene raziskave [13]. Čeprav se je v tednu po 11. marcu 2020 predpisovanje zdravil iz skupine J nekoliko povečalo, je v nadaljevanju leta sledilo znatno zmanjšanje števila DDD, glede na predvidene vrednosti. Ugotovili so zmanjšano uporabo antibiotikov zaradi padca pojavnosti resnih infekcij, predvsem v dihalih. Navedli so, da je bil razlog vzdrževanje večje fizične razdalje in izboljšane higienske navade v pandemiji.
Na osnovi slovenskih podatkov [12] lahko zaključimo, da se je v dveh letih pandemije zmanjšal obseg predpisanih zdravil iz ATC skupine D, z zdravili za bolezni kože in podkožnega tkiva. V letu 2020 je bilo predpisanih 10,87 % manj škatel oziroma 9,61 % manj receptov s temi zdravili kot leto prej. Vendar v absolutnih vrednostih razlike niso velike (81.291 v številu škatel oziroma 46.596 v številu receptov). Zmanjšan obseg predpisovanja teh zdravil bi lahko pripisali spremenjenemu številu pacientov v ambulantah v pandemiji, oziroma delno tudi s fizično razdaljo povezanim učinkom na širjenje določenih kožnih bolezni.
Kljub nekaterim razlikam v letih pandemije, z oziroma na leti pred pandemijo, lahko zaključimo, da predpisovanje zdravil za kronične bolezni ni bilo bistveno spremenjeno. Tem ugotovitvam pritrjujejo tudi ugotovitve švedske raziskave [13], v kateri so raziskovalci zaključili, da pri večini najbolj uporabljenih zdravil ni bilo opazne spremembe v vzorcih izdaje zdravil v 2020, glede na obdobje med 2017 in 2019. Raziskovalci iz ZDA [14] pa so ugotovili, da je začetnemu povečanju predpisovanja zdravil sledilo zmanjšano predpisovanje zdravil za kronično zdravljenje. Ta pojav pripisujejo manjšemu obsegu komuniciranja z zdravnikom, omejenemu dostopu do lekarn, zmanjšanim zalogam zdravil v lekarnah, izgubi zavarovanja zaradi nezaposlenosti oziroma temu, da so pacienti povečali svoje zaloge zdravil.
Ambulante v obdobju pandemije v Sloveniji delujejo na drugačen način, z več komuniciranja na daljavo in omejenim številom istočasno prisotnih pacientov, da se čim bolj prepreči prenos okužbe. Elektronski recept omogoča predpisovanje zdravil brez neposrednega stika z ambulanto.
Ugotavljali [13] so tudi znaten porast prodaje zdravil brez recepta, vključno z vitamini, zdravili za lajšanje bolečin, za nižanje povišane telesne temperature, za lajšanje simptomov v nosu in grlu, za lajšanje kašlja in drugimi zdravili brez recepta.

5. ZAKLJUČEK

V času pandemije bolezni COVID-19 so bile razvidne znatne demografske spremembe, kot je presežna umrljivost. Po spremljanju nadaljnjih, globalnih demografskih razmer bodo znane tudi morebitne druge demografske spremembe.
Ugotovitve kažejo, da so se v Sloveniji zdravila iz večine glavnih ATC skupin v dveh letih pandemije predpisovala v podobnem obsegu kot v dveh letih pred pandemijo, z določenimi odstopanji pri posameznih ATC skupinah. Tudi v ATC skupinah z velikim deležem zdravil za kronično zdravljenje je bil obseg predpisovanja zdravil podoben in skladen s predvidevanji. Znatno zmanjšanje obsega predpisovanja zdravil v letih 2020 in 2021, glede na 2018 in 2019, je bilo razvidno v ATC skupini J, ki zajema zdravila za sistemsko zdravljenje infekcij. Pripisan razlog je vzdrževanje fizične razdalje in upoštevanje higienskih ukrepov v času pandemije.

LITERATURA IN VIRI

[1] Eoin McElroy, Praveetha Patalay, Bettina Moltrecht, Mark Shevlin, Adrienne Shum, Cathy Creswell in Polly Waite, 2020. Demographic and health factors associated with pandemic anxiety in the context of COVID-19. *British Journal of Health Psychology* 25 (2020), 934–944. DOI: https://discovery.ucl.ac.uk/id/eprint/10109259/1/bjhp.12470.pdf.

[2] Tracking SARS-CoV-2 variants. 2022. WHO. DOI: https://www.who.int/activities/tracking-SARS-CoV-2-variants.

[3] *WHO Coronavirus (COVID-19) Dashboard.* 2022. WHO. DOI: https://covid19.who.int.

[4] *WHO Coronavirus (COVID-19) Dashboard*, Situation by Region, Country, Territory & Area, Table View. 2022. WHO. DOI: https://covid19.who.int/table.

[5] *Informacije o cepivih – cepiva in specifični imunoglobulini.* 2022. NIJZ. DOI: https://www.nijz.si.

[6] *Kako cepiva delujejo.* 2022. Evropski portal za cepljenje. DOI: https://vaccination-info.eu/sl/dejstva-o-cepivih/kako-cepiva-delujejo.

[7] *What is monoclonal antibody?.* 2022. United States Department of Health and Human Services. DOI: https://combatcovid.hhs.gov/what-are-monoclonal-antibodies.

[8] *COVID-19, zdravljenje in zdravila.* 2022. CDC. DOI: https://www.cdc.gov/coronavirus/2019-ncov/your-health/treatments-for-severe-illness.html.

[9] *Interni viri.* 2022. NIJZ (vključno s podatki iz povzetkov glavnih značilnosti zdravil).

[10] *Struktura klasifikacijskega sistema ATC.* 2022. JAZMP. DOI: https://www.jazmp.si/humana-zdravila/podatki-o-zdravilih/atchum-klasifikacija/struktura-klasifikacijskega-sistema-atc.

[11] *UN News*. 2022. United Nations. DOI: https://news.un.org/en/node/1039401/date/2020-04-11.

[12] *Receptna lista 2012-2021*. 2022. Zavod za zdravstveno zavarovanje Slovenije. DOI: https://partner.zzzs.si/wps/portal/portali/aizv/zdravila.

[13] Pär Karlsson, Aya Olivia Nakitanda, Lukas Löfling in Carolyn E. Cesta, 2021. Patterns of prescription dispensation and over-the-counter medication sales in Sweden during the COVID-19 pandemic. *PLoS ONE* 16(8), e0253944. DOI: 10.1371/journal.pone.0253944.

[14] Muthiah Vaduganathan, Jeroen van Meijgaard, Mandeep R. Mehra, Jacob Joseph, Christopher J. O'Donnell in Haider J. Warraich, 2020. Prescription Fill Patterns for Commonly Used Drugs During the COVID-19 Pandemic in the United States. *JAMA* (June 23/30 2020) 323(24), 2524-2526. DOI: 10.1001/jama.2020.9184.

Coalovi indeksi v Sloveniji v letih 1991, 2011 in 2021/

Coale's indexes of fertility in Slovenia in the years 1991, 2011 and 2021

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POVZETEK

Coalovi indeksi so bili definirani in uporabljeni za analizo dejavnikov rodnosti in njihovih sprememb v času demografskega prehoda v Evropi. Kljub starosti pa še zmeraj lahko pokažejo, kako pomembni sta zakonska rodnost in rodnost izven zakonske zveze ter primerjavo dejanske rodnosti z maksimalno rodnostjo Huteritov. Coalovi indeksi za Slovenijo kažejo, da se je med letoma 1991 in 2021 povečal pomen tako poročnosti kot rojevanj izven zakonske zveze. Vse to pa ni vodilo do povečanja naše splošne rodnosti, saj je prišlo do izrazitih strukturnih sprememb v smeri od poročanja k ne-poročanju.

Ključne besede: Coalovi indeksi, Slovenija, zakonska in izvenzakonska rodnost

ABSTRACT

American demographer A.J. Coale defined four fertility indexes to study the demographic transition in Europe at the level of micro regions. The indexes show the importance of childbearing inside and outside marriage. In Slovenia, during the last thirty years marital and non-marital fertility have increased. However, overall fertility has not increased due to structural changes in favour of extra marital couples.

Key words: Coale's indexes, Slovenia, marital and non-marital fertility

1 UVOD

Ameriški demograf A.J. Coale je sredi dvajsetega stoletja s svojo raziskovalno skupino zelo podrobno analiziral potek demografskega prehoda v Evropi na ravni relativno majhnih regij (Coale, 1965, str. 205-207). Pri tem ga je posebej zanimalo, kaj se je v času prehoda dogajalo z rodnostjo znotraj zakonske zveze, izven zakonsko rodnostjo in poročenostjo. Hkrati pa je dejanske ravni rodnosti v zakonski zvezi in izven nje primerjal z najvišjo kadarkoli zabeleženo rodnostjo človeških populacij. V demografski literaturi je splošno sprejeto, da je najvišja rodnost, ki je bila kadarkoli ugotovljena v primeru konkretne človeške populacije, rodnost ameriške verske sekte Huteriti. V tej populaciji bi ženska, ki bi se poročila pri 15. letu in bi ostala poročena do 49. leta starosti v povprečju rodila 12,4 otrok.

A.J. Coale je v svoji analizi izhajal iz splošno sprejetega stališča med demografi, da je bilo za prehod od visokih stopenj rodnosti, ki so bile značilne za tradicionalni demografski režim, na nizke stopnje rodnosti, ki so se uveljavile v modernem demografskem režimu po končanem demografskem prehodu, najpomembnejše dogajanje na področju rodnosti znotraj zakonske zveze. To dogajanje se je zelo lepo pokazalo na ravni manjših regij. Pokazalo pa se je tudi, da so se z uveljavitvijo modernega demografskega režima začeli dogajati novi procesi, ki so mlade postopoma osvobodili vpliva tradicionalnih reproduktivnih norm. Rojevanje otrok izven zakonske zveze postopoma ni bilo več tabu in se je temu primerno v evropskih državah vse bolj razširilo. Ta trend je bil najprej bolj izrazit v protestantskih državah Zahodne in Severne Evrope, nato pa se je vse bolj širil tudi v tradicionalne katoliške države Južne Evrope.

Danes še ni mogoče reči, da se je zgoraj opisana liberalizacija razširila tudi izven Evrope. V nerazvitem delu sveta demografski prehod še ni končan. Zato so tam tradicionalne reproduktivne norme še močne. Za zunaj evropske razvite države pa velja, da se liberalizacija postopoma širi tudi vanje. To še posebej velja za anglo saksonski svet. Tam, kjer pa so tradicionalne patriarhalne norme posebej močne, kot npr. v Južni Koreji in nekaterih sosednjih državah Vzhodne Azije, pa imamo danes najnižje stopnje rodnosti. V Južni Koreji je bila stopnja celotne rodnosti v letu 2021 le 0,81.

V tem besedilu bom analiziral Coalove indekse za Slovenijo v letih 1991, 2011 in 2021. Še posebej me zanima, ali so ti indeksi še uporabni v družbi, kjer pravni sistem izenačuje pravno formalno sklenjene zakonske zveze z izven zakonskimi skupnostmi in kjer je število otrok rojenih v zakonski zvezi veliko manjše od števila otrok rojenih zunaj zakonske zveze. Hkrati pa bodo Coalovi indeksi pokazali primerjavo dejanske rodnosti v Sloveniji v izbranih letih z rodnostjo Huteritov.

2 COALOVI INDEKSI V SLOVENIJI V LETIH 1991, 2011 IN 2021

Coalovi indeksi najprej razčlenijo dejavnike rodnosti na tiste, ki delujejo v zakonski skupnosti in izven nje ter na vpliv poročenosti, nato pa dejansko rodnost v konkretni populaciji z upoštevanjem prej omenjenih dejavnikov

standardizirajo z najvišjo kadarkoli zabeleženo rodnostjo v konkretni človeški populaciji. Samo za ponazoritev navedimo petletne starostno specifične stopnje rodnosti Huteritov v starostnih razredih od 15-19 pa vse do 45-49. Te stopnje so zaporedoma 0,300, 0,550, 0,502, 0,447, 0,406, 0,222 in 0,061 (Malačič, 2006, str. 53).

Poglejmo sedaj za prebivalstvo Slovenije, kakšno je bilo število vseh živorojenih ter živorojenih staršem v zakonski zvezi in tistim zunaj nje v letih 1991, 2011 in 2021. Ti podatki so skupaj z indeksom 2021/1991 za navedene tri kategorije podatkov o živorojenih prikazani v tabeli 1.

Tabela 1: Število vseh živorojenih (N) ter živorojenih v zakonski zvezi (N_z) in izven nje (N_{nz}) v Sloveniji v letih 1991, 2011 in 2021. Vir: Malačič, 2006, str. 53-54 in SISTAT, dostop 25. 8. 2022.

N Leto, I	1991	2011	2021	$I_{2021/1991}$
1	2	3	4	5
N	21.583	21.947	18.984	88,0
N_z	15.881	9.484	8.026	50,5
N_{nz}	5.702	12.463	10.958	192,2

Število živorojenih v izbranih letih nam ne pokaže dobro, kaj se je dogajalo s slovensko rodnostjo v zadnjih tridesetih letih, čeprav podatki v tabeli kažejo, da je rodnost padla in je bil indeks za število vseh živorojenih 88,0. Veliko bolj zanimiva in jasna sta indeksa za zakonsko in izven zakonsko rodnost. Prvi indeks kaže, da je bilo število živorojenih znotraj zakonske zveze leta 2021 samo polovica tistega števila iz leta 1991. V nasprotju s tem številom pa se je število otrok rojenih izven zakonske zveze tako do leta 2011 kot do leta 2021 zelo povečalo. Za tridesetletno obdobje je indeks kar 192,2. Delež živorojenih otrok v Sloveniji, ki so bili rojeni izven zakonske zveze je bil leta 1991 26,4 %, do let 2011 in 2021 pa je zaporedoma narastel na 56,8 in 57,7 %.

A.J. Coale je definiral štiri indekse, ki jih bom tukaj samo na kratko vsebinsko opredelil, ne bom pa navajal obrazcev za njihov izračun. Ti obrazci so na voljo v literaturi (Malačič, 2006, str.53-54). Prvi indeks I_f je indeks splošne rodnosti, ki kaže, kolikšna je splošna rodnost v Sloveniji v izbranih letih v primerjavi s hipotetično rodnostjo ženski v Sloveniji, če bi te rojevale tako kot pri Huteritih. Naslednja dva indeksa sta indeks zakonske rodnosti I_g in indeks nezakonske rodnosti I_h , ki sta definirana enako kot prvi indeks, vendar posebej za zakonsko in nezakonsko rodnost v Sloveniji. Zakonska in nezakonska rodnost se primerja s tisto hipotetično rodnostjo poročenih in neporočenih žensk v Sloveniji, če bi te rojevale kot ženske pri Huteritih. Četrti indeks pa je indeks poročnosti I_m , ki pokaže prispevek poročnosti k splošni rodnosti v Sloveniji v izbranih letih. I_m je v resnici razmerje med živorojenimi poročenim ženskam ob maksimalni rodnosti in številom živorojenih v primeru, da bi bile poročene vse ženske in bi hkrati imele tudi maksimalno rodnost. Navedeni štirje Coalovi indeksi so med seboj povezani tako kot kaže naslednji obrazec (zvezdica pomeni pri obrazcu množenje):

$$I_f = I_g * I_m + (1 - I_m) * I_h$$

Za izračun vseh štirih indeksov potrebujemo za posamezna izbrana leta število žensk rodnega kontingenta in število poročenih žensk tega kontingenta po petletnih starostnih razredih od 15-19 do 45-49 let, število živorojenih v zakonski zvezi in izven nje v izbranih letih ter petletne starostno specifične stopnje rodnosti Huteritov za razrede od 15-19 do 45-49 let. Dodajmo še, da indeks I_h izračunamo s pomočjo zgornjega obrazca, saj dobimo z vrednostmi ostalih indeksov enačbo z eno neznanko. Konkretni izračuni posameznih indeksov so na voljo pri avtorju in jih tukaj ne bom navajal. Vzorec izračuna za leto 1991 pa je na voljo v literaturi (Malačič, 2006, str. 54-55). Vrednosti izračunanih Coalovih indeksov za Slovenijo za leta 1991, 2011 in 2021 so prikazane v tabeli 2, ki vsebuje tudi časovni indeks 2021/1991 za vse štiri Coalove indekse.

Tabela 2: Coalovi indeksi za Slovenijo v letih 1991, 2011 in 2021 ter časovni indeks 2021/1991 za vsakega izmed njih. Vir: Malačič, 2006, str. 54-55 in SISTAT, dostop 25. 8. 2022.

Leto I	I_f	I_g	I_m	I_h
1	2	3	4	5
1991	0,117	0,148	0,582	0,074
2011	0,131	0,186	0,306	0,102
2021	0,132	0,204	0,274	0,105
$I_{2021/1991}$	112,8	137,8	47,1	141,9

Coalovi indeksi v tabeli 2 za Slovenijo v letih 1991, 2011 in 2021 kažejo, da so se deleži splošne, zakonske in nezakonske rodnosti v Sloveniji v primerjavi z rodnostjo Huteritov za te tri skupine povečali. Obseg povečanja kažejo indeksi v zadnji vrstici tabele v stolpcih 2, 3 in 5. Največje povečanje je pri indeksu nezakonske rodnosti, vendar vrednost tega indeksa v letu 2021 še zmeraj zaostaja za vrednostjo indeksa splošne rodnosti. To nam tudi razloži, zakaj se je indeks splošne rodnosti v tridesetih letih povečal le za 12,8 %. Dejansko je to posledica tega, da se v Sloveniji že dalj časa večina otrok rojeva izven zakonske zveze. Indeksa za leto 2021 v tretjem in petem stolpcu nam kažeta, da je rodnost poročenih žensk v Sloveniji bila tega leta na ravni petine rodnosti Huteritov, medtem ko je bila rodnost neporočenih žensk znotraj rodnega kontingenta na ravni desetine rodnosti Huteritov. Relativno največjo spremembo v zadnjih tridesetih letih v Sloveniji pa kaže indeks poročnosi. V tej spremembi se skriva veliko razlogov za drastičen padec slovenske rodnosti daleč pod raven, ki bi zagotavljala dolgoročno nemoteno obnavljanje prebivalstva. V zadnjih nekaj letih slovenska rodnost zagotavlja manj kot tri četrtine ravni, ki bi bila potrebna za enostavno obnavljanje modelskega prebivalstva. V konkretnih podatkih je to razmerje 1,56 proti 2,1 na primeru stopnje celotne ali totalne rodnosti. Še posebej zaskrbljujoče pri naši rodnosti pa je, da bodo v prihodnjih letih strukturne spremembe, ki se skrivajo v starostno spolni strukturi slovenskega prebivalstva izrazito negativno vplivale na število živorojenih v Sloveniji.

Indeks poročnosti I_m v tabeli 2 za leto 2021 kaže, da bi se ob maksimalni rodnosti poročenih žena v Sloveniji realiziralo le 27,4 % maksimalne možne rodnosti rodnega kontingenta našega prebivalstva. To je samo 47,1 % vrednosti tega indeksa v letu 1991 v Sloveniji. Poročeni pari imajo v povprečju pri nas še zmeraj precej višjo rodnost kot neporočeni pari ali posamezniki. Vendar je v zadnjih treh desetletjih prišlo do velikega znižanja poročnosti, pa tudi do velikega povečanja razvez pri poročenih. Zakonske zveze so postale zelo nestabilne in trajajo v povprečju manj časa kot v preteklosti. Vse to pa se izrazito kaže v ravni in v trendih rodnosti v Sloveniji.

3 SKLEP

Ob velikih spremembah na področju poročnosti in razvez ter pomena izven zakonskih partnerskih skupnosti v Sloveniji v zadnjih tridesetih letih bi pričakovali, da nam Coalovi indeksi, ki so bili uporabljeni za analizo demografskega prehoda v Evropi, ne bodo povedali veliko novega. Vendar temu ni tako. Coalovi indeksi za Slovenijo v izbranih letih zadnjih treh desetletij kažejo, da se je do leta 2021 povečal pomen tako poročnosti kot rojevanj izven zakonske zveze. Vse to pa ni vodilo do povečanja naše splošne rodnosti, saj je prišlo do izrazitih strukturnih sprememb v smeri od poročanja k neporočanju.

LITERATURA IN VIRI

1. Coale, A.J.: Factors Associated with the Development of Low Fertility: An Historical Summary. V knjigi: *United Nations World Population Conference,* Belgrade, 1965, Vol. 2. New York 1965, str. 205-207.
2. Coale, A.J.: *The Demographic Transition,* International Population Conference, Liege 1973, IUSSP, Vol. I, Liege 1973, str. 53-72.
3. Coale, A.J., Hoover, M.E.: *Population Growth and Economic Development in Low Income Countries*, Princeton University Press, Princeton 1958.
4. Coale, A.J., Watkins, S.C., eds.: *The Decline of Fertility in Europe*, Princeton University Press, Princeton 1986.
5. Malačič, J.: *Demografija. Teorija, analiza, metode in modeli*, 6. izdaja, Ekonomska fakulteta Univerze v Ljubljani, Ljubljana 2006.
6. *SISTAT*, dostop 25. 8. 2022, Statistični urad Republike Slovenije, Ljubljana.

Odločitev za življenje

A decision for life

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POVZETEK

Demografska zima se je iz starega kontinenta razširila na ves svet. Zadnjih deset let se število novorojenih otrok nikjer na svetu več ne povišuje, temveč se zmanjšuje. Število prebivalstva (še) raste izključno zahvaljujoč podaljševanju človeškega življenja, nikjer pa ne zaradi rodnosti. Politiki, ki se zavedajo tragičnosti tega demografskega dejstva, v svojih državah ukrepajo na različne načine. V demokratični družbi nobena zunanja prisila na državljane ne more demografske krivulje usmeriti navzgor; ne zakonodaja, ne religijski nauki in ne materialne stimulacije. Ljudje se moramo za rodnjo odločiti sami. Zdi se, da je za odločitev za rodnjo otrok učinkovita vzgoja za spoštovanje svetosti življenja.

Ključne besede: demografska zima, rodnost, abortus, ekstremizem, osebna svobodna odločitev.

ABSTRACT

The demographic winter has spread from the old continent to the whole world. For the last ten years, the number of new-born children has not increased anywhere in the world, but rather decreased. The population is (still) growing exclusively thanks to the extension of human life, and nowhere due to the birth rate. Politicians, who are aware of the tragic nature of this demographic fact, act in different ways in their countries. In a democratic society, no external coercion on citizens can direct the demographic curve upwards; not legislation, not religious teachings, and not material stimulation. People have to make their own decisions about the birth of their children. To accept life, an education to respect the sanctity of life seems to be effective.

Keywords: demographic winter, birth rate, abortion, extremism, personal free decision.

Uvod

Demografska stroka in statistika v zadnjih letih ugotavljata, da nataliteta pada po vsem svetu, tudi na afriškem kontinentu, ki je »zibelka človeštva« v dveh pomenih besede: tam naj bi bili začetki človeške vrste in tam se rodi največ otrok na svetu. Ker se v zadnjih desetih letih število novorojenih otrok na svetu ne povečuje več[1], temveč se zmanjšuje, je stanje zaskrbljujoče. Pri nekaterih narodih je nataliteta padla krepko pod mejo reprodukcije, ki je 2,1 otroka na žensko. Ob tem dejstvu se politiki sprašujejo, kaj narediti, da bi se število rojstev povečalo in bi se tako izognili izginotju narodov in, v najslabšem primeru, celega človeštva. V prispevku najprej predstavljamo demografski položaj na svetu, nato pa nanizamo nekaj ukrepov politike v različnih državah, ki želijo povečati nataliteto, reakcije civilne javnosti na demografsko stanje in nauk Katoliške Cerkve o spoštovanju življenja. Razmišljanje zaključimo s spoznanjem, da v sodobni demokratični družbi nihče ne more prisiliti mater in parov, da bi sprejeli otroka ali več otrok. Za rodnjo se morajo svobodno sami odločiti.

Prvo poglavje: Demografska zima na našem planetu[2]

V medijih stalno prebiramo novice o klimatskih spremembah na našem planetu in javno mnenje je sprejelo dejstvo, predvsem zaradi vse bolj vročih poletnih mesecev, da se zemeljsko ozračje segreva. Redko pa v javnih medijih preberemo, da človeštvu grozi zima; demografska zima namreč. Na videz je to kontradiktorna trditev, toda demografska zima lahko še hitreje od vročega ozračja ogrozi obstoj človeške vrste. Znanstveniki ugotavljajo, da izumirajo živalske vrste[3]. Čeprav število ljudi eksponentno še narašča, je žal v trendu izumiranja tudi človeška vrsta. Ko govorimo o demografski sliki človeštva, namreč ne moremo ne opaziti, da kljub naraščanju prebivalstva radikalno pada rodnost. Razlog za to trditev lahko najdemo v okolju[4] in v kulturno-socioloških razlogih. Število novorojenih otrok se v zadnjih 10 letih v svetu praktično ne povečuje več.[5] Gams in

[1] Pearce, Fred. 2008. Peoplequake, Mass Migration, Ageing Nations and the Coming Population Crash. London: Transworld Publishers

[2] Belo knjigo Slovenske demografije so avtorji podnaslovili »Evropska demografska zima«. Zdi se nam primerno, da ta pojem ne omejujemo samo na stari kontinent, temveč da v skladu s statističnimi podatki govorimo o demografski zimi celotnega našega planeta.

[3] Kolbert, Elizabeth. 2014. The Sixth Extinction: An Unnatural History. New York: Bloomsbury.

[4] Levine, Hagai, in Shanna H. Swan. 2015. Is dietary pesticide exposure related to semen quality? Positive evidence from men attending a fertility clinic. Human Reproduction 30, št. 6:1287– 1289 in Swan, Shanna H., in Stacey Colino. 2021. Count Down: How Our Modern World Is Threatening Sperm Counts, Altering Male and Female Reproductive Development, and Imperiling the Future of the Human Race. New York: Scribner.

[5] Pearce, Fred. 2008. Peoplequake, Mass Migration, Ageing Nations and the Coming Population Crash. London: Transworld Publishers

Osredkar sta zapisala, da se je rodnost v svetovnem merilu od leta 1955, ko je beležila 4,97 otroka na žensko, do leta 2020 zmanjšala na 2,47[6]. Večanje števila prebivalstva je zavajajoče, ker ga beležimo le na račun podaljšane življenjske dobe ljudi, torej zahvaljujoč boljši zdravstveni oskrbi, v resnici pa se število rojstev po vseh kontinentih drastično zmanjšuje[7]. V zahodnem svetu je rodnost v večini držav padla pod stopnjo 2,1 rojenega otroka na žensko in gospodarstvo v teh državah »rešujejo« priseljenci iz dežel tretjega sveta, kjer rodnost še lahko ohranja ali celo nekoliko povečuje prebivalstvo. Vsekakor moramo priznati, da demografski problem na svetu ni (več) preveliko število prebivalcev (ki v resnici nikoli ni bil pravi problem), temveč vse manjša rodnost, ki lahko človeški rod resnično pahne v izumrtje, če se bo tak trend rodnosti nadaljeval. Navedli bomo nekaj tipičnih primerov demografske zime.

V Evropi že nekaj desetletij beležimo negativni naravni prirastek. »Na začetku stoletja se je v Evropi začela skupna stopnja rodnosti zniževati. V letih 2001 in 2002 je stopnja znašala 1,46 živorojenega otroka na žensko. Do leta 2010 se je sicer povišala na 1,62, nato se je do leta 2013 znižala na 1,54, leta 2014 pa znova povišala na 1,58. V razvitih delih sveta se za stopnjo naravnega obnavljanja prebivalstva, tj. za raven, na kateri bi bilo število prebivalstva brez priseljevanja ali izseljevanja dolgoročno stabilno, šteje skupna stopnja rodnosti 2,10 živorojenega otroka na žensko.«[8] Na starem kontinentu nobena država ne izvaja zunanje fizične ali pravne prisile glede rojevanja otrok, toda liberalistično hedonistične težnje ustvarjajo javno mnenje, ki ni naklonjeno povečanju natalitete. To mnenje preko klasičnih in spletnih medijev vpliva na pare, da se odločajo za minimalno število otrok, ali se celo ne odločajo za otroke. Posledica zmanjšane natalitete je staranje prebivalstva in izumiranje narodov[9]. Nasprotno pa v primeru kitajske demografske zime lahko govorimo o državni pravni prisili, ki je deželo pahnilo v sedanji težek demografski položaj.

Kitajsko prebivalstvo je v zadnjih šestdesetih letih močno naraslo. Leta 1960 je bilo 660 milijonov Kitajcev, leta 2020 pa milijardo in 400 milijonov. Ob informacijah o hitri rasti prebivalstva in uničevanju človekovega okolja, ki je s to rastjo povezano, je vlada moderne Kitajske sprejela sklep, da je potrebno omejiti demografsko rast. Leta 1979 je kitajska oblast, iz strahu pred hitrim večanjem števila prebivalcev zapovedala, da ima vsaka kitajska družina lahko samo enega otroka. Kitajski komunistični partiji je uspelo zmanjšati nataliteto z zakonodajno prisilo. Še več, število prebivalcev se je na Kitajskem, prvič po prevzemu njihove oblasti v letu 1949, v letu 2018 zmanjšalo. Raziskovalec YI Fuxian, ki deluje na ameriški univerzi Wisconsin-Madison, je navedel podatek, da se je v letu 2018 prvič v zgodovini moderne Kitajske zgodilo, da se je število prebivalcev na Kitajskem zmanjšalo – za 1,27 milijona. Število smrti je za toliko preseglo število rojstev.[10] Glede na skoraj milijardo in pol prebivalcev v tej državi je milijon skoraj zanemarljiv, toda pomenljiv.

Zdi se, da svetovne elite, pogosto preko dobrodelnih organizacij forsirajo sistem vrednot potrošništva in proti-rodnosti. Med njimi je gotovo tudi fundacija Billa in Melinde Gates, ki deluje prioritetno v dobro človeštva in zato predvsem v Afriki širi izobraževalne programe, ki imajo za cilj širiti kontracepcijo in posledično zmanjšanje rojstev[11] Del tega ideološkega pritiska pa ni znan, morda se pojavlja sam od sebe, tj. emergentno, kot del moderne informacijske družbe. Pritisk je nesporno globalen, torej ni opazen samo v Sloveniji, ampak tudi v Evropi in po svetu. Ve se tudi, s katerimi ukrepi ustaviti preveliko število rojstev: razbiti družino, omogočiti lahke ločitve, razbiti poroko in druge ustanove družine, propagirati svobodno izbiro partnerjev, otežiti starševstvo, povečati strošek in ceno otrok, trgati tradicionalne oblike socialnih vezi, povečati lahkotnost ločitev.[12]

Tam, kjer se politika zaveda nevarnosti demografski zime in »obrnjene demografske piramide«, države in različne ustanove iščejo različne načine, kako bi obrnili demografski trend.

Drugo poglavje: Zakonodaja za povečanje natalitete

Potrebno je poudariti, da imajo samo politične entitete, torej države, vzvode prisile, ki lahko vplivajo na nataliteto. V primeru neposlušnosti jih namreč lahko sankcionirajo. Verske skupnosti in druge civilne ustanove teh vzvodov nimajo. V prejšnjem poglavju smo omenili, kako je kitajska oblast z zakonodajo prisilila svoje prebivalce v zmanjšanje rodnosti. Ko pa so demografski kazalci v začetku tretjega tisočletja začeli opominjati kitajske voditelje, da njihova demografska politika deželo pelje proti katastrofi, je spremenila zakonodajo. Število starostnikov je namreč skokovito naraščalo, demografska piramida se je začela obračati in stanje je ogrozilo gospodarstvo. Leta 2016 so odpravili politiko enega otroka, vendar novi zakon, ki omenja tri otroke v družini, ni pospešil večje natalitete. Izgleda, da je bila kitajska zakonodajna prisila učinkovita zgolj pri »prepovedi rojevanja«. Nima pa moči, da bi dvignila rodnost. Stopnja rodnosti je namreč na Kitajskem leta 2021 padla na 1,3 živorojenega otroka na žensko. Kitajska vlada je zato v avgustu 2022 napovedala nove motivacijske ukrepe za spodbujanje višanja rodnosti. Kitajska državna komisija za zdravje je pozvala vlado, naj poveča izdatke za reproduktivno zdravje ter izboljša otroško varstvo. Ministrstvo za zdravje tako priporoča, da se odločanje staršev za več otrok podpre s subvencijami in davčnimi olajšavami za mlade družine ter s pomočmi na področjih izobraževanja, stanovanjske politike in zaposlovanja. V kitajskih provincah morajo do konca leta tudi zagotoviti dovolj vrtcev za otroke od dveh do treh let starosti. Kitajske oblasti so se za te ukrepe odločile, potem ko so v nekaterih najbolj razvitih kitajskih mestih take spodbude za mlade družine padle na plodna tla. Z objavljenimi smernicami želijo kitajske oblasti tako politiko razširiti na vso državo, poročanje AFP povzema STA.[13]

Primerno je, da se v našem razmišljanju nekoliko zaustavimo pri zakonodaji, ki dovoljuje ali prepoveduje »prekinitev nosečnosti« v zdravstvenih ustanovah. Vprašanje zakonodaje glede abortusa je namreč danes zelo aktualno. Na tem mestu želimo zgolj omeniti nekaj dejstev glede politike do vprašanja abortusa, ki vsekakor vpliva na nataliteto. Zagovorniki zakonsko dovoljenega opravljanja splava navajajo celo vrsto razlogov, zakaj mora zakonodaja tovrstni poseg dovoliti. Predvsem pa ga razumejo kot »pravico« ženske. Po vsej verjetnosti se je splav prakticiral skozi celotno zgodovino

[6] Gams, Matjaž, in Osredkar, Mari Jože. 2021, v: *Bogoslovni vestnik*, Katoliški nauk in znanost o demografskih vprašanjih, str. 555-567.
[7] Svetovna populacija – temeljni demografski podatki. Vir: https://www.worldometers.info/world-population.
[8] Eurostat: https://ec.europa.eu/eurostat/statistics-explained/pdfscache/19886.pdf
[9] Gams, Matjaž, in Osredkar, Mari Jože. 2021, v: *Bogoslovni vestnik*, Katoliški nauk in znanost o demografskih vprašanjih, str. 555-567.
[10] Dnevnik: https://www.dnevnik.si/1042855773
[11] Gams, Matjaž, in Osredkar, Mari Jože. 2021, v: *Bogoslovni vestnik*, Katoliški nauk in znanost o demografskih vprašanjih, str. 555-567.
[12] Gams, Matjaž, in Osredkar, Mari Jože. 2021, v: *Bogoslovni vestnik*, Katoliški nauk in znanost o demografskih vprašanjih, str. 555-567.
[13] STA: https://www.sta.si/3070806/kitajska-ob-upadanju-rodnosti-z-novimi-spodbudami-za-mlade-druzine

človeštva. Politika pa ga je dovoljevala ali prepovedovala. Začnimo s primerom Romunije, kjer je komunistični diktator Nocolae Ceausescu v 60-tih letih prejšnjega stoletja želel spodbuditi rast romunskega prebivalstva in je zakonsko prepovedal splav, ki je bil predhodno dovoljen, prav tako je prepovedal uporabo kontracepcij. [14] Politika je tam uspela povečati rodnost od 1,9 na 3,7 živorojenega otroka na žensko.[15] »V ZDA se danes kaže trend politike, da bi zakonsko omejila opravljanje abortusa. Medtem ko so na Irskem, v tradicionalno katoliški državi, pred leti na referendumu podprli spremembo ustave in legalizirali splav, gre trend v nekaterih drugih evropskih državah v obratni smeri. Na Hrvaškem ima ugovor vesti okrog 60 odstotkov ginekologov v Splitu, na Poljskem pa poskušajo splav popolnoma prepovedati, celo v primeru incesta ali posilstva.«[16]. V Sloveniji zakonodaja dovoljuje abortus. V 55. členu slovenske ustave je zapisano, da je odločanje o rojstvu otrok svobodno. To ustavno pravico ureja zakon, ki dovoljuje opravljanje splava na zahtevo razsodne ženske (pri mladoletnih ni potrebno soglasje staršev) od 10. tedna nosečnosti. Kasneje pa lahko opravijo splav takrat, ko komisija na ginekoloških klinikah odloči, da nosečnost ogroža življenje oz. zdravje matere ali če je za to utemeljen socialni razlog. V večini evropskih držav, kjer je splav zakonsko omogočen vsem, ki ga želijo opraviti, ne poznamo neposrednih zakonodajnih ukrepov za zvišanje natalitete. Na temelju različnih teorij rodnosti pa države izpeljujejo načrte in spodbude za povečanje rodnosti.

Več ali manj se večina teorij »vrti« okoli ekonomskega položaja staršev. Pred odločitvijo za družino pari preračunajo koristi in ekonomske stroške in se glede na spoznanja odločajo za otroke oz. o številu otrok, ki jih bodo v družini sprejeli. Če stroški presegajo koristi, se pari ne odločijo za otroke. Nekatere države zato z materialnimi stimulacijami in davčnimi olajšavami motivirajo svoje državljane za rodnjo otrok.[17]

Tretje poglavje: Izražanje volje ljudstva

Omenili smo primere različnih zakonodaj, ki želijo dvigniti nataliteto v posameznih državah, spregovorili pa smo tudi o zakonodajah, ki v večini držav materam omogoča prekinitev nosečnosti. Predvsem glede slednje je v zahodnem svetu javnost zelo odzivna. Na eni strani imamo veliko demonstracij v podporo zakonu, ki dovoljuje abortus, na drugi strani pa mu mnogi izražajo nasprotovanje.

Na Hrvaškem se že nekaj časa organizira »Pohod za življenje«, na katerem udeleženci pozivajo k zakonski zaščiti nerojenih otrok. Gibanje za življenje vsekakor vpliva na odločitev mater in ginekologov, ali bo prišlo do splava ali bo otrok rojen. Od 29 javnih bolnišnic na Hrvaškem v šestih nimajo ginekologa, ki bi opravil splav na zahtevo ženske, ker uveljavlja možnost ugovora vesti.[18] V Sloveniji se od leta 2016 organizirajo tako imenovane molitve pred ginekološkimi klinikami, kjer se opravljajo abortusi. Skupine »Božjih otrok« se zberejo pred porodnišnico, v rokah imajo transparente in molijo. S svojim početjem nikogar ne motijo, so pa opazni in tako izražajo svoje nasprotovanje abortusu. Tak način izražanja nasprotovanja zakonodaji, ki omogoča prekinitev nosečnosti, izvira iz ZDA, v Evropi pa se je najprej začelo prakticirati v Veliki Britaniji. V Sloveniji tovrstne proteste organizira zavod »Božji otroci«. Podobne primere imamo tudi drugod po Evropi oz. zahodnem svetu. Več ali manj je njihov protest utemeljen na krščanskem nauku.

Mnogi kritiki, predvsem iz levega pola slovenske politike, te skupine in njihove dejavnosti opredeljujejo kot ekstremistične. Primerno je, da tudi mi na tem mestu spregovorimo o fundamentalizmu in ekstremizmu. Če se vernik, kristjan ali musliman, odloči, da bo svoje življenje utemeljil na Božji besedi oz. na nauku v katerem prepoznava Božje razodetje in Božjo voljo ter vsa svoja dejanja utemeljuje na Božji besedi, ga imenujemo fundamentalist. Temelj njegovega življenja je Božja beseda. Takoj, ko bo želel prisiliti tudi ljudi v svoji okolici, da bi živeli kot živi on, pa se njegov fundamentalizem spremeni v ekstremizem. Verski ekstremizem je prisila drugih k sprejemanju vrednot, ki jih spoštuje ekstremist. Fundamentalizem je v svoji osnovi nekaj dobrega, ekstremizem pa je nekaj slabega, ker vključuje prisilo, nasilje nad drugimi. Vsekakor pa izpovedovanje vere oz. življenje po Božjih zapovedih ni ekstremizem.

Četrto poglavje: Primer religijskega nauka za povečanje natalitete

V strokovni literaturi pogosto najdemo opombo, da imajo katoliške družine več otrok kot tiste, ki se ne držijo verskega nauka. Tadej Strehovec je v svojem predavanju na demografskem posvetu v Državnem svetu RS, maja 2018, pokazal, da v nasprotju z upadanjem prebivalstva v Sloveniji in Evropi, verno prebivalstvo ohranja dovolj visoko stopnjo rodnosti za ohranjanje števila članov verskih skupnosti. [19] To drži, vendar je potrebno priznati, da so se tudi mnoge moderne katoliške družine prepustile družbenemu trendu, ki daje materialnim vrednotam prednost pred verskimi vrednotami oz. pred otroki. Podobno lahko govorimo tudi o muslimanskih družinah. Toda, pri katoliškem nauku o družini ne gre prvenstveno za ohranjevanje narodov in človeštva. Gre za spoštovanje svetosti življenja. Posledično pa »sprejetje« življenja vsekakor pripelje do večje natalitete.

Katoliški nauk prepoznava človeško osebo od združenja moške in ženske spolne celice pri spočetju zarodka, pa do človekove biološke smrti. Nihče se ni odločil, da bo živel in nihče nima nobene zasluge, da živi. Življenje nam je bilo vsem podarjeno. Ker krščanski nauk uči, da je življenje Božji dar, je življenje sveto v etimološkem pomenu besede. Kar pa je sveto, tega se človek »ne sme dotakniti«! Ne dotakniti se življenja pa pomeni sprejeti vsakega spočetega človeka in ohranjati njegovo življenje do biološke smrti. To pomeni, da Bog, in ne človek, odloča o življenju in smrti. Iz te predpostavke sledi, da »želja po materinstvu in očetovstvu ne upravičuje nobene »pravice do otroka«, pač pa so očitne pravice tistega, ki prihaja na svet. Temu je treba zagotoviti najustreznejše bivanjske razmere s trdno – na zakonu in komplementarnosti dveh podob, očetovske in materinske – utemeljeno družino«[20]**.** Isti dokument nadaljuje, da morajo biti »Otrokove pravice zavarovane s pravnim

[14] Pejič Nina, http://ipes-si.org/blog/2019/06/05/kdo-se-bo-postavil-za-naso-pravico-do-splava/

[15] Horga M, Gerdts C, Potts M The remarkable story of Romanian women's struggle to manage their fertility Journal of Family Planning and Reproductive Health Care 2013;39:2-4. Dostopno na: https://srh.bmj.com/content/39/1/2.full

[16] Intihar, Anja dostopno na: https://www.delo.si/sobotna-priloga/prepoved-abortusa-ima-v-resnici-zelo-kratko-zgodovino/

[17] To tematiko predstavlja Milivoja Šircelj v delu Rodnost v Sloveniji od 18. do 21. stoletja, Statistični urad RS, Ljubljana 2006. V svojem delu se nanaša na Mcdonald.

[18] DELO : https://www.delo.si/novice/svet/v-zagrebu-pohod-za-zivljenje-vedno-vec-ginekologov-z-ugovorom-vesti/

[19] Strehovec, Tadej. 2019, v: Gams, Matjaž, in Janez Malačič, ur. *Bela knjiga slovenske demografije*. Ljubljana: Inštitut Jožef Stefan, str. 92-95.

[20] Kompendij družbenega nauka Cerkve, čl. 235.

redom… Prva otrokova pravica pa je, da se rodi v družini z materjo in očetom, pravica, katere spoštovanje je bilo vedno težavno in ki pozna danes zaradi razvoja genetske tehnologije nove oblike kršitev«[21] Katoliška Cerkev je prepričana, da ima država dolžnost, da varuje družino in otroke : »Politična skupnost ima dolžnost, da družino spoštuje, jo podpira in ji zagotavlja predvsem sledeče: svobodo, da si osnuje svoje ognjišče, da ima otroke in jih vzgaja v skladu s svojimi nravnimi in religioznimi prepričanji; zaščito trdnosti zakonske zveze in družinske ustanove; svobodo, da izpoveduje svojo vero, jo predaja naprej, vzgaja v njej svoje otroke s potrebnimi sredstvi in ustanovami; pravico do zasebne lastnine, svobodo, da osnuje podjetje, dobi delo, stanovanje, pravico, da se izseli; na podlagi institucij dežele pravico do zdravstvenega varstva, do pomoči za ostarele in do družinskih doklad; zaščito varnosti in zdravstva, zlasti z ozirom na nevarnosti kot so mamila, pornografija, alkoholizem, itd. svobodo, da skupaj z drugimi družinami osnujejo združenja in da so tako zastopane tudi pri civilnih oblasteh«[22].

Jeseni 2010 je evropska škofovska konferenca povabila vse evropske katoliške škofe na posvet z naslovom *Katoliška cerkev je vznemirjena zaradi »demografske zime« v Evropi*[23]. Zavedajoč se, da koeficient 1,5 otroka na žensko še zdaleč ne zadošča za ohranjanje evropske populacije, ki se stara, so škofje zaključili, da je edina rešitev za Evropo trdna in za življenje odprta družina. Rezultat posveta je knjiga *I vescovi europei su demografia e famiglia in Europa*, v kateri je izražena spodbuda evropskim državam, da bi stimulirale družino. V bistvu so samo povzeli nauk, ki ga Katoliška cerkev oznanja že 2000 let.

Sklep

Nobena politika ali zakonodaja, sama na sebi, ne more dvigniti natalitete oz. prisiliti žensko ali par, da bi rodila otroka. Tudi nobena druga zunanja prisila, verski vpliv ali ekstremistične težnje nimajo odločilnega vpliva na nataliteto. Zdi se, da tako početje zgolj povzroča razkole v družbi in nima željenega učinka. Za rodnjo otrok se morajo starši, konec koncev, odločiti sami. Na odločitev pa bolj kot neki zakonski predpisi ali priložnostni zunanji vplivi, odloča vzgoja za starševstvo, ki lahko mladim ljudem omogoči sprejetje življenja. Ne le zato, da se ohrani narod in človeški rod, temveč predvsem zaradi spoštovanja do življenja – ker je življenje sveto. Imamo družine, ki se odločajo za veliko število otrok kljub zakonski pravici do abortusa. Ker se za to odločijo sami. Da bi še bolj utemeljili naše sklepno spoznanje, se vrnimo k primeru Kitajske. S svojo zakonodajo je kitajska politika zavrgla življenje kot vrednoto. S političnim odlokom je lahko zmanjšati nataliteto. Ne da pa se z lahkoto zakoncev prepričati, da bi bili odprti za življenje svojih otrok. Ekonomska rast in kitajsko potrošništvo je razlog, da Kitajci tudi po odpravi »zakonodaje omejevanja rodnosti« ostajajo pri enem otroku ali celo brez njih. Tragedija kitajskih političnih odločitev je ta, da so uničili vrednote, sedaj pa jih ne morejo kar tako, čez noč, uvesti v človekovo mentaliteto. Za življenje kot vrednoto vzgaja tudi Katoliška Cerkev. Nekateri jo zaradi tega okarakterizirajo kot zaostalo, pravijo, da živi še v srednjem veku, ker zagovarja življenje kot vrednoto. Toda, ne gre za vprašanje, ali neka vrednota izhaja iz Biblije, iz »srednjega veka« ali pa se je rodila med komunistično revolucijo. Vprašanje, ki je pomembno, je naslednje: Katera vrednota človeštvu omogoča življenje in preživetje? V bistvu se lahko vprašamo: Kaj je vrednota? To je cilj, ki omogoča življenje in preživetje; ne le posamezniku, temveč vsem posameznikom in družbi kot celoti. V bistvu je vrednota samo to, kar omogoča preživetje. Če neka drža vodi v izumrtje, to ni vrednota.

Res je, da si katoličani prizadevamo, da bi zakonodaja ščitila življenje še nerojenih otrok. Toda, ne glede na zakonodajo in javno mnenje, je vsak človek lahko svoboden in se odloča po svoji vesti in kakor spozna, da je dobro; torej, da je odprt za življenje. K temu nas spodbuja Deklaracija človekovih pravic[24], dokument Drugega vatikanskega koncila o Verski svobodi in Kristus sam je zagovarjal, da se je zanj in za evangeljski nauk potrebno odločiti.

[21] Kompendij družbenega nauka Cerkve, čl. 244.
[22] Katekizem Katoliške Cerkve, čl. 2211.

[23] Blangiardo, Giancarlo, in Simona Maria Mirabelli, ur. 2012. I Vescovi europei su demografia e famiglia in Europa. Siena: Edizione Cantagalli.
[24] Deklaracija človekovih pravic, člen 19.

REFERENCE

Blangiardo, Giancarlo, in Simona Maria Mirabelli, ur. 2012. I Vescovi europei su demografia e famiglia in Europa. Siena: Edizione Cantagalli.

Deklaracija človekovih pravic.

DELO : https://www.delo.si/novice/svet/v-zagrebu-pohod-za-zivljenje-vedno-vec-ginekologov-z-ugovorom-vesti/
Dnevnik: https://www.dnevnik.si/1042855773

Eurostat: https://ec.europa.eu/eurostat/statistics-explained/pdfscache/19886.pdf

Gams, Matjaž, in Janez Malačič, ur. 2019. Bela knjiga slovenske demografije. Ljubljana: Inštitut Jožef Stefan.

Gams, Matjaž, in Osredkar, Mari Jože. 2021, v: *Bogoslovni vestnik,* Katoliški nauk in znanost o demografskih vprašanjih, str. 555-567.

Horga M, Gerdts C, Potts M The remarkable story of Romanian women's struggle to manage their fertility Journal of Family Planning and Reproductive Health Care 2013;39:2-4. Dostopno na: https://srh.bmj.com/content/39/1/2.full

Intihar, Anja dostopno na: https://www.delo.si/sobotna-priloga/prepoved-abortusa-ima-v-resnici-zelo-kratko-zgodovino/

Katekizem Katoliške Cerkve

Koncilski odloki, Odlok o verski svobodi

Kompendij družbenega nauka Cerkve, čl. 235.

Kolbert, Elizabeth. 2014. The Sixth Extinction: An Unnatural History. New York: Bloomsbury.

Levine, Hagai, in Shanna H. Swan. 2015. Is dietary pesticide exposure related to semen quality? Positive evidence from men attending a fertility clinic. Human Reproduction 30, št. 6:1287– 1289.

Pearce, Fred. 2008. Peoplequake, Mass Migration, Ageing Nations and the Coming Population Crash. London: Transworld Publishers

Pejič Nina, http://ipes-si.org/blog/2019/06/05/kdo-se-bo-postavil-za-naso-pravico-do-splava/

STA: https://www.sta.si/3070806/kitajska-ob-upadanju-rodnosti-z-novimi-spodbudami-za-mlade-druzine

Strehovec, Tadej. 2019, v: Gams, Matjaž, in Janez Malačič, ur. *Bela knjiga slovenske demografije*. Ljubljana: Inštitut Jožef Stefan, str. 92-95.

Sveto pismo

Svetovna populacija – temeljni demografski podatki. Vir: https://www.worldometers.info/world-population
ŠIRCELJ, Milivoja. Rodnost v Sloveniji od 18. do 21. stoletja. Statistični urad Republike Slovenije, Ljubljana, 2006.

Pomen izkušenj iz izvorne družine za razumevanje povezave med obrambnimi mehanizmi in tveganim uživanjem alkohola*

The importance of experiences from the family of origin for understanding the link between defense mechanisms and hazardous alcohol use

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POVZETEK

Tvegano uživanje alkohola je pereč in razširjen pojav v naši družbi in mu je zato potrebno nameniti posebno pozornost. Obrambni mehanizmi naj bi se povezovali s tveganim vedenjem, v naši raziskavi pa nas zanima ali lahko razložimo vlogo obrambnih mehanizmov pri vzdrževanju tveganega uživanja alkohola z neugodnimi izkušnjami iz izvorne družine. V raziskavo je bilo vključenih 623 udeležencev. Kot merski pripomočki so bili uporabljeni Vprašalnik o stopnji tveganosti pitja alkohola (AUDIT - The Alcohol Use Disorders Identification Test), Mednarodni vprašalnik o negativnih izkušnjah v otroštvu (ACE-IQ - Adverse Childhood Experiences International Questionnaire), Lestvica izvorne družine (Family of Origin) vprašalnika STIC (Systemic Therapy Inventory of Change) in Vprašalnik obrambnih stilov (DSQ 40 - Defense style questionnaire). Z raziskavo smo potrdili razlike med posamezniki glede na stopnjo tveganega uživanja alkohola v uporabi nezrelih obrambnih mehanizmov (devalvacija, disociacija, razcep in racionalizacija). Nadaljnje raziskovanje korelacij teh obrambnih mehanizmov pa so pokazale statistično pomembne pozitivne povezave: zloraba substanc v izvorni družini se pozitivno povezuje z pogostostjo uporabe devalvacije in razcepa v odraslosti, izkušnja zlorabe in negativno vzdušje v izvorni družini se pozitivno povezuje z uporabo disociacije kot obrambnega mehanizma, vsiljivost v izvorni družini se pozitivno povezuje z racionalizacijo. V prispevku podamo možno interpretacijo pomena izkušenj iz izvorne družine za razumevanje tveganega uživanja alkohola.

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KLJUČNE BESEDE

alkoholizem, obrambni mehanizmi, izvorna družina, zloraba, čustvena regulacija

ABSTRACT

Hazardous alcohol use is a pressing and widespread phenomenon in our society and needs special attention. Defence mechanisms are thought to be associated with risky behaviour, and in our study we are interested in whether the role of defence mechanisms in maintaining hazardous drinking can be explained by adverse family of origin experiences. The study included 623 participants. The measures used were the Alcohol Use Disorders Identification Test (AUDIT), the Adverse Childhood Experiences International Questionnaire (ACE-IQ), the Family of Origin Scale of the Systemic Therapy Inventory of Change (STIC), and the Defense Style Questionnaire (DSQ 40). The study confirmed differences between individuals in the use of immature defence mechanisms (devaluation, dissociation, splitting and rationalisation) according to their level of hazardous alcohol use. Further exploration of the correlations of these defence mechanisms revealed statistically significant positive associations: substance abuse in the family of origin is positively associated with the frequency of use of devaluation and splitting in adulthood, the experience of abuse and negative atmosphere in the family of origin is positively associated with the use of dissociation as a defence mechanism, and intrusiveness in the family of origin is positively associated with rationalisation. In this paper, we provide a possible interpretation of the relevance of the family of origin experience for understanding risky drinking.

KEYWORDS

alcoholism, defence mechanisms, family of origin, abuse, emotional regulation

1 TVEGANO UŽIVANJE ALKOHOLA

Glede na nacionalno raziskavo o uporabi alkohola v Sloveniji [1] 68% oseb zmerno pije, vsak drugi se je v zadnjem letu vsaj enkrat visoko tvegano opil in vsak deseti Slovenec(ka) pije alkohol v čezmerni količini, med katerimi so bolj pogosti moški; med ranljive skupine pa spadajo moški in ženske z osnovnošolsko izobrazbo ali manj, moški in ženske v starosti 15-17 in 18-24 let, moški in ženske, ki živijo brez partnerja, šolajoči se ženske in moški in moški iz spodnjega socialnoekonomskega razreda. Tvegano uživanje alkohola je tako razširjen pojav in mu je zato potrebno nameniti posebno pozornost in razumevanje.

Duševne motnje povezane s tveganim uživanjem alkohola opredeljujemo kot odvisniško vedenje, ki je motivirano bodisi z iskanjem užitka ali z somodestruktivnimi motivi. Z vidika duševnega zdravja diagnosticiramo alkoholizem kot vzorec škodljivega uživanja psihoaktivne snovi (alkohola), ki povzroča okvare zdravja in sindrom odvisnosti, za katerega je značilna močna želja po zaužitju alkohola, vztrajanje pri uživanju kljub škodljivih posledicam, večje posvečanje uživanju alkohola kot drugimi aktivnostim in obveznostim, povečano toleranco in včasih telesne motnje zaradi odtegnitve snovi [2]. Čeprav tvegano uživanje alkohola pogosto povezujemo z odvisniškim vedenjem, pa sodobne paradigme poudarjajo, da je v ozadju takega vedenja močna psihična bolečina [3] in da lahko alkoholizem razumemo tudi kot kronično fizično bolezen, saj uporaba alkohola trajno spremeni in tudi poškoduje biološko ravnovesje v možganih [4]. Tvegano uživanje alkohola tako lahko razumemo kot način neprimerne regulacije notranje napetosti oziroma motnjo samoregulacije, katero lahko povezujemo s travmatično izkušnjo [5,6], z oblikami ne-varne navezanosti [3], kot sistemsko prilagoditev odnosov na nefunkcionalne vzorce vedenja [7] oziroma kot način soočanja oziroma kot posledico uporabe nezrelih obrambnih mehanizmov [8,9,10]. Psihodinamska teorija predpostavlja, da zasvojenost sprva služi doseganju užitka in lajšanju psihične bolečine, v naslednjem koraku v osredje stopi izogibanje tesnobi in nazadnje samotolažbi in ohranjanju navidezne psihične stabilnosti [11]. Obrambni mehanizmi pa v vseh primerih služijo kot poskus razrešitve neobvladljive psihične bolečine.

2 OBRAMBNI MEHANIZMI

Obrambni mehanizem najpogosteje opisujemo kot relativno nezavedni psihični mehanizem, ki ščiti pred bolečimi čustvi, mislimi ali situacijami. Sprožajo jih notranji ali zunanji stresorji. Perry [12] definira sedem nivojev obrambnega delovanja, od nezrelih do bolj zrelih. Čeprav nezreli obrambni mehanizmi ščitijo osebo pred stisko oziroma notranjim konfliktom, so le-ti manj prilagojeni, oseba se jih pogosto ne zaveda, in pogosto vodijo v negativne izide čustvovanja in vedenja. Nezreli obrambni mehanizmi so rigidni in zmanjšujejo občutek fleksibilnosti in sposobnost odločanja [8]. Zreli obrambni mehanizmi so bolj prilagojeni, oseba se jih bolj pogosto zaveda, jih zavestno izbira in uporablja, kar povečuje možnost pozitivnega izida. Čeprav imajo obrambni mehanizmi na začetku vedno adaptacijsko funkcijo, lahko s časom izgubijo svoj namen zaščite in zaradi popačenega doživljanja sedanjosti postanejo nefunkcionalni [11]. Posameznik v tem primeru lahko doživlja nevarnost, kjer je realno ni ali pa se ne odzove primerno na dejansko nevarnost, pred katero se je potrebno zaščititi. V naši raziskavi izhajamo iz razdelitve obrambnih mehanizmov na tri osnovne skupine: zreli obrambni mehanizmi (odražajo zdrav in zaveden odnos z realnostjo), nevrotični obrambni mehanizmi (odražajo izogibajoče vedenje) in nezreli obrambni mehanizmi (odražajo zaviranje čustvenega zavedanja) [13]. Predhodne raziskave [9,10,11] kažejo predvsem na povezavo med tveganim pitjem alkohola in nezrelimi obrambnimi mehanizmi, zaradi česar smo v našo raziskavo vključili le dimenzijo nezrelih obrambnih mehanizmov. Raziskave kažejo, da zasvojeni posamezniki v primerjavi s kontrolno skupino pogosteje uporabljajo pasivno agresijo, izolacijo, zanikanje, disociacijo in racionalizacijo [11] ter odigravanje in razcep [10].

3 IZKUŠNJE IZ IZVORNE DRUŽINE

Zgodnje travmatične izkušnje vplivajo na razvoj možganov in povzročajo disregulirane odzive na biološki stres, zaradi česar povečujejo možnost razvoja zasvojenosti z alkoholom [5]. Odnosi v zgodnjem razvoju namreč oblikujejo samoregulativne mehanizme, ko starši igrajo pomembno vlogo v čustveni regulaciji otrok kot zunanji podporni sistem, ki pomaga uravnavati nova čustvena stanja [14]. Odrasel človek je tako sposoben regulacije čustvenega stanja, ki jo kot spremembo telesnega stanja prepoznamo v sebi (regulacija afekta v sebi) in tudi vplivanja na doživljanje, čustvovanje in vedenje drugega (regulacija afekta v drugem) [15]. Osebe, ki so bile izpostavljene travmi pa imajo težave pri integraciji travmatičnih izkušenj in tudi motnje v sistemu regulacije afekta [16], ki jo prepoznamo kot pretirano doživljanje afekta oziroma odsotnost afekta. Močno psihično bolečino, ki jo posameznik doživlja zaradi disregulacije, pa lahko ublaži s hitro spremembo razpoloženja oziroma z uporabo obrambnih mehanizmov. Odvisno vedenje tako v tem kontekstu razumemo kot samozdravljenje notranje bolečine [3,6] oziroma kot nezavedno uporabo nezrelih obrambnih mehanizmov [10]. Odvisno vedenje nato nadalje uničuje možganske celice in okvari nevrotransmiterske sisteme v možganih [4], kar povzroči kronično motnjo samoregulacije zaradi česar posamezniki niso sposobni funkcionalno regulirati lastnih čustev, se ne primerno odzivajo na čustva drugih in ne morejo čustveno poskrbeti zase [3] ter se vedno znova zatekajo k nezrelim obrambnim mehanizmom [11].

4 RAZISKAVA

4.1 Metoda

S predstavljeno raziskavo smo preverjali na kakšen način lahko povezujemo travmatično izkušnjo iz izvorne družine z razvojem obrambnih mehanizmov ter na kakšen način lahko s po povezavo razložimo tvegano uživanje alkohola. Uporabljeni merski instrumenti so:

Vprašalnik o stopnji tveganosti pitja alkohola (AUDIT - The Alcohol Use Disorders Identification Test) [17] . Meri tri vidike zlorabe alkohola, od katerih bomo v raziskavo vključili dimenzijo tveganega uživanja alkohola (nizko tveganje,

tveganje ali nevarno pitje, visoko tveganje ali škodljivo pitje, višje tveganje ali odvisnost).

Mednarodni vprašalnik o negativnih izkušnjah v otroštvu (ACE-IQ - Adverse Childhood Experiences International Questionnaire). Vprašalnik identificira 13 kategorij negativnih izkušenj v otroštvu, od katerih bomo v našo raziskavo vključili naslednje: fizično zlorabo v družini, spolno zlorabo, doživljanje nasilja nad drugim družinskim članom, čustveno zanemarjanje, fizično zanemarjanje in psihično nasilje.

Lestvica izvorne družine (Family of Origin) vprašalnika STIC (Systemic Therapy Inventory of Change) [18], ki vsebuje 22 postavk, razdeljenih na naslednja področja: pozitivnost vzdušja v izvorni družini, negativnost vzdušja v izvorni družini, vzajemnost in jasnost pričakovanj v izvorni družini, prisotnost fizične zlorabe v izvorni družini, vsiljivost in zlorabo substanc v izvorni družini.

Vprašalnik obrambnih stilov (DSQ 40 - Defense style questionnaire) [13] vsebuje 40 vprašanj, ki so zasnovana za merjenje psihičnih obrambnih mehanizmov oz. stilov, ki se delijo tri sklope: zreli, nevrotični in nezreli obrambni stili. V raziskavi bo uporabljen samo del vprašalnika, ki meri nezrele obrambne mehanizme (idealizacija, projekcija, pasivna agresija, odigravanje, devalvacija, sanjarjenje, zanikanje, disociacija, razcep, racionalizacija, somatizacija).

V raziskavi preverjamo naslednje hipoteze:

H1: Obstajajo statistično pomembne razlike v uporabi nezrelih obrambnih mehanizmov med posamezniki z različnimi stopnjami tveganega uživanja alkohola.

H2: Neugodne izkušnje iz izvorne družine se pozitivno povezujejo s pogostostjo uporabe nezrelih obrambnih mehanizmov.

4.2 Udeleženci

Raziskava vključuje 623 udeležencev. 27 % moških in 73 % žensk, 64,6 % udeležencev je starih manj kot 40 let, 29,2 % udeležencev je samskih, 62,3 % udeležencev je v zakonska oziroma izvenzakonski skupnosti, 35,4 je študentov in 42,7 je zaposlenih.

4.3 Rezultati

Tabela 1: Opisne statistike za lestvice tveganega pitja alkohola (AUDIT), lestvice negativnih izkušenj v otroštvu (ACE-IQ), lestvica izvorne družine (STIC-FOO) in lestvice obrambnih mehanizmov (DSQ)

Lestvica	Moški		Ženske	
	M	SD	M	SD
AUDIT - skupaj	13.3	12.1	3.4	2.7
tvegano uživanje	5.7	3.9	0.5	1.6
odvisnost	2.8	3.8	1.4	3.0
posledice	4.8	5.4	5.2	6.4
ACE-IQ				
čustveno zanema.	6.6	2.2	6.7	2.1
fizično zanema.	11.1	1.6	11.2	1.5
družinsko nasilje	9.1	2.4	9.2	2.4
psihično nasilje	5.9	1.8	5.8	1.7
fizična zloraba	6.3	1.6	6.6	1.6
spolna zloraba	15.9	0.4	15.1	2.3
STIC-FOO - skupaj	85.5	15.3	84.7	17.6
pozitivno vzdušje	23.1	0.4	22.2	6.6
negativno vzdušje	11.9	4.5	13.1	5.3
vzajemnost	7.7	1.9	7.7	1.8
zloraba	5.3	2.7	5.1	2.8
vsiljivost	4.4	2.1	4.4	2.1
zloraba substanc	7.6	3.1	6.3	2.8
DSQ - skupaj	85.1	23.2	79.9	21.9
idealizacija	6.6	4.6	9.2	4.7
projekcija	5.4	3.3	5.8	3.8
pasivna agresija	6.8	4.1	5.5	3.4
odigravanje	6.1	4.2	6.7	3.6
devalvacija	6.1	3.5	5.0	3.2
sanjarjenje	7.4	4.8	7.2	4.6
zanikanje	7.4	3.6	6.0	3.3
disociacija	8.3	3.8	7.3	3.6
razcep	9.6	3.6	8.2	3.9
racionalizacija	12.9	3.8	13.3	2.9
somatizacija	5.4	3.5	6.1	3.6

Opombe: M – aritmetična sredina, SD – standardni odklon

Primerjava značilnosti razlik med povprečji s testom ANOVA je pokazala, da obstajajo statistično pomembne razlike med skupinami glede na oceno stopnje tveganega pitja alkohola v uporabi nezrelih psihičnih obrambnih mehanizmov devalvacije (sig. 0,004), disociacije (sig. 0,039), razcepa (sig. 0,002) in racionalizacije (sig. 0,002). Ugotavljamo, da obstajajo statistično pomembne razlike v uporabi nezrelih obrambnih mehanizmov med posamezniki z različnimi stopnjami tveganega uživanja alkohola. S POST-HOC testom smo ugotavljali pomembnost in smer razlik med posameznimi skupinami (Tabela 2). Ugotavljamo statistično pomembno povezanost skupine z nizkim tveganjem uživanja alkohola in ostalimi skupinami. Smer povezanosti pa kaže na dejstvo, da v primeru obrambnega mehanizma devalvacije skupina z nizkim tveganjem dosega statistično pomembno nižjo stopnjo devalvacije; skupina z škodljivim pitjem dosega statistično pomembno višji nivo disociacije kot ostale skupine, skupina z odvisnostjo pa dosega višje višji nivo razcepa od skupine z nizkim tveganjem ter nižji nivo racionalizacije od skupine z nizkim tveganje in od skupine z nevarnim pitjem.

Tabela 2: Prikaz statistično pomembni razlik v uporabi obrambnih med skupinami glede na stopnjo tveganega uživanja alkohola

			MD	SD	Sig.
deval-vacija	nizko tveganje	nevarno pitje	-1.196*	0.478	0.013
		odvisnost	-1.262*	0.458	0.006
disoci-acija	škodljivo pitje	nizko tveganje	3.542*	1.230	0.004

		nevarno pitje	3.224*	1.302	0.014
razcep	odvisnost	odvisnost	3.355*	1.296	0.010
		nizko tveganje	1.764*	0.536	0.001
Racio-nalizacija	odvisnost	nizko tveganje	-1.558*	0.429	0.000
		nevarno pitje	-1.437*	0.565	0.011

Opombe:* razlika je pomembna z 0.05% tveganjem, MD – razlika med aritmetičnimi sredinami; SD – standardni odklon.

Nadaljnja analiza korelacij nezrelih obrambnih mehanizmov, za katere smo dokazali razlike, z izkušnjami iz izvorne družine pa je pokazala nekatere statistično pomembne povezave (glej Tabela 3). Ugotavljamo, da hipoteze o tem, da se neugodne izkušnje iz izvorne družine pozitivno povezujejo s pogostostjo uporabe nezrelih obrambnih mehanizmov ne moremo v celotni potrditi. Poleg pozitivnih povezav med nezrelimi obrambnimi mehanizmi in neugodnimi izkušnjami iz izvorne družine (npr. devalvacija in razcep se pomembno statistično pozitivno povezujeta z zlorabo substanc v izvorni družini), ugotavljamo tudi nekatere pozitivne povezave med nezrelimi obrambnimi mehanizmi in ugodnimi izkušnjami iz izvorne družine (npr. racionalizacija se pomembno statistično pozitivno povezuje z pozitivnim vzdušjem in vzajemnostjo v izvorni družini) in nekatere negativne povezave med obrambnimi mehanizmi in neugodnimi izkušnjami iz izvorne družine (npr. devalvacija se statistično pomembno negativno povezuje s fizičnim zanemarjanjem in psihičnim nasiljem v izvorni družini).

Tabela 3: Korelacije med obrambnimi mehanizmi in izkušnjami iz izvorne družine

	DSQ				
	deval-vacija	disoci-acija	razcep	racio-naliza-cija	SKU AJ
ACE-IQ čustveno zanemar.	-0.050	-0.048	-0.061	0.022	-.114*
fizično zanemar.	-.133**	-0.036	-0.033	0.031	-0.088
družinsko nas.	-0.049	-0.036	-0.028	0.026	-.113*
psihično nasilje	-.098*	-0.058	-0.023	0.045	-.133**
fizična zloraba	0.021	-0.040	0.035	-0.068	-0.018
spolna zloraba	0.048	-0.025	0.074	-0.003	0.013
STIC-FOO	-0.045	-0.078	-0.032	.105*	-.176**
pozitivno vzdušje	-0.024	-0.011	0.034	.119*	0,080
negativno vzdušje	0.082	.098*	0.046	-0.059	.212**
vzajem-nost	0.027	-0.009	-0.009	.183**	-0.071
zloraba	-0.001	.114*	0.021	-0.001	.137**
vsiljivost	0.008	0.020	0.093	-.102*	.219**
zloraba substanc	.107*	0.093	.110*	-0.054	.182**

Opombe: * pomembnost na nivoju 0,05; ** pomembnost na nivoju 0,01; DSQ - lestvice obrambnih mehanizmov; ACE-IQ - lestvice negativnih izkušenj v otroštvu; STIC-FOO lestvica izvorne družine vprašalnika STIC.

5 RAZPRAVA

Tako kot predhodne raziskave [10,11], tudi predstavljeni rezultati potrjujejo razlike v uporabi nezrelih obrambnih mehanizmov med osebami z odvisniškim vedenjem in med osebami z nizkim tveganjem uporabe alkohola. Razlike so se pokazale le pri nekaterih nezrelih obrambnih mehanizmih (devalvacija, disociacija, razcep in racionalizacija), medtem ko za ostale ne moremo dokazati statistično pomembnih razlik glede na stopnjo tveganega uživanja alkohola. Tako ugotavljamo, da osebe z večjo stopnjo tveganega uživanja alkohola bolj pogosto uporabljajo obrambni mehanizme devalvacije pri obrambni pred nezaželenimi čustvenimi doživljanji oziroma tesnobo. Devalvacija je obrambni mehanizem, ki vključuje zanikanje pomembnosti nečesa ali nekoga, vključno s samim seboj [12]. V povezavi s tveganim uživanjem alkohola lahko predvidevamo, da osebe z bolj tveganim vedenjem svojo tesnobo bolj pogosto poskušajo umiriti z razvrednotenjem odnosov, v katere so vključeni in tudi z razvrednotenjem samega sebe. Devalvacija pa je lahko tako posledica odvisnega vedenja ali pa izvor le tega. Relacijska paradigma devalvacijo razume kot posledico prekinitve stika [19] oziroma kot nezadovoljene relacijske potrebe [20], ko se posameznik zaradi pretirane tesnobe v odnosu zateče v doživljanje razvrednotenja. Ugotavljamo tudi, da skupina s škodljivim pitjem alkohola bolj pogosto doživlja disociacijo od vseh ostalih skupin (tudi od skupine visokega tveganja oziroma odvisnost). Disociacija je obrambni mehanizem kjer se nasprotujoči se impulzi razcepijo oziroma se ogrožajoči občutki ločijo od ostalega psihičnega doživljanja [12] in iz rezultatov lahko predvidevamo, da je najbolj ogrožajoča za razvoj škodljivega pitja alkohola, ne pa tudi odvisnosti. Razcep pomeni delitev doživljanja v skrajno dobrega ali negativnega in racionalizacija pomeni dajanje racionalnih razlogov nesprejemljivemu doživljanju [12] in rezultati kažejo, da je bolj pogost pri osebah z odvisnostjo kot pri osebah z nizkim tveganjem pitja alkohola. Racionalizacija pa se glede na rezultate bolj pogosto povezuje z nižjim tveganjem pitja alkohola, saj osebe z nižjim tveganjem dosegajo statistično pomembno višje rezultate od skupine z odvisnostjo. Racionalizacij kot iskanje logičnih razlogov za utemeljitev nesprejemljivega vedenja [12] se tako kaže kot najbolj pogost obrambni mehanizem škodljivega pitja alkohola.

Korelacije v raziskavi pa kažejo na povezavo teh obrambnih mehanizmov z izkušnjami iz izvorne družine. Zloraba substanc v izvorni družini se pozitivno povezuje z pogostostjo uporabe devalvacije in razcepa v odraslosti. Tako lahko predvidevamo,

da izkušnja odvisnosti v izvorni družini predstavlja dejavnik za doživljanje devalvacije in razcepa. Z razvrednotenjem drugih ali samega sebe ali pa s skrajnim doživljanjem se otrok v ranljivem obdobju zaščiti pred psihično bolečino. Kasneje pa ta nezrela obrambna mehanizma lahko omogočata tudi razvoj tveganega vedenja. Prav tako ugotavljamo, da se izkušnja zlorabe in negativno vzdušje v izvorni družini pozitivno povezuje z uporabo disociacije kot obrambnega mehanizma, ter da se vsiljivost v izvorni družini pozitivno povezuje z racionalizacijo. Že predhodne raziskave so potrdite povezavo med nezrelimi obrambnimi mehanizmi in odvisnostjo [11] ter povezavo med neugodnimi izkušnjami izvorne družine in nezrelimi obrambnimi mehanizmi [10]. Tudi na podlagi ugotovitev te raziskave pa lahko to povezavo z uporabo nezrelih obrambnih mehanizmov. Predvidevamo, da neugodne izkušnje iz izvorne družine omogočijo pogoje za nezrele obrambne mehanizme, ki zaradi svoje narave kasneje v razvoju vodijo v nefunkcionalne oblike vedenje, tudi v tvegano uživanje alkohola. Našteti obrambni mehanizmi predstavljajo načine ublažitve tesnobe in jih lahko povezujemo s tveganim vedenjem, saj so največkrat nezavedni, rigidni in omejujemo sposobnost odločanja [8].

Dejstvo, da se nekateri nezreli obrambni mehanizmi povezujejo s pozitivni izkušnjami iz izvorne družine in da se tudi negativno povezujejo z neugodnimi izkušnjami iz izvorne družine, pa kaže na možnost, da se nekateri obrambni mehanizmi niso učinkoviti v zaščiti pred psihično bolečino. Negativna povezava med fizičnim zanemarjanjem in psihičnim nasiljem v izvorni družini in uporabo devalvacije, namreč kaže na možnost, da te izkušnje zmanjšajo uporabo tega nezrelega obrambnega mehanizma. Za dokazovanje te povezave pa bi bile potrebne nadaljnje raziskave, ki bi že bolj neposredno preučevale povezave med izkušnjami iz izvorne družine in tveganim uživanjem alkohola.

Rezultati dajejo poglobljeno razumevanje dinamike tveganega pitja alkohola v povezavi z obrambnimi mehanizmi. Delo z obrambnimi mehanizmi pri obravnavi tveganega uživanja alkohola je tako lahko ključno v procesu okrevanja. Raziskave kažejo, da udeleženci terapije, ki tekom terapije izboljšajo terapevtsko zavezništvo pomembno zmanjšajo tudi uporabo nezrelih obrambnih mehanizmov [8], kar pomeni da je lahko prav terapevtski odnos pomemben pri obravnavi tveganega uživanja alkohola. Načine dela z obrambnimi mehanizmi pri obravnavi oseb s tveganim pitjem alkohola bi bilo potrebno dodatno raziskati in njihovo učinkovitost preverjati s primernimi raziskovalnimi metodami.

ZAHVALA

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REFERENCES

[1] Helena Koprivnikar, Maja Zorko, Andreja Drev, Marjetka Hovnik Keršmanc, Ines Kvaternik, Mirna Macur. 2015. *Uporaba tobaka, alkohola in prepovedanih drog med prebivalci Slovenije ter neenakosti in kombinacije te uporabe*. Nacionalni inštitut za javno zdravje, Ljubljana.

[2] Mednarodna klasifikacija bolezni in sorodnih zdravstvenih problemov za statistične namene. Avstralska modifikacija (MKB-10-AM). 2013. *Pregledni seznam bolezni*. Nacionalni inštitut za javno zdravje, Ljubljana.

[3] Edward J. Khantzian. 2014. The Self-Medication Hypothesis and attachment theory: pathways for understanding and ameliorating addictive suffering. In: Gill R, editor. *Addictions from an attachment perspective Do broken bonds and early trauma lead to addictive behaviours?* Karnac Books Ltd, London, 33–56.

[4] Harold C. Urschel. 2009. *Healing the addicted brain*. Sourcebooks, Inc., Naperville, Illinois.

[5] Michael D. De Bellis. 2002. Developmental traumatology: A contributory mechanism for alcohol and substance use disorders. *Psychoneuroendocrinology*. 27, 1–2, 155–70. https://doi.org/10.1016/S0306-4530(01)00042-7

[6] Jason Wright. 2014. Addiction: treatment and its context. In: Gill R, editor. *Addictions from an attachment perspective Do broken bonds and early trauma lead to addictive behaviours?* Karnac Books Ltd, London, 11–32.

[7] Arlene Vetere. 2014. Alcohol misuse, attachment dilemmas, and triangles of interaction: a systemic approach to practice. In: Gill R, editor. *Addictions from an attachment perspective Do broken bonds and early trauma lead to addictive behaviours?* Karnac Books Ltd, London, 57–68.

[8] Gilles Ambresin, Yves de Roten, Martin Drapeau, Jean Nicolas Despland. 2007. Early change in maladaptive defence style and development of therapeutic alliance. *Clin Psychol Psychother*. 14, 2, 89–95. https://psycnet.apa.org/doi/10.1002/cpp.521

[9] Raffaella Calati, Osmano Oasi, Diana De Ronchi, Alessandro Serretti. 2010. The use of the defence style questionnaire in major depressive and panic disorders: A comprehensive meta-analysis. *Psychol Psychother Theory, Res Pract.* 83, 1, 1–13. https://doi.org/10.1348/147608309x464206

[10] Cuneyt Evren, Serap Ozcetinkaya, Muge Ulku, Dilara Cagil, Peykan Gokalp, Turan Cetin, Sera Yigiter. 2012. Relationship of defense styles with history of childhood trauma and personality in heroin dependent inpatients. *Psychiatry Res*. 200, 2–3, 728–33. https://doi.org/10.1016/j.psychres.2012.07.026

[11] Pranami Barua, Maitrayee Dutta, Ranjan Kumar. 2016. Defense mechanism and coping styles in individuals with psychoactive substance use disorders and controls : A comparative study. *Indian Journal of Health and Wellbeing*. 7, 5, 505–9.

[12] Christopher Perry, Steven Cooper. 1989. An empirical study of defense mechanisms: I. Clinical interview and life vignette ratings. *Arch Gen Psychiatry*. 46, 5, 444–452. https://doi.org/10.1001/archpsyc.1989.01810050058010

[13] Gavin Andrews, Michelle Singh, Michael Andrews Bond. 1993. The Defense Style Questionnaire. *Journal of Nervous and Mental Disease*. 181, 4, 246–256. https://doi.org/10.1097/00005053-199304000-00006

[14] Mark E. Cummings, Julia M.Braungart-Rieker, Tina Du Rocher-Schudlich. 2003. Emotion and Personality Development in Childhood. In: Lerner RM, Easterbrooks MA, Mistry J, editors. *Handbook of psychology*. John Wiley & Sons, Inc., New Jersey, 211–40.

[15] James J. Gross. 2008. Emotional Regulation. In: Lewis M, Haviland-Jones JM, Feldman Barrett L, editors. *Handbook of Emotion*. 3rd ed. The Guilford Press, New York, 497–512.

[16] Allan N. Schore. 2012. *The science of the art of psychotherapy*. W. W. Norton & Company, New York.

[17] John B.Saunders, Olaf G.Aasland, Thomas F. Babor, Juan De La Fuente, Marcus Grant. 1993. Development of the alcohol use disorders identification test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption-II. *Addiction*. 88, 6, 791–804. https://doi.org/10.1111/j.1360-0443.1993.tb02093.x

[18] William M.Pinsof, Richard E. Zinbarg, Jay L. Lebow, Lynne Marie Knobloch-Fedders, Emily Durbin, Anthony Chambers, Tara Latta, Eli Karam, Jacob Goldsmith Greg Friedman. 2009. Laying the foundation for progress research in family, couple, and individual therapy: The development and psychometric features of the initial systemic therapy inventory of change. *Psychotherapy Research*. 9, 2, 143–56. https://doi.org/10.1080/10503300802669973

[19] Allan N. Schore. 2001. Effects of a secure attachment relationship on right brain development, affect regulation, and infant mental health. *Infant Mental Health Journal*. 22, 1–2, 7–66. https://psycnet.apa.org/doi/10.1002/1097-0355(200101/04)22:1%3C7::AID-IMHJ2%3E3.0.CO;2-N

[20] Richard G. Erskine, Jenet P. Moursund, Rebeca L. Trautmann. 1999. *Beyond empathy: A therapy of contact-in-relationship*. Brunner/Mazel, Philadelphia.

Zasvojenosti v odraslosti v povezavi z zlorabami v otroštvu

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POVZETEK

Travmatične izkušnje zlorabe v zgodnjem otroštvu nedvomno povečujejo možnost, da bodo te osebe v odraslosti razvile katero zasvojenost, saj zgodnja travma podpira neustrezno čustveno regulacijo in regulacijo avtonomnega živčnega sistema. V tem kontekstu imamo v mislih t. i. odvisne možgane, ki ves čas iščejo način, kako bi dosegli regulacijo, stabilnost in pomiritev (amigdale) [1]. V teoretičnem prispevku bomo najprej predstavili glavne komponente, ki so značilne za vsako zasvojenost ter nadaljevali z opisom stopenj, v katerih se izmenjuje dinamika sramu s fazo izživljanja in fazo zadrževanja. Za lažje razumevanje, zakaj se zlorabljeni največkrat vedno znova vrtijo v začaranem krogu sramu, strahu, gnusa, jeze in podobnih težkih čutenj, ki spominjajo na izvorno zlorabo, bomo osvetlili dinamiko kompulzivnega ponavljanja v kontekstu kemično-hormonske zasvojenosti. Pogoj za prekinitev zasvojenosti je popolna abstinenca in razreševanje psihičnih stisk, zaradi katerih je zasvojeni vedno znova posegel po zasvojenosti, da je zapolnil čustveno praznino.

KLJUČNE BESEDE: zasvojenost, zloraba, kompulzivno ponavljanje, regulacija afekta.

Abstract: Traumatic experiences of abuse in early childhood undoubtedly increase the possibility that these individuals will develop an addiction in adulthood, as early trauma supports inadequate emotional regulation and regulation of the autonomic nervous system. In this context, we mean so called dependent brain that is constantly looking for a way to achieve regulation, stability and reassurance (amygdala) [1]. In the theoretical contribution, we will first present the main components that are characteristic of each addiction and continue with a description of the stages in which the dynamics of shame alternate with the phase of experiencing and the phase of retention. In order to better understand why the abused often turn again and again in a vicious circle of shame, fear, disgust, anger and similar difficult feelings that remind of the original abuse, we will shed light on the dynamics of repetition compulsion in the context of chemical-hormonal addiction. The condition for breaking the addiction is total abstinence and the resolution of the psychological distress that caused the addict to reach for the addiction again and again to fill the emotional emptiness.

Key words: addiction, abuse, repetition compulsion, affect regulation.

Doseženi rezultati so nastali v okviru projekta št. J5-2570, ki ga je financirala Javna agencija za raziskovalno dejavnost RS iz državnega proračuna.

1 KDAJ GOVORIMO O ZASVOJENOSTI?

Zasvojenost je način bega, iskanja sprostitve, varnosti in nadzora. Otopi bolečine in močne občutke, potlači spomine, ki niso sprejemljivi, in je lahko eden od načinov, kako preživeti s posledicami travme, kot je tudi zloraba [2]. Raziskava narejena v Sloveniji [3] kaže, da je bilo med vključenimi 18% spolno zlorabljenih, povprečno vsaka šesta oseba. Od tega 19% žensk (približno vsaka peta) in 15% moških (približno vsak sedmi).
Različni avtorji [4, 5, 6, 7] različno definirajo zasvojenosti, vsem opisom pa je skupnih pet komponent:

1. Nadaljevanje zasvojitvene aktivnosti ali vedenja ne glede na negativne posledice.
2. Preokupacija oziroma obsesija z zasvojitveno aktivnostjo, substanco ali vedenjem.
3. Zasvojeni nima nadzora nad zasvojitveno aktivnostjo, substanco ali vedenjem, ampak ravno obratno – zasvojenost ima nadzor nad njim.
4. Nivo tolerance se spreminja: za isti učinek je potrebna vedno večja doza.
5. Abstinenčna kriza oz. simptomi umika. Če oseba ne dobi ustrezne doze, se pojavijo psihični in telesni simptomi (tesnoba, nemir, nespečnost, strah, jeza, …), ki največkrat ponovno vodijo v zasvojitveno aktivnost ali vedenje, ki pomiri posameznika. Bolj kot se zasvojeni trudi, da bi abstiniral, hujše postajajo njegove težave.

Zasvojenost je tako psihična kot organska. Na organskem nivoju govorimo o kemični in hormonski zasvojenosti, na psihičnem nivoju pa predstavlja nesposobnost posameznika, da bi reguliral težka čustva, hkrati pa tudi nesposobnost, da bi vzpostavil pristne odnose z drugimi [8].

Smith [9] opredeli zasvojenost kot kompleksno kronično bolezen možganov v področjih, ki ustvarjajo občutke nagrade, motivacije in spomina, z možnimi recidivi, kar predpostavlja, da je bolnik vedno v nevarnosti, saj se pričakuje, da se bo bolezen ponovila. Vsaka zloraba

zasvojitvenih substanc vedno aktivira isto nevronsko pot – dopaminski mezolimbični center za nagrajevanje [10] in nevarno spreminja delovanje možganov, dolgoročno pa povzroči velike spremembe v strukturi in delovanju možganov, ki zmanjšujejo zavestni nadzor [11]. Podobno kot pri drugih kroničnih boleznih, tudi zasvojenost pogosto vključuje cikluse zdrsov nazaj v zasvojenost (faza recidiva) in remisije bolezni (faza abstinence). Če ne pride do zdravljena in posameznik ni vključen v proces okrevanja, postane zasvojenost progresivna in lahko povzroči trajne posledice ali prezgodnjo smrt [12].
Številni avtorji [13, 14, 15, 16] se strinjajo, da travmatične izkušnje iz otroštva in mehanizmi spoprijemanja s travmatičnimi situacijami, ki so zaznamovale posameznika, lahko vodijo v zasvojenost.

2 STOPNJE VSAKE ZASVOJENOSTI

Zasvojenost se ne zgodi čez noč, ampak pot do nje traja tudi več let, z vsemi izkušnjami, ki jih posameznik doživlja in odnosi, ki ga oblikujejo. Bradshaw [17] opisuje stopnje, cikel vsake zasvojenosti.

1. Cikel se začne, ko se v notranjosti posameznika začne ustvarjati in naraščati čustven pritisk. Zasvojeni začne razmišljati o svoji zasvojenosti.
2. Nekaj se zgodi, kar še dodatno izzove zasvojitveno (npr. kak konflikt).
3. Notranji pritisk postane tako neznosen, da zasvojeni teh občutij ne zmore več prenašati in poseže po substanci ali obnašanju (npr. zlorabi nekoga ali se pusti zlorabiti). S tem dejanjem pomiri čustva in zapolni praznino, utiša bolečino, ki bi jo sicer čutil.
4. Zaključni del te stopnje je, ko je oseba, zasvojeni, popustil, se predal substanci, nekemu vedenju in začne ob tem čutiti krivdo, nizko samopodobo, sram, strah ... Na tej stopnji lahko zasvojeni celo začuti, da ga je sram, in obljublja, da tega ne bo nikoli več počel, se bo opravičeval.
5. Obstaja možnost, da bi lahko prišlo do intervencije. Zasvojeni največkrat spozna, da vsa hrana, droge, alkohol, pornografija ali katero drugo vedenje (npr. zlorabljanje), do katerega pride, ker mora utišati, pomiriti pritisk čustev, ne pomaga in ni prava rešitev za probleme. Ob tem lahko pride do spoznanja in ukrepanja, da začne pravo rešitev iskati drugje. Nekateri zasvojeni zelo hitro dosežejo ta nivo, pridejo do tega spoznanja, drugi lahko porabijo večino življenja, da naredijo spremembo in se začnejo zdraviti, tretji pa tega ne storijo nikoli in lahko celo umrejo zaradi zasvojitvene substance (npr. zbolijo zaradi alkohola, vzamejo prekomeren odmerek droge ...).

V tem kontekstu Fossum in Mason [18] govorita o notranji izkušnji sramu pri zasvojeni osebi, ki jo imenujeta »ciklus sramu«. Zasvojeni se izmenično gibljejo od ene skrajnosti k drugi, kar pa izhaja najpogosteje iz izvirne družine, kjer so kot otroci morali »delati vse prav«, skušali doseči nemogoče, da bi le izpolnili potrebe in zahteve staršev, vendar je bila kljub temu ljubezen do otrok pogojevana. Otroci so tako potlačili svoje želje in potrebe, ki pa kasneje v življenju silijo na površje prek raznih oblik izživljanja ali acting out-a (npr. kompulzivnost glede seksualnosti, hrane, alkohola, drog, zapravljanja, tveganja in dela …). Na ta način se sprosti napetost, ublaži bolečina in občutek prikrajšanosti za osnovne življenjske potrebe. Zasvojenega v trenutku olajšanja njegovo vedenje popolnoma prevzame, kar onemogoči njegovo sposobnost presojanja. V večini primerov se takrat pojavijo sram, razočaranje in občutek izgubljenosti ter ničvrednosti. Ko izgubi nadzor nad svojim vedenjem, se zasvojeni trudi, da bi ga spet vzpostavil. To počne na vse mogoče načine, ki predstavljajo drugo skrajnost zasvojitvenega vedenja. Faza se imenuje acting in (npr. kompulzivnost glede diet, varčevanja, izogibanja seksualnosti, nagibanja k religiji, abstinence) – to je faza nadzora.

Dejstvo je, da zasvojeni ni v stiku s tem, kar je resnično, ali bolje rečeno s svojo bolečino, kadar se preda, popusti zasvojitveni substanci ali vedenju. Podobno je bilo med zlorabo, ko sta se telo in psiha zavarovala pred bolečino tako, da je prišlo do odklopa, disociacije, sicer kot otrok ne bi preživel vseh stisk [2, 19]. Zasvojenost mu vedno bolj škoduje in mu le začasno zapolni praznino, ki je v njegovi notranjosti. Zdržati z vsemi intenzivnimi občutki, ki prihajajo na dan, s sindromi umika, pa je za zasvojenega največja groza, a edini izhod na pot do okrevanja [19].

3 ZASVOJENOST KOT ANASTEZIJA ALI REGULACIJA AFEKTA

Knauer [6] v povezavi z zasvojenostjo uporablja izraz anestezija, s katerim opisuje načine oziroma sredstva, ki jih uporabljajo osebe, ki so preživele zlorabo, da lahko funkcionirajo iz dneva v dan s čustveno, včasih celo fizično bolečino. Nekateri so navzven zelo funkcionalni in bodo opravljali vsa mogoča dela, bili odgovorni za ogromno nalog in zadolžitev, lahko bi celo rekli, da bodo zasvojeni z delom, da le preusmerijo in ublažijo bolečine ali le misli na zlorabo. Drugi bodo padli v depresijo in bodo brez volje, motivacije in energije, da bi kaj naredili. Prespali bodo cele dneve, se tolažili s hrano in odpovedovali na vseh področjih. Tako eni kot drugi bodo potrebovali ogromno energije in moči, da bodo zadrževali oziroma prikrivali bes in nemoč, ki sta med drugim posledica zlorabe. Avtorica govori o več vrstah anestezije, vsem pa je skupno, da je žrtev, kadar koli se zaplete v neko vedenje, tako prevzeta, prav kot suženj gnana od te anestezije, da bi lahko celo rekli, da je v stanju, ki je zelo podobno transu, ki ga povzroči hipnoza. Različne osebe se bodo različno vedle, da bi si olajšale bolečino zlorabe.
Namen anestezije je preusmeritev, odvrnitev pozornosti, žarišča bolečine zlorabe. Načinov, kako žrtve omamijo bolečino zlorabe, je toliko, kolikor je načinov zlorabljanja.

Čeprav poznamo razne oblike zasvojenosti, pa je skupni imenovalec vsem, da služijo zelo podobnim namenom – regulaciji neznosnih psihobioloških stanj v človeku, ki so lahko posledica doživete zlorabe v otroštvu [20]. Zasvojenost dejansko predstavljajo kompulzivno iskanje rešitve preko ponavljanja določenih vzorcev vedenja, razmišljanja, čutenja in v svojem najglobljem bistvu pomenijo hrepenenje po razrešitvi strahu in groze, praznine, negotovosti, pomanjkanja samozavesti in samospoštovanja. Gre za globoko željo po odnosu in hkrati grozo pred njim, pred čemer se posameznik umika v odvisnost, ki kljub svoji destruktivnosti, vseeno prinaša iluzijo varnosti pred občutki izničenja [19]. Težko je

razumeti, zakaj globoko ranjeni ljudje največkrat ponavljajo prav tisto, kar jih še bolj prizadene in rani. Odgovor bi lahko iskali tudi v kemično-hormonski dinamiki zasvojenosti, ki je pri osebah z zgodovino zlorabe lahko zelo močno prisotna.

4 KEMIČNO-HORMONSKA ZASVOJENOST IN KOMPULZIVNO PONAVLJANJE

Nihče ne ponavlja istih vzorcev zato, ker bi se zaradi njih dobro počutil, ampak zato, ker ne zna, ne more ali še ne želi drugačne poti, ki je največkrat težja. Ponavljati domače, poznano in staro pomeni »cono udobja«, čeprav se lahko posameznih pritožuje nad svojim življenjem. Narediti novo, drugače pa je tveganje in strah pred spremembo [2].

4.1 Psihološka razlaga kompulzivnega ponavljanja

Zelo pomembno je razumeti, da je ponavljanje pretekle travme prek vseh možnih simptomov (npr. motnje hranjenja, konfliktni odnosi, psihosomatika, nasilje, zasvojenosti ...) za travmirane ljudi prisila. Četudi si zavestno želijo potlačiti ta spomin, v njihovi psihi obstaja nasprotna potreba po ozaveščanju potlačenih vsebin. Na ta način se potlačene in razcepljene izkušnje pojavljajo v novi situaciji na nov način. Chu [21] je to potrebo po ponavljanju celo primerjal z biološko potrebo po mokrenju, ki je, ko se pojavi, tako nujna, da človek razmišlja le še o tem, kako bi čim prej lahko pomiril telo in uriniral. Podobno bo tisti, ki ga ženejo afekti, povezani s spolno zlorabo, tako dolgo iskal situacijo, osebo, vzdušje, da bo sprostil to napetost v telesu. Podobne intervale je zlorabljena oseba doživljala ob tistem, ki je zlorabljal. Potem ko je spolno zlorabil, se je vsaj za nekaj časa umaknil in je morda za žrtev to pomenilo edino mirno obdobje, ki pa se je seveda končalo, ko se je storilec ponovno približal in ponovil zlorabo. Zloraba gre lahko celo tako daleč, da spremeni kemično-hormonski sistem zlorabljene osebe in potem ta znova in znova nezavedno išče oziroma se zapleta v odnose, v katerih se ponovi zloraba [2, 19]. Lahko bi rekli, da so te osebe dobesedno zvezane oziroma zavezane preteklosti in ti travmatični dogodki oziroma vzdušja in afekti, ki izhajajo iz teh travm, nenehno oblikujejo njihovo sedanjost. To se dogaja s tako močjo, da travmirane osebe doživljajo, kot da nimajo izbire, da se jim preteklost enostavno samo ponavlja [22, 23]. Ponavljanje starega je nezavedno edino privlačno, poznano, domače, vendar vsakič z upanjem in željo, da se zloraba ne bi ponovila, ampak da bi prišlo do nečesa novega, do razrešitve in odrešenja – da bi dobili tisto pravo varnost, spoštovanje in ljubezen, ki so jih vedno pogrešali [24].

Da novo vedenje postane avtomatično, je potrebnih vsaj tisoč ponovitev vedenja. Na nevroplastičnost možganov (vseživljenjske zmožnosti možganov, da na podlagi novih izkušenj prerazporejajo nevronske poti), lahko posameznik deluje na različne načine: z novimi izkušnjami, novim učenjem, spreminjanjem starih spominov z novimi informacijami. Najbolj pa so pomembne nove čustvene izkušnje, kot so osebni in varni odnosi (partnerski, terapevtski, prijateljski) in psihoterapija, saj le-ti močno olajša kreacijo novih nevronskih povezav in pripomorejo k celjenju travmatičnih izkušenj in k spreminjanju strukture in funkcij možganov [25].

4.2 Biokemična razlaga kompulzivnega ponavljanja

Biokemična razlaga kompulzivnega ponavljanja [19, 26] pa temu dodaja še zasvojitvene hormone, ki se sproščajo med samo travmo zlorabe. Ko pride do travmatičnega dogodka, nevrotransmiterja epinerfin in kortizol sprožita alarmni sistem telesa. Istočasno se možgani odzovejo s povečano količino nevrotransmiterjev norepinerfina in endorfina v korteksu in limbičnem sistemu. Norepinerfin opozori možgane na krizo in korteks začne iskati najboljši odziv. Približno trideset sekund kasneje, ko se sprosti norepinerfin, možgani poženejo v tek endorfine, ki na osebo delujejo pomiritveno in sprostitveno.
Endorfini imajo 2 vlogi:
1. omogočajo jasnejše mišljenje in pomnjenje ter usposobijo osebo, da ostane mirna, in
2. delujejo kot analgetik ali sredstvo proti bolečinam. Ko so osebe v šoku, ne čutijo bolečine. Ta šok je lahko prometna nesreča, izguba uda, fizične zlorabe, spolne zlorabe ali kaki drugi močni stresi. Bolečina se običajno pojavi šele potem, ko je boleča, vznemirjujoča situacija že mimo. Ko prvi šok mine, se, gledano z biokemičnega stališča, količina norepinerfina, endorfinov in serotonina zmanjša in pojavijo se simptomi umikanja, kot npr. depresija in občutek nemoči. Dolgotrajen stres ali ponavljajoča se travma lahko povzroči umik vase, ki je podoben tistemu, kakršnega povzroča opij (zanj je značilna raztresenost, vznemirjenost, šibko tresenje celega telesa itd.). To pa lahko pripelje do kompulzivnega ponavljanja in drugih oblik zasvojenosti. PTSD ali ponavljajoča se zloraba lahko dokončno ali trajno spremeni limbični sistem. Temu simptomu pravimo ponovno prižiganje. Ko se pojavijo simptomi umika, se mnoge žrtve prestrašijo, s čimer ponovno povzročijo povišanje količine norepinerfina, pojavi se ponovno prižiganje in žrtev začne spet doživljati začetne fizične in vsiljene simptome. Tako se krog sklene in kompulzivno ponavlja [2].

Na tak način lahko postane nekdo, ki je žrtev hudih travm, zasvojen s temi hormoni ter prav zaradi ugodja zasvojenosti, ki ga nudijo hormoni, ko se sprostijo, se težko odreče pravi adrenalinski privlačnosti iskanja novih situacij in okoliščin, kjer se travma ali le vzdušje lahko ponovi. Tovrstna zasvojenost je podobna zasvojenosti z alkoholom ali mamili [27].

5 ZAKLJUČEK

Zlorabe v otroštvu vsekakor predstavljajo poseben dejavnik tveganja za zasvojenosti v odraslosti, saj se ob uživanju substanc ali kompulzivnem ponavljanju določenega vedenja, sproža izločanje velikih količin dopamina, kar posledično prinaša občutke ugodja, pomiritve in užitka.
Klinična praksa, pa tudi raziskave [20] kažejo, da ne glede na to, kakšno vrsto zlorabe so doživeli posamezniki kot otroci ali mladostniki, so v zgodnji odrasli dobi (med 18.

in 25. letom) nagnjeni k večjemu tveganju, da bodo zlorabljali psihoaktivne snovi, in sicer ne le eno, ampak celo več vrst kot njihovi nezlorabljeni vrstniki. Pri kemičnih zasvojenostih gre najpogosteje za zlorabo alkohola, nikotina in kanabisa, pri nekemičnih pa za zasvojenost z odnosi, s hrano, z igrami na srečo, s spolnostjo ter raznimi oblikami nasilja in avotdestrukcije (npr. samopoškodovanjem). Na podobna spoznanja kažejo tudi izkušnje tistih, ki so bili v otroštvu zanemarjeni.

V raziskavi mladostnic [28] se je izkazalo, da so imele spolno zlorabljene ženske 1,65-krat večjo verjetnost uživanja alkohola, 1,48-krat večjo verjetnost uživanja marihuane in 1,50-krat večjo verjetnost uživanja drugih drog kot nikoli spolno zlorabljene ženske. Podobno Hannan s sodelavci [29] meni, da je prav zaradi velike verjetnosti, da bodo spolno zlorabljene ženske doživele v adolescenci reviktimizacijo ali simptome PTSM, bistveno povečana možnost zlorabe alkohola kot načina regulacije težkih čutenj.

Oseba, ki je bila zlorabljena in se sooča s stiskami, se psihično in organsko pomiri, ko poseže po zasvojitveni substanci ali vedenju. Zasvojenost postane način regulacije bolečih in nepredelanih težkih čutenj iz zlorabe, kot so sram, gnus, strah, jeza, krivda, … Ko ni zadostnega vnosa substance, ponavljajočega vedenja, pride do odtegnitvenega sindroma (t. i. abstinenčne krize), ko se še posebej v visceralnih organih sprožajo boleče telesne senzacije [23]. Čeprav se stopnje zasvojenosti lahko vedno znova ponavljajo v začaranih krogih, pa je možna prekinitev in izhod ter začetek nove poti – zdravljenje. Pri takih odločitvah je nujna strokovna pomoč, ničla toleranca oziroma popolna abstinenca, po kateri je zelo zaželena terapija, kjer oseba, ki je (bila) zasvojena, na čustvenem področju razreši travmo iz preteklosti in s pomočjo terapevtskega odnosa in novih izkušenj začne živeti drugačno življenje – brez zasvojenosti.

REFERENCE

[1] R. Scaer. *8 Keys to Brain-body Balance.* New York: W. W. Norton & Company. 2012.

[2] T. Repič. *Nemim kriki spolne zlorabe in novo upanje*. Celjska Mohorjeva družba. 2015.

[3] T. Repič. Avtonomija in intimnost v družini kot dejavnika tveganja za spolno zlorabo. *Psihološka obzorja* št.15, 1:111-125. 2006.

[4] P. J. Carnes, D. L. Delmonico, E. Griffin in J. M. Moriarity. *V senci interneta.* Ljubljana: Modrijan založba d.o.o. 2010.

[5] R. Holman Coombs in W. A. Howatt. *The addiction counselor's desk reference*. New York, US: Wiley & Sons. 2005.

[6] S. Knauer. *Recovering from sexual abuse, addictions, and compulsive behaviors: "Numb" survivors.* New York, NY: Haworth Press. 2002.

[7] P. Topić. *Zasvojenost s seksualnostjo v digitalni dobi*. Maribor: Založba Pivec. 2015.

[8] C. Gostečnik, T. Repič, M. Cvetek in R. Cvetek. Hidden Mission of the Psyche in Abuse and Addiction. *Journal of Religion and Health* 49:361-376. 2010.

[9] D. E. Smith. 2012. "Editor's note: The process addictions and the new ASAM definition of addiction." *Journal of Psychoactive Drugs* 44, št.1:1-4. 2012.

[10] L. Šprah. *"Možgani-droge-odvisnost."* 2006. accessed 24.06.2022. http://www.sinapsa.org/rm/file.php?id=37&db=tm_priponke.

[11] B. J. Everitt in T. W. Robbins. "Neural Systems of reinforcment for drug addiction: From actions to habits to complusion." *Nature Neurosience* 8, št. 11:1481-1489. 2005.

[12] American Society of Addiction Medicine (ASAM). 2011. *"ASAM releases new definition of addiction."* accessed 1. 8. 2012. https://www.asam.org/docs/pressreleases/asam-definition-of-addiction-2011-08-15.pdf.

[13] R. Holman Coombs, ed. *Handbook of addictive disorders: A practical guide to diagnosis and treatment.* New Jersey: John Wiley & Sons. 2004.

[14] M. Herkov, Michael. *"What is sexual addiction."* Psych Central. 2018. accessed 31. januarja 2020. https://psychcentral.com/lib/what-is-sexual-addiction/.

[15] G. Maté. *Ko telo reče ne. Skriti stres terja davek.* Brežice: Primus. 2019.

[16] R. West. *"Prime theory of motivation and its application to addiction."* SSA Annual Conference, York, London. 2006.

[17] J. Bradshaw. *Bradshaw on: The family. A new way of creating solid self-esteem.* Deerfield Beach, FL: Health Communications. 1996.

[18] M. A. Fossum. in J. M. Marilyn. *Facing shame: Families in recovery.* New York: W. W. Norton & Company. 1986.

[19] C. Gostečnik. *Nevroznanost in relacijska družinska terapija.* Ljubljana: Brat Frančišek in Frančiškanski družinski inštitut. 2021.

[20] G. Buljan-Flander in D. Kocijan-Hercigonja. *Zlostavljanje i zanemarivanje djece.* Zagreb: Marko M. usluge d.o.o. 2003.

[21] J. A. Chu. The repetition compulsion revisited: Reliving dissociated trauma. *Psychotherapy* 28, št. 2:327-32. 1991.

[22] R. Cvetek. *Bolečina preteklosti: travma, medosebni odnosi, družina, terapija.* Celje: Celjska Mohorjeva družba. 2010.

[23] A. N. Svhore. *Early relational trauma, disorganized attachment, and the development of a predisposition to violence*. V: J. D. Siegel in M. F. Solomon, ur. *Healing trauma: Attachment, mind, body, and brain*, 107-67. New York: W. W. Norton & Company. 2003.

[24] C. Gostečnik. *Relacijska paradigma in travma.* Ljubljana: Brat Frančišek in Frančiškanski družinski inštitut. 2008.

[25] M. Rus Makovec. *"Nekaj informacij o povezanosti psihoterapije, nevroznanosti in psihiatrije* " I. kongres Zakonskih in družinskih terapevtov Bohinjska Bistrica. 2010.

[26] R. B. Flannery. *Post-traumatic stress disorder: The victim's guide to healing and recovery*. New York: Crossroad Publishing. 1992.

[27] B. A. van der Kolk. *Beyond the talking cure: Somatic experience and subcortical imprints in the treatment of trauma.* V: Francine Shapiro, ur. *EMDR as an integrative psychotherapy approach: Experts of diverse orientations explore the paradigm prism*, 57-83. Washington: American Psychological Association. 2002.

[28] K. Tusson, M. Wheeler, F. Butcher in J. Kretschmar. The role of sexual abuse in trauma symptoms, delinquent and suidical behaviors, and criminal justice outcomes among females in a juvenile justice diversion program. *Violence Against Women* 24, 8: 973-993. 2018.

[29] S. M. Hannan, H. K. Orcutt, L. R. Miron in K. L. Thompson. Childhood sexual abuse and later alcohol-related problems: investigating the roles of reviktimization, PTSD, and drinking motivations among college women. *Journal of Interpersonal Violence* 32, 14: 2118-2138. 2017.

Poznejše umikanje iz zaposlitve in nižja indeksacija za izboljšanje dolgoročne vzdržnosti pokojninskega sistema

Later withdrawing from the employment and lower indexation for improving long-term sustainability of the pension system

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POVZETEK

Evropska komisija je leta 2021 objavila Poročilo o staranju – »The 2021 Ageing Report« [1], kjer je predstavila, da bi bila že v letu 2060 Slovenija država z drugimi najvišjimi izdatki za pokojnine glede na bruto domači proizvod (BDP). V prihodnje bomo namreč priča hitremu naraščanju deleža starih 65 let in več, ki so praviloma v pokoju, na drugi strani pa zmanjševanju deleža prebivalcev v delovni starosti 20-64 let. V tem članku predstavimo domet dveh možnih ukrepov za izboljšanje dolgoročne vzdržnosti pokojninskega sistema. Zagovarjamo predvsem daljše ostajanje v zaposlitvi, saj se glede na druga države v Sloveniji hitro umikamo iz zaposlitve in hkrati pa ima daljše ostajanje v zaposlitvi močan oziroma dvojno pozitiven učinek, saj posamezniki še naprej prispevajo v pokojninsko blagajno namesto da bi začeli iz nje prejemati pokojnino. Močan pozitiven učinek na vzdržnost pokojninskega sistema bi imelo tudi znižanje usklajevanja rasti pokojnin z rastjo plač.

KLJUČNE BESEDE

Izdatki za pokojnine, Staranje prebivalstva, Slovenija, Indeksacija pokojnin, Daljše ostajanje v zaposlitvi

ABSTRACT

In 2021, the European Commission published The 2021 Aging Report [1], where they presented that already by 2060, Slovenia would be the country with the second highest public pensions expenditures relative to gross domestic product (GDP). In the future, we will witness a rapid increase in the share of people aged 65 and over, who will be in retirement, and on the other hand, a decrease in the share of the working age population between age 20 and 64. In this article, we present the impact of two possible measures to improve the long-term sustainability of the pension system. We advocate above all a longer stay in employment, because compared to other countries, in Slovenia we withdraw from employment early, and at the same time, staying longer in employment has a strong or double positive effect, as individuals continue to contribute to the pension fund instead of starting to receive a pension from it. Reducing the indexation of the pension growth to the wage growth would also have a strong positive effect on the sustainability of the pension system.

KEYWORDS

Pension expenditures, Population ageing, Slovenia, Indexation of pensions, Staying longer in employment

1 UVOD

Evropska komisija je leta 2021 objavila Poročilo o staranju – »The 2021 Ageing Report« [1], kjer je predstavila, da bi do leta 2070 bila Slovenija država z drugimi najvišjimi izdatki za pokojnine glede na bruto domači proizvod (BDP). Hitro povišanje je rezultat izrazito zaostrenih demografskih razmer, ki jim bomo priča v Sloveniji, vendar se jim zaenkrat nismo dovolj prilagodili s spremembo pokojninske zakonodaje.

2 DEMOGRAFSKE SPREMEMBE

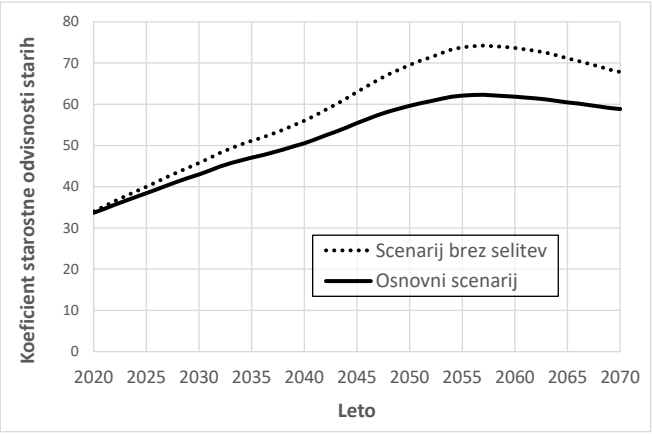
V ozadju pritiska na vzdržnost pokojninske blagajne je hitro staranje prebivalstva Slovenije, ki se bo glede na demografske projekcije nadaljevalo tudi v prihodnjih treh desetletjih. Tudi druge razvite države so soočene s hitrim staranjem prebivalstva, vendar pa je v Sloveniji staranje še posebej hitro. Prvič zaradi tega, ker smo imeli v 1990-ih in 2000-ih še posebej nizko rodnost, ko je v letu 2003 znašala stopnja celotne rodnosti zgolj 1,2 otroka na žensko, kar je bila ena najnižjih vrednosti v svetu nasploh. To je bilo skoraj smo pol toliko kot je potrebno za obnavljanje prebivalstva, to je 2,1 otroka na žensko. Stopnja celotne rodnosti kaže, koliko otrok bi morala roditi ena ženska tekom svoje rodne dobe, da bi se število prebivalstva na dolgi rok obnavljalo. Zahtevana vrednost je v razvitih državah 2,1 rahlo višja kot povprečno dva otroka na žensko. Malo več kot dva otroka mora ženska roditi zato, ker mora v povprečju roditi eno deklico in s tem nadomestiti samo sebe. Med živorojenimi je namreč deklic nekoliko manj kot dečkov, saj znaša delež deklic okrog 48,5 %, delež fantkov pa okrog 51,5 % vseh živorojenih. Hkrati pa tudi v primeru, če ženska rodi eno deklico, ta lahko umre preden se ona reproducira tekom svoje rodne dobe. Ker je umrljivost v razvitih državah zelo nizka, je zahtevana višja rodnost zaradi tega dejavnika minimalna. Najnovejše tablice umrljivosti za Slovenijo kažejo, da po podatkih za leto 2021 kar 99,1 % žensk dočaka starost 40 let, ko je večina rodnosti že realizirana, 98,2 % pa starost 50 let [2], ko je rodna doba povsem zaključena, zato ni potrebno, da bi bila za obnavljanje prebivalstva iz tega naslova rodnost kaj bistveno višja. V državah v razvoju pa tudi npr. vrednost

2,3 lahko ni dovolj za obnavljanje prebivalstva, saj je lahko v teh državah umrljivost žensk še zelo visoka.

Drugi dejavnik, ki vpliva na hitro staranje prebivalstva, je hitro podaljševanje življenjskega pričakovanja. Najdaljše življenjsko pričakovanje ob rojstvu na svetu so v letu 1940 imele ženske na Švedskem, in sicer okrog 45 let. V letu 2010 so bile to ženske na Japonskem, in sicer že 87,5 let [3]. To pomeni, da se že 180 let najvišje življenjsko pričakovanje ob rojstvu podaljšuje za skoraj 2,5 leti na desetletje. V Sloveniji v zadnjih nekaj desetletjih je poviševanje življenjskega pričakovanja ob rojstvu še nekoliko večje, saj se je npr. od leta 1982 do 2019 za oba spola skupaj povišalo s 71,0 na 81,6 leta, kar pomeni za 2,9 leti na desetletje [4]. V zadnjih dveh letih se je zaradi covid-19 nekoliko znižalo, in sicer na 80,6 v letu 2020 in 80,9 v letu 2021.

Tretji, najpomembnejši dejavnik hitrega staranja prebivalstva v prihodnjih treh desetletjih pa je obstoječa starostna struktura prebivalstva. Številčno večje generacije se bodo namreč iz delovne starosti pomikale v starost 65 let in več, na drugi strani bodo v delovno starost vstopale številčno manjše generacije otrok in mladih. Hkrati bodo s tem mlade ženske vstopale tudi v rodno dobo, kar bo vodilo do zmanjševanja števila živorojenih otrok, kljub temu, da se v projekcijah predpostavlja, da bo stopnja celotne rodnosti tekom obdobja projekcij naraščala. Obstoječa starostna struktura prebivalstva je dana, zato so projekcije glede prihodnjega hitrega staranja prebivalstva zelo robustne tudi ob različnih predpostavkah glede prihodnjega gibanja rodnosti, umrljivosti in selitev.

Selitve, na drugi strani, naj bi v prihodnje blažile staranje prebivalstva Slovenije, saj naj bi se letno v Slovenijo priseljevalo nekaj čez 5 tisoč prebivalcev [5]. Selijo se pretežno mladi, zato predpostavljeno neto priseljevanje v demografskih projekcijah blaži staranje prebivalstva Slovenije. Hkrati so v demografskih projekcijah selitve najbolj negotova kategorija. Zato v Sliki 1 prikazujemo poleg osnovnega scenarija tudi rezultate za scenarij, če selitev ne bi bilo.



Slika 1: Koeficient starostne odvisnosti starih (število prebivalcev, starih 65 let in več na 100 prebivalcev v starosti 20-64) [5].

V Sliki 1 vidimo, da bomo v prihodnje v Sloveniji priča zelo močnemu povečanju razmerja med starimi 65 let in več na eni strani ter številom prebivalcev v delovni starosti (20-64 let) na drugi strani. Po najnovejših demografskih projekcijah Eurostata [5] naj bi se to razmerje, ki se imenuje »koeficient starostne odvisnosti starih« že do leta 2050 skoraj podvojilo. Leta 2019 je namreč na 100 prebivalcev delovne starosti prišlo 33 prebivalcev v starosti 65 let in več, v letu 2050 pa naj bi to bilo že 60. Če pa ne bi bili deležni pozitivnih neto selitev, ki blažijo staranje prebivalstva, bi do leta 2050 vrednost tega kazalnika narasla že na 70, torej na več kot dvakrat toliko kot je bila v letu 2019.

3 UKREPI ZA IZBOLJŠEVANJE DOLGOROČNE VZDRŽNOSTI POKOJNINSKEGA SISTEMA

Prikazano zaostrovanje razmerja med starimi 65 let in več ter tistimi v delovni starosti bo imelo v prihodnje številne ekonomske posledice. Med drugim bomo priča močnemu pritisku na javnofinančne izdatke za pokojnine. Gre za velik del javnofinančnega sistema, ki je v Sloveniji skoraj izključno financiran skozi javnofinančni sistem, kjer tekoče generacije zaposlenih skozi prispevke financirajo pokojnine upokojencev. V sistemih oziroma državah, kjer je financiranje v pomembnem deležu tudi naložbeno, bodo pritiski demografskih sprememb na vzdržnost pokojninskega sistema v prihodnjih desetletjih manjši. V tem primeru namreč privarčevana sredstva čakajo posameznika ob upokojitvi na njegovem računu in za ta del finančno ne obremenjuje kohort zaposlenih.

Evropska komisija na vsaka tri leta objavi projekcije pokojninskih izdatkov na osnovi najnovejših Eurostatovih demografskih projekcij in na osnovi makroekonomskih predpostavk, pri oblikovanju katerih izhaja iz njihovega gibanja v preteklosti. Zadnje poročilo je bilo objavljeno leta 2021 [1]. Slovenija je bila glede javnofinančnih izdatkov za pokojnine, ki so znašali 10,0 % BDP, v letu 2019 približno v sredini razvrstitve EU-27 držav – in sicer na 12. mestu med 27 članicami EU. Najvišji odstotek sta imeli Grčija z 15,7 % in Italija s 15,4 %, najnižjega pa Nizozemska s 6,8 % in Irska s 4,6 %. Zaskrbljujoče pa so projekcije prihodnjega gibanja javnofinančnih izdatkov za pokojnine glede na BDP. Upoštevaje obstoječo pokojninsko ureditev, Eurostatove demografske projekcije in makroekonomske predpostavke Evropske komisije naj bi že do leta 2050 javnofinančni izdatki za pokojnine v Sloveniji narasli na kar 15,7 %, kar bi bila druga najvišja vrednost med EU-27 državami, takoj za Luksemburgom z 16,2 % [1].

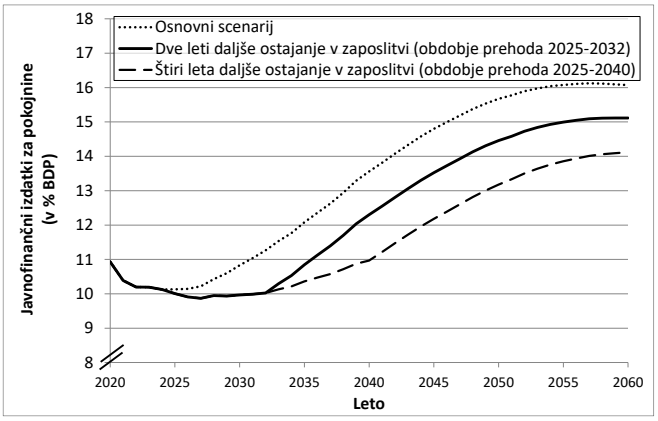
Podobno kot v drugih EU državah so za hitro povečanje javnih izdatkov za pokojnine razlog predvsem demografske spremembe, ki pa se jim z obstoječo pokojninsko ureditvijo zaenkrat še nismo dovolj prilagodili. Slovenija izstopa z nižjo zaposlenostjo v višjih starostnih razredih, predvsem v starosti 60-64 let in 65-69 let. V skladu z veljavno zakonodajo se lahko posameznik upokoji že s 60 leti starosti, če ima 40 let pokojninske dobe.

Hkrati je glede na druge države visoka tudi indeksacija pokojnin. Indeksacija oz. usklajevanje pokojnin z rastjo plač namreč znaša kar 60:40, kar pomeni, da se pokojnine povečajo za 60 % rasti povprečne bruto plače in 40 % z inflacijo. Če bi se npr. povprečna plača v Sloveniji povečala za 4 %, inflacija pa bi znašala 1 %, bi se pokojnine obstoječim upokojencem povišale za 2,8 % (4*0,60+1*0,40=2,8). Glede na druge države je to zelo visoko usklajevanje, saj jih je v luči dolgoročne vzdržnosti medtem veliko sprejelo odločitev, da se jim pokojnine usklajujejo samo še inflacijo. To pomeni, da se upokojencem po upokojitvi življenjska raven ohranja, ne participirajo pa več pri višji produktivnosti zaposlenih, ki se zrcali v rasti plač, ki je višja od inflacije. Da so ohranja življenjska raven upokojencev, velja v primeru, če se cene proizvodov in storitev, ki jih kupujejo upokojenci, gibljejo približno enako kot cene povprečnega potrošnika. V nasprotnem primeru se lahko življenjska raven tekom obdobja upokojitve zvišuje ali znižuje, odvisno od gibanja cen v njihovi »porabniški košarici« glede na porabniško košarico zaposlenih, študentov in drugih podskupin potrošnikov.

Glede na opisano sta daljše ostajanje v zaposlitvi in znižanje indeksacije lahko dva aktualna ukrepa za izboljšanje dolgoročne vzdržnosti slovenskega pokojninskega sistema. V nadaljevanju zato prikazujemo nekaj scenarijev možnih sprememb, da dobimo občutek, kakšen je domet teh dveh ukrepov glede velikosti in tempiranja sprememb. Pri tem uporabimo model generacijskih računov, razvit s strani Inštituta za ekonomska raziskovanja [6], ki se uporablja tudi pri izračunih, predstavljenih v poročilu od Evropske komisije [1]. Rezultati osnovnega scenarija so tako enaki rezultatom, objavljenim v njihovem poročilu »The 2021 Ageing Report« [1], rezultati ostalih scenarijev pa so usklajeni s tem modelom in predpostavkami, pri čemer pa velikosti in tempiranje ukrepov po posameznih scenarijih oblikujemo sami.

V Sliki 2 prikazujemo rezultate efektivnega poznejšega izstopanja iz zaposlitve glede na osnovni scenarij. Pri tem se ne spuščamo v to, za koliko bi morali spremeniti kombinacijo zahtevane starosti in pokojninske dobe za upokojitev, da bi dosegli to efektivno daljše ostajanje v zaposlitvi, temveč navedeno efektivno podaljšanje ostajanja v zaposlitvi kar predpostavljano.

Vidimo lahko (Slika 2), da bi podaljšanje ostajanja v zaposlitvi za dve leti med 2025 in 2032 (za 3 mesece na leto) preprečilo naraščanje javnofinančnih izdatkov za pokojnine glede na BDP vse do leta 2032. Dolgoročni pozitivni učinek tega ukrepa je nekaj manj kot eno odstotno točko, saj bi javnofinančni izdatki za pokojnine v letu 2060 namesto na 16,1 % (osnovni scenarij) narasli na 15,1 %. Postopno podaljšanje ostajanja v zaposlitvi za štiri leta med 2025 in 2040 (prav tako za 3 mesece na leto) bi javnofinančne izdatke za pokojnine v letu 2060 znižalo na 14,1 %, kar je za dve odstotni točki manj kot v osnovnem scenariju.



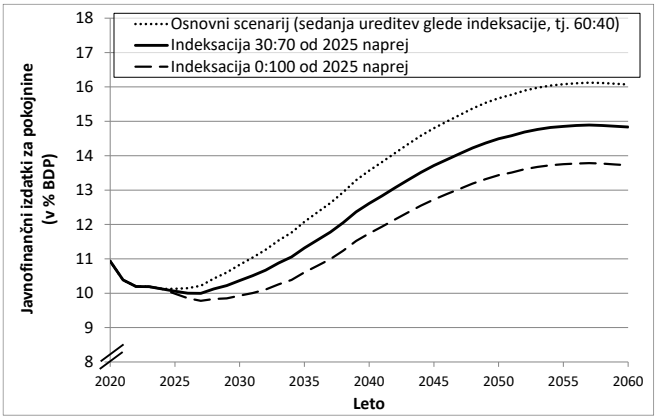
Slika 2: Javnofinančni izdatki za pokojnine kot % BDP ob podaljševanju ostajanja v zaposlitvi za dve oz. štiri leta [6].

To torej pomeni, da za štiri leta daljše ostajanje v zaposlitvi dolgoročno za približno dvakrat bolj zniža izdatke za pokojnine kot za dve leti daljše ostajanje v zaposlitvi. Učinek je pričakovano proporcionalen, kar pomeni, da eno leto efektivno daljše ostajanje v zaposlitvi dolgoročno zniža izdatke za pokojnine (glede na BDP) za okrog pol odstotne točke.

Ukrep, ki bi z višjo starostjo za upokojitev in/ali zahtevano pokojninsko dobo povzročil daljše ostajanje v zaposlitvi bi bil logičen ukrep, glede na to, da se nam pričakovano trajanje življenja hitro podaljšuje in glede na to, da Slovenija v mednarodnih primerjavah izstopa po tem, da se hitro umikamo iz zaposlitve [7], [8]. Daljše ostajanje v zaposlitvi ima dvojno pozitiven učinek, saj posamezniki še naprej delajo in plačujejo prispevke v pokojninsko blagajno namesto da bi iz pokojninske blagajne prejemali pokojnine. Daljše ostajanje v zaposlitvi je ukrep, ki prizadene samo posameznike, ki še niso upokojeni, medtem ko se za obstoječe upokojence ničesar ne spremeni.

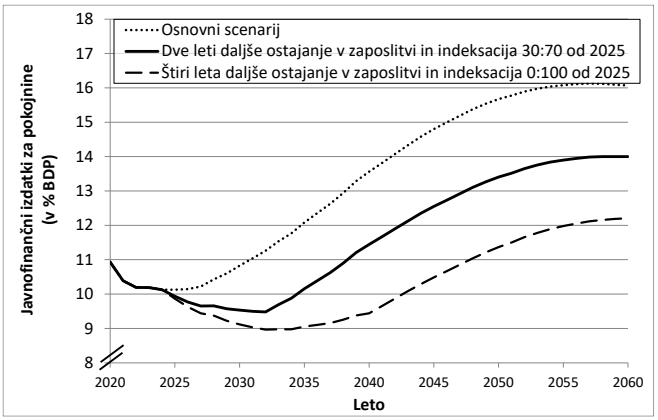
Ukrep, ki pri izboljševanju dolgoročne vzdržnosti pokojninskega sistema porazdeli breme čez vse generacije pa je indeksacija oz. usklajevanje rasti pokojnin z rastjo plač. Kot že povedano, se po trenutni ureditvi rast plač v 60 % usklajuje z rastjo povprečne bruto plače, v 40 % pa z rastjo cen življenjskih potrebščin, torej inflacijo. Če gledamo v realnem izrazu, to pomeni, da realna rast pokojnin znaša 60 % realne rasti povprečne bruto plače.

V izračunih predpostavljamo dva scenarija. V prvem indeksacijo v letu 2025 znižamo s sedanje 60 % realne rasti povprečne bruto plače na 30 %, v drugem scenariju pa na 0 %, kar pomeni da bi se po vzoru številnih drugih evropskih držav pokojnine poviševale samo še nominalno z inflacijo, realno pa ne bi več naraščale.



Slika 3: Javnofinančni izdatki za pokojnine kot % BDP ob znižanju indeksacije s sedanjih 60:40 (rast povprečne bruto plače:inflacija) na 30:70 oz. 0:100 od leta 2025 naprej [6].

Končno prikazujemo še kombinacijo obeh ukrepov – torej podaljševanja ostajanja v zaposlitvi in znižanju indeksacije rasti pokojnin na rast povprečne bruto plače. Pri tem prikazujemo samo dve kombinaciji prikazanih posameznih učinkov. Prvi je manj ambiciozen scenarij s podaljšanjem ostajanja v zaposlitvi za dve leti in indeksacijo 30:70 od leta 2025, bolj ambiciozen scenarij pa predpostavlja podaljšanje ostajanja v zaposlitvi za dve leti in indeksacijo 0:100 (torej rast plač zgolj z inflacijo).



Slika 4: Javnofinančni izdatki za pokojnine kot % BDP ob znižanju indeksacije s sedanjih 60:40 (rast povprečne bruto plače:inflacija) na 1) 30:70 in dve leti podaljšano ostajanje v zaposlitvi od leta 2025 ter 2) 0:100 in štiri leta podaljšano ostajanje v zaposlitvi od leta 2025 [6].

V Sliki 4 tako vidimo, da se učinki posameznih ukrepov približno seštevajo, zato ostali dve kombinaciji indeksacije in podaljšanja ostajanja v zaposlitvi ne prikazujemo. Ugotovili smo, da bi že kombinacija podaljšanja ostajanja v zaposlitvi za dve leti in indeksacije 30:70 od leta 2025 naprej dolgoročno znižala javnofinančne izdatke za pokojnine glede na BDP s 16,1 % v letu 2060 na okrog 14 %. Ob tem bi še več kot desetletje izdatki ostajali na približno enaki ravni oz. celo nekoliko nižji ravni kot so sedaj. Kombinacija podaljšanja ostajanja v zaposlitvi za štiri leta in indeksacija 0:100 od leta 2025 pa bi javnofinančne izdatke za pokojnine glede na BDP znižala na okrog 12 % BDP v letu 2060, ob tem ko bi vse do okrog leta 2043 izdatki ostajali na nižji ravni kot so trenutno.

4 ZAKLJUČEK

Demografska struktura prebivalstva Slovenije se hitro spreminja. Razmerje med številom starih 65 let in več na eni strani in prebivalci v delovni starosti (20-64 let) se bo hitro poviševalo tudi v prihodnje in bo leta 2060 predvidoma skoraj dvakrat višje kot v letu 2019. Ukrepa, ki bi imela močan pozitiven učinek na dolgoročno vzdržnost, sta podaljševanje ostajanja v zaposlitvi in znižanje indeksacije, torej usklajevanja rasti pokojnin z rastjo plač. Efektivno podaljšanje ostajanja v zaposlitvi za eno leto dolgoročno zniža javnofinančne izdatke za pokojnine glede na BDP za okrog pol odstotne točke. Tako bi se ob štiri leta daljšem ostajanju v zaposlitvi javnofinančni izdatki za pokojnine glede na BDP v letu 2060 znižali s 16,1 % na 14,1 %. Če pa bi hkrati še znižali indeksacijo s sedanjih 60:40 (rast povprečne bruto plače:inflacija) na 0:100 (torej bi bila rast plač samo še z inflacijo, ki naj bi realno ohranjala življenjsko raven), kakor imajo številne druge evropske države, bi javnofinančni izdatki za pokojnine v letu 2060 znašali samo še 12,2 %, kar je porast za zgolj dobri dve odstotni točki glede na leto 2019, ko so javnofinančni izdatki za pokojnine znašali 10 % [6].

LITERATURA IN VIRI

[1] European Commission, "The 2021 Ageing Report: Economic and Budgetary Projections for the EU Member States (2019-2070)," 2021. [Online]. Available: https://ec.europa.eu/info/publications/2021-ageing-report-economic-and-budgetary-projections-eu-member-states-2019-2070_en

[2] Statistični urad RS, "Skrajšane tablice umrljivosti prebivalstva po spolu, Slovenija, letno," *https://pxweb.stat.si/SiStat/sl/Podrocja/Index/100/prebivalstvo*, 2022. https://pxweb.stat.si/SiStatData/pxweb/sl/Data/-/05L4004S.px

[3] M. Roser, "Breakdown of life expectancy at birth in total and by gender in Japan from 2001 to 2019." 2022. Accessed: Nov. 12, 2019. [Online]. Available: https://www.statista.com/statistics/611813/japan-life-expectnancy-total-gender/

[4] Eurostat, "Life expectancy by age and sex," 2022. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=demo_mlexpec&lang=en (accessed Sep. 13, 2022).

[5] Eurostat, "Population projections EUROPOP2019," 2020. https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=proj_19np&lang=en (accessed Aug. 20, 2020).

[6] Inštitut za ekonomska raziskovanja, "Model generacijskih računov." 2022.

[7] J. Sambt, B. Hammer, and T. Istenič, "The European National Transfer Accounts: Data and Applications," *Econ. Bus. Rev.*, vol. 23, no. 3, p. 4, 2021.

[8] J. Sambt and J. Malačič, "Slovenia : independence and the return to the family of European market economies," in *Population aging and the generational economy : a global perspective*, R. D. Lee and A. Mason, Eds. Cheltenham, Northampton: Edward Elgar, 2011, pp. 340–353.

Vpliv izboljševanja izobrazbene strukture prebivalstva na javnofinančno vzdržnost

The impact of improving the educational structure of the population on the financial sustainability of the public sector

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POVZETEK

Prispevek prikazuje rezultate metodologije računov nacionalnih transferjev, ki so poleg po starosti razčlenjeni tudi po stopnji izobrazbe. Rezultati kažejo, da imajo višje izobraženi bistveno višji dohodek iz dela kot nižje izobraženi, hkrati je višja tudi njihova potrošnja, vendar je slednje manj izrazito. Višje izobraženi v javnofinančni sistem vplačujejo več davkov in socialnih prispevkov, na drugi strani pa so deležni višjih prilivov javnih transferjev, predvsem v obliki pokojnin. Izkaže se, da je razmerje med plačanimi in prejetimi javnimi transferji enako 0,71 za osnovno izobražene, 0,93 za srednješolsko izobražene in 1,43 za terciarno izobražene. Terciarno izobraženi torej v javnofinančni sistem vplačujejo več kot iz njega prejemajo in tako izboljšujejo finančno vzdržnost javnofinančnega sistema, ki bo v prihodnjih desetletjih pod močnim pritiskom staranja prebivalstva.

KLJUČNE BESEDE

Dolgoročna vzdržnost javnofinančnega sistema, medgeneracijski transferji, računi nacionalnih transferjev (NTA), izobraževanje, Slovenija.

ABSTRACT

The paper presents the results of the National Transfer Accounts methodology, decomposed not only by age but also by education level. The results show that the higher educated earn more than the less educated, and at the same time their consumption is also higher, but the latter is less pronounced. The more highly educated pay more taxes and social contributions into the public financial system, and on the other hand, they receive higher public transfer inflows, mainly in the form of pensions. It can be seen that the ratio between public transfers paid and received is 0.71 for those with primary education, 0.93 for those with secondary education, and 1.43 for those with tertiary education. Thus, the results show that tertiary-educated individuals pay more into the public financial system than they receive from it and therefore they improve the financial sustainability of the public sector that will be in the following decades under heavy pressure of population ageing.

KEYWORDS

Long-term sustainability of the public system, intergenerational transfers, National Transfer Accounts (NTA), education, Slovenia.

1 UVOD

Otroci in stari prebivalci porabijo več, kot proizvedejo s svojim delom. Razlika se lahko financira z javnimi in zasebnimi transferji s strani posameznikov v delovni dobi ali pa s sodelovanjem posameznikov na finančnem in kapitalskem trgu (v obliki kredita, prejetih obresti, dividend itd.). V tem prispevku uporabljamo metodo računov nacionalnih transferjev (angl. *National Transfer Accounts, NTA*) za celovito analizo transferjev med starostnimi skupinami. Pretekle raziskave so pokazale, da imajo lahko države zelo različne ureditve za financiranje potrošnje posameznikov v starosti, ko je potrošnja višja od proizvodnje. Na splošno so v manj razvitih državah sorazmerno pomembnejši zasebni transferji, medtem ko je v razvitih državah veliko funkcij družine prevzel javni sektor. Vendar pa so tudi med razvitimi državami lahko ureditve zelo različne. Na primer, v ZDA se starejši v večji meri zanašajo na varčevanje in posledično premoženje kot vir dohodka, medtem ko se na Švedskem ekonomsko odvisni posamezniki močno zanašajo na javni sektor. V tem prispevku razširimo standardne rezultate NTA z razčlenitvijo rezultatov po stopnji izobrazbe. Posamezniki z osnovno, srednješolsko in terciarno izobrazbo namreč različno prispevajo v javnofinančni sistem in iz njega različno prejemajo.

2 METODOLOGIJA IN PODATKI

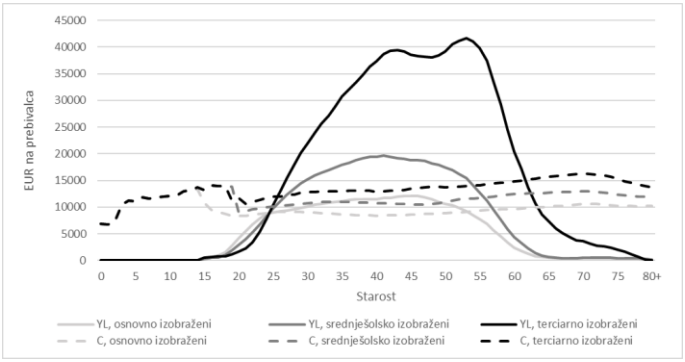
Za analizo ekonomskih tokov med različnimi starostnimi skupinami moramo oceniti velik nabor starostnih profilov (t.j. povprečnih vrednosti posameznih ekonomskih kategorij v posameznih starostih), ki sestavljajo standardni nabor rezultatov NTA. Javni transferji na strani prilivov vključujejo javne transferje v denarju in naravi, kot so npr. javno financiranje izobraževanja, zdravstva in pokojnin [1], [2]. Na strani odlivov pa javni transferji vključujejo davke in socialne prispevke, ki jih posamezniki plačujejo. Zasebni transferji vključujejo tokove znotraj gospodinjstev (t.j. med člani gospodinjstva) in tokove med (različnimi) gospodinjstvi. Javne in zasebne prerazdelitve sredstev vključujejo dohodke od kapitala, zasebne prihranke, obresti, ki se plačajo na javni dolg itd. Starostni profili se ocenjujejo na osnovi anketnih in administrativnih podatkov. V tem prispevku predstavljamo rezultate NTA za Slovenijo v letu 2010, kjer večina starostnih profilov temelji na Anketi o porabi gospodinjstev (APG) [3]. Izračunani relativni starostni profili (relativna razmerja med posameznimi starostnimi razredi) se nato prilagodijo s faktorjem popravka. Ta faktor je tolikšen, da se povprečja posameznih ekonomskih kategorij po starosti (t.j. starostni profili), pomnožena s porazdelitvijo posameznikov po starosti in temi faktorji popravka, ravno izenačijo z vrednostjo makroekonomskih agregatov. Makroekonomski agregati so prevzeti ali izračunani iz sistema nacionalnih računov (angl. *System of National Accounts, NTA*).

Javnofinančne prilive in odlive tako razčlenimo na tri stopnje izobrazbe: osnovno (ravni ISCED 0-2), srednješolsko (ravni ISCED 3-4) in terciarno (ravni ISCED 5-6). Tiste starostne profile NTA, ki so ocenjeni z uporabo anketnih podatkov, je mogoče razčleniti po stopnji izobrazbe relativno preprosto. Namesto da bi za posamezne ekonomske tokove izračunali povprečja samo glede na starost, izračunamo povprečja glede na starost in stopnjo izobrazbe hkrati. Na drugi strani pa agregatni podatki, razčlenjeni po stopnji izobrazbe, običajno niso na voljo. Starostni profili, razčlenjeni po stopnji izobrazbe, so zato prilagojeni na način, da dosežemo skladnost z (nerazčlenjenimi) agregatnimi vrednostmi NTA.

3 REZULTATI

Slika 1 prikazuje povprečno potrošnjo in povprečni dohodek iz dela na prebivalca po stopnji izobrazbe. Kot pričakovano, je dohodek iz dela najvišji za terciarno izobražene. Dohodek iz dela terciarno izobraženih je relativno visok, saj terciarno izobraženi zaslužijo več, hkrati pa je višja tudi njihova stopnja zaposlenosti. Dohodek iz dela je najnižji pri posameznikih z osnovno izobrazbo. Enako zaporedje velja tudi za potrošnjo, vendar so razlike tu manjše zaradi davčne progresivnosti, socialnih programov v javnem sektorju in nagnjenosti k varčevanju.

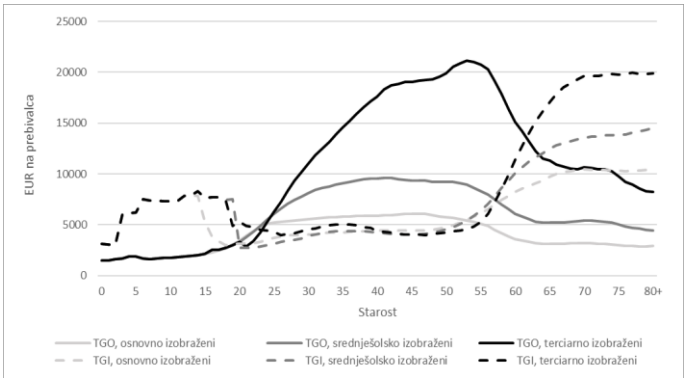
Slika 1: Dohodek iz dela (YL) in potrošnja (C) za osnovno, srednješolsko in terciarno izobražene; Slovenija, 2010



Viri: *APG 2010, Eurostat , drugi viri.*

Tudi Slika 2 prikazuje močno prerazporejanje v okviru javnega sektorja. Razlike v vplačilih v javni sistem so tudi tokrat velike. V delovni starosti terciarno izobraženi prispevajo v javni sistem skoraj trikrat toliko kot tisti z osnovno izobrazbo in skoraj dvakrat toliko kot tisti s srednješolsko izobrazbo. Hkrati so razlike v prilivih, ki jih posamezniki s posamezno stopnjo izobrazbe prejmejo od javnega sektorja, odvisne od starosti. V nižji starosti so prilivi enaki za vse izobrazbene skupine, saj so vsi posamezniki vpisani v osnovnošolsko izobraževanje, hkrati pa tudi predpostavljamo, da prejemajo enako zdravstveno oskrbo. Po končani osnovni šoli se javni prilivi močno zmanjšajo za osnovno izobražene, nekaj let pozneje še za tiste s srednješolsko izobrazbo (ko dosežejo svojo stopnjo izobrazbe) in po nadaljnjih nekaj letih še za terciarno izobražene, ko še oni zaključijo z izobraževanjem. V delovni starosti skoraj ni razlike med izobrazbenimi skupinami v prejetih prilivih iz javnega sistema. Nekateri javni programi so namreč sorazmerni s tistim, kar ljudje prispevajo v javni sistem (npr. nadomestila za brezposelnost), drugi pa so celo obratno sorazmerni (npr. otroški dodatek). Po upokojitvi pa postanejo javni prilivi (kjer večino predstavljajo pokojnine) za terciarno izobražene mnogo višji v primerjavi s tistimi s srednješolsko izobrazbo in še bolj v primerjavi s posamezniki z osnovno izobrazbo.

Slika 2: Javni odlivi (TGO) in javni prilivi (TGI) za osnovno, srednješolsko in terciarno izobražene; Slovenija, 2010

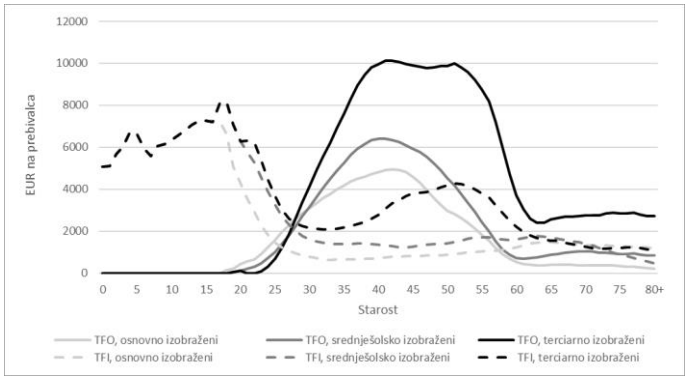


Viri: *APG 2010, Eurostat, drugi viri.*

Zasebni transferji potekajo predvsem od staršev k otrokom. Starostni vzorci odlivov zasebnih transferjev so zelo podobni starostnim profilom dohodka iz dela (Slika 1), vendar so zneski manjši, saj posamezniki plačujejo javnemu sistemu le del svojega dohodka. Prilivi v obliki zasebnih transferjev so

koncentrirani v nižjih starostnih skupinah. Pri terciarno izobraženih posameznikih so zasebni transferji zanimivo visoki v zgodnjih 50-ih letih starosti.

Slika 3: Zasebni odlivi (TFO) in zasebni prilivi (TFI) za osnovno, srednješolsko in terciarno izobražene; Slovenija, 2010



Viri: *APG 2010, Eurostat, drugi viri.*

Raven in starostna porazdelitev dohodka iz dela in potrošnje imata zelo pomembne gospodarske posledice. Izračunali smo povprečno starost dohodka iz dela, potrošnje, prilivov (javnih in zasebnih) ter odlivov (javnih in zasebnih) za vse tri stopnje izobrazbe. V Tabeli 1 je prikazana povprečna starost za navedene glavne kategorije NTA - razčlenjena glede na stopnjo izobrazbe.

Tabela 1: Povprečna starost dohodka od dela (YL), potrošnja (C), javni odlivi (TGO), javni prilivi (TGI), zasebni odlivi (TFO) in zasebni prilivi (TFI) po stopnji izobrazbe; Slovenija, 2010 Slovenija

	YL	C	TGO	TGI	TFO	TFI
Osnovna	40,6	41,4	42,0	47,3	42,0	26,6
Srednješolska	41,8	42,3	44,9	49,3	42,4	26,7
Terciarna	45,5	43,5	48,3	51,7	48,3	32,3

Viri: *APG 2010, Eurostat, drugi viri.*

V letu 2010 je bil potek zasebnih transferjev po starosti »navzdol«, saj je bila povprečna starost prejemanja zasebnih transferjev 28 let, povprečna starost dajanja zasebnih transferjev pa 45 let. V nasprotju s tem so javni transferji potekali »navzgor«, saj je bila povprečna starost prejema 48 let, medtem ko je bila povprečna starost plačevanja davkov in prispevkov 45 let. Ta razlika je približno enaka na vseh ravneh izobraževanja, vendar je bila velikost transferjev (zlasti javnih) za terciarno izobražene veliko večja. Razmerje med plačanimi in prejetimi javnimi transferji je bilo 0,71 za osnovno izobražene, 0,93 za srednješolsko izobražene in 1,43 za terciarno izobražene.

4 ZAKLJUČEK

Metoda Računov nacionalnih transferjev (NTA) se uporablja za celovito analizo tokov med starostnimi skupinami. V tem prispevku uporabimo razčlenitev NTA rezultatov za Slovenijo v letu 2010 glede na stopnjo izobrazbe. Smer poteka zasebnih transferjev (predvsem staršev, ki financirajo potrošnjo svojih otrok) je bila po starosti »navzdol«, saj je bila povprečna starost prejemanja zasebnih transferjev 28 let, povprečna starost dajanja zasebnih transferjev pa 45 let. V nasprotju s tem so javni transferji potekali »navzgor«, saj je bila povprečna starost prejemanja 48 let, medtem ko je bila povprečna starost plačevanja davkov in prispevkov 45 let. Ta razlika je približno enaka na vseh ravneh izobraževanja, vendar je bila velikost transferjev (zlasti javnih) za terciarno izobražene veliko večja. Razmerje med plačanimi in prejetimi javnimi transferji je bilo 0,71 za osnovno izobražene, 0,93 za srednješolsko izobražene in 1,43 za terciarno izobražene. Spodbujanje višje izobrazbene ravni prebivalstva je tako lahko kanal za izboljševanje finančne vzdržnosti javnega sektorja, ki bo v prihodnjih desetletjih pod močnim pritiskom staranja prebivalstva. Rezultati za Slovenijo so predstavljeni kot prikaz razširitve NTA analize na stopnjo izobrazbe in izpeljavo kazalnikov na podlagi pridobljenih rezultatov. V prihodnosti načrtujemo primerjalno analizo rezultatov vseh EU držav, ki imajo na voljo vse potrebne podatke za te izračune.

LITERATURA IN VIRI

[1] United Nations, *National Transfer Accounts manual: Measuring and Analysing the Generational Economy*. New York: United Nations, 2013.

[2] T. Istenič, A. Šeme, B. Hammer, A. Lotrič Dolinar, and J. Sambt, "The European NTA Manual," *AGENTA Public Deliv. Download Httpwwwagenta-Proj.-14-Submitt. Accessed 13 Sept. 2016*, 2016.

[3] Statistični urad Republike Slovenije, *Anketa o porabi v gospodinjstvih 2010*. Ljubljana: Statistični urad Republike Slovenije, 2016.

Funkcionalnost družinskega življenja v družinah z alkoholizmom in odrasli otroci alkoholikov

Functionality of family life in alcoholic families and adult children of alcoholics

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POVZETEK*

Alkoholizem predstavlja velik javnozdravstveni in družbeni problem. Posledice škodljive rabe alkohola prizadenejo posameznika, njegovo družino in širšo okolico in družbo. V družini, kjer je prisoten alkoholizem, se spremeni družinska dinamika in razvijejo spremljajoči pojavi, ki so škodljivi za psihosocialni razvoj otroka, posledice tega pa so vidne tudi v odraslosti. Rezultati raziskave, v katero je bilo vključenih 187 odraslih otrok alkoholikov (OOA) in 244 oseb, ki niso OOA, kažejo, da je v primarnih družinah OOA bilo prisotnih statistično pomembno več nefunkcionalnih vidikov družinskega življenja kot v družinah oseb, ki niso OOA. Več nefunkcionalnosti v primarni družini pa je statistično pomembno povezano z vidiki funkcionalnosti v odraslosti, kjer je prisotnih več individualni problemov in manj moči, slabša je regulacija čustev, prav tako je slabša kvaliteta družinskega življenja v trenutnih družinah in nižje je zadovoljstvo s partnerskim odnosom. OOA so zaradi slabših odnosov v primarnih družinah bolj ranljivi za razvoj problematičnih okoliščin, zato je utemeljena in smiselna potreba po psihosocialni in terapevtski podpori tudi v njihovi odrasli dobi.

KLJUČNE BESEDE

Alkoholizem, zasvojenost, družina, otroci, razvoj

ABSTRACT

Alcoholism is a major public health and social problem. The consequences of harmful alcohol use affect the individual, the whole family, the wider community and society. In a family where alcoholism is present, family dynamics are changed and accompanying phenomena develop which are harmful to the psychosocial development of the child, with consequences that continue into adulthood. The results of the study, which included 187 adult children of alcoholics (ACoA) and 244 non-ACoA, show that in ACoA's families of origin significantly more dysfunctional aspects of family life were present than in non-ACoA's families. However, more dysfunctionality in the primary family is significantly associated with aspects of functionality in adulthood, where there are more individual problems and less strengths, more difficulties in emotion regulation, lower quality of family life in current families and lower satisfaction with the partner relationship. ACoA are more vulnerable to the development of problematic circumstances due to less functional relationships in their primary families, and there is a justified and reasonable need for psychosocial and therapeutic support in their adulthood.

KEYWORDS

Alcoholism, addiction, family, children, development

1 ALKOHOLIZEM STARŠEV IN DRUŽINSKO ŽIVLJENJE

Po podatkih Nacionalnega inštituta za javno zdravje [1] 43 % prebivalcev Slovenije, starih 25–64 let, pije visoko tvegano (pije alkohol v količinah ali na način, ki lahko kratko- in/ali dolgoročno vodijo do razvoja škodljivih posledic zaradi alkohola). V času epidemije se je pitje še povečalo, saj naj bi 7,8 do 13,9 % oseb pilo več [2]. Ob takih številkah je veliko tudi oseb, ki jih škodljiva raba alkohola posredno prizadene in zaznamuje. Med njimi so predvsem partnerji in otroci oseb s problematičnim uživanjem alkohola.

Alkoholizem staršev ima dolgoročen in uničujoč vpliv na celoten družinski sistem – tako na partnerski odnos, kot na otroke. Alkoholične družine imajo v primerjavi z nealkoholičnimi višji nivo konfliktov, borbenosti, obtoževanj in nasprotovanj ter nižji nivo povezanosti in družinske bližine. Prav tako je prisotna nižja stopnja telesnega in verbalnega izražanja pozitivnih čustev, manj čustvene podpore, topline in skrbi med družinskimi člani [4, 5]. Prekomerno pitje in odvisnost od alkohola negativno vplivata na zadovoljstvo in stabilnost v zakonu. Partnerji odvisnih od alkohola izkušajo več stresa v zakonu, fizične in psihične zlorabe, pogoste pa so tudi ločitve [6], kar pušča posledice tudi pri otrocih.

Izrazita raba alkohola pri staršu pomembno povečuje tveganje, da bo do otroka na nek način zlorabljajoč. Več kot je v družini članov, ki zlorabljajo ali so odvisni od alkohola, bolj bo verjetno, da bodo otroci v družini zlorabljeni ali zanemarjeni [7]. Prav tako se znatno poveča tudi tveganje, da bo otrok v odraslosti postal problematičen pivec, kar potrjujejo rezultati študij o obremenjujočih izkušnjah v otroštvu, ki so velikokrat prisotne v družinah s starši alkoholiki [8]. Prisotnost alkoholizma staršev tudi zelo poveča možnost, da se bo pri potomcih razvila neka oblika mentalne motnje [9]. Otroci alkoholikov pogosto kažejo veliko vedenjskih težav, npr. prestopništva, odvisniškega vedenja, odpora do družbenih norm [10]. Številne družine, ki jih

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prizadene pitje staršev, tako utrpijo ekstremno in direktno škodo, lahko pa je ta tudi bolj indirektne oblike, vedno pa je škoda prisotna [8].

2 ODRASLI OTROCI ALKOHOLIKOV

Odraščanje v družini, ki je zaznamovana z alkoholno zasvojenostjo enega ali obeh staršev, ima za otroka težke posledice. V takšni družini se ob travmatičnih okoliščinah pogosto izoblikuje nefunkcionalen starševski pristop, v katerem starši otroku ne nudijo podpore in zdravega okolja za rast in razvoj, kar pri otroku pušča medosebne, čustveno-vedenjske in socialne posledice, ki lahko vztrajajo še v odrasli dobi otroka. T. i. »odrasli otroci alkoholikov« (OOA), ki so del ali celo svoje otroštvo odraščali v disfunkcionalni družini, kjer je bil največji problem alkoholna zasvojenost enega ali obeh staršev, so bolj občutljivi na življenjske stresorje in imajo več prilagoditvenih težav [11]. V sebi nosijo številna nerešena vprašanja iz otroštva, potlačene in nerazrešene vsebine, ki sooblikujejo njihovo funkcioniranje v odrasli dobi, ki se velikokrat izkaže za čustveno in socialno nezrelo [12]. Vse to je posledica odraščanja ob starših, ki otroku niso nudili varnega in zdravega razvojnega okolja.

Odrasli otroci staršev alkoholikov poročajo o kaotičnem in stresnem otroštvu, ki jih je prikrajšalo za številne potenciale zdravega razvoja. Za njihovo otroštvo so bili značilni nepredvidljivost in travme, saj v disfunkcionalnem alkoholičnem družinskem sistemu njihove osnovne potrebe po skrbi in čustveni podpori (razvijanje zdrave samopodobe, občutka, da so dragoceni in ljubljeni, občutek varnosti) niso mogle biti zadovoljene [13, 14]. Mnogi poročajo o primerih zanemarjanja in slabega ravnanja, na primer o tem, da so ostali sami brez starševskega nadzora in oskrbe; da so bili izpostavljeni manipulativnemu, kritičnemu ali odklonilnemu vedenju staršev, odvisnih od alkohola; bili so priče starševskim konfliktom in partnerskemu nasilju; lahko so bili sami žrtve fizičnega nasilja s strani staršev [13]. Poleg tega OOA pogosto poročajo o izkušnjah neprimernih razmejitev in zamenjave družinskih vlog, kjer je za družinsko življenje značilna večja nepredvidljivost in negotovost zaradi sprememb v vedenju od alkohola odvisnega starša in kjer otroci na koncu prevzamejo vloge in odgovornosti odraslih (postareni otroci) [15, 16].

Vse to so družinski stresorji, ki pojasnjujejo razvoj in pojavnost številnih psihosocialnih zapletov pri OOA. Seveda pa je treba opozoriti, da številni otroci staršev, ki imajo težave z alkoholom, odrastejo v zdrave in funkcionalne osebe, ki se zmorejo v odrasli dobi učinkovito soočati z ranami iz otroštva in obvladovati posledice zgodnjih negativnih izkušenj [17, 18]. Vseeno pa raziskave ugotavljajo, da OOA zaradi izkušnje odraščanja v družini z alkoholizmom staršev gredo skozi življenje s čustvenimi brazgotinami. Imajo tudi več fizičnih težav kot osebe, ki so odraščale v nealkoholičnih družinah [19]. Prisotne so višje stopnje depresije in anksioznosti [20], motenj hranjenja, številni živijo v konstantnem strahu, da bi tudi sami postali alkoholiki, kar se velikokrat dejansko zgodi [21]. V primerjavi z odraslimi iz nealkoholičnih družin imajo OOA višje stopnje anksioznosti in izogibanja v partnerskih odnosih, na splošno se lahko bojijo oblikovati navezanost z drugimi odraslimi [22]. Pogosto se čutijo negotove, samoobsojajoče in se bojijo intime. Imajo težave z zaupanjem, odvisnostjo v odnosih, samokontrolo, identiteto in izražanjem občutkov [21]. OOA imajo velikokrat težave na področju doživljanja in reguliranja svojih čustev, saj so v disfunkcionalni družini doživljali veliko čustvenih bremen, obenem pa ni bilo prave možnosti za zdrav razvoj regulacije teh čustev. Na osnovi tega so oblikovali specifične načine doživljanja sebe, drugih in odnosov [23], ki običajno pomenijo zaplete v vsakdanjem funkcioniranju.

3 OPREDELITEV PROBLEMA IN HIPOTEZE

Zloraba alkohola ne vpliva negativno le na posameznika, ki uživa alkohol, temveč tudi na družinski sistem, v katerem alkoholik živi. Zaradi disfunkcionalnosti staršev alkoholikov, kot je pomanjkanje odgovornosti in neprimerno prevzemanje družinskih vlog, lahko družinsko okolje postane bolj kaotično in nestabilno. V teh razmerah se težave pojavijo tudi pri družinskih članih, ki niso alkoholiki. Še posebej ranljivi so pri tem otroci, kjer razmere, ki se zaradi odvisnosti vzpostavijo v družinskem sistemu, vplivajo na njihov psihosocialni razvoj. Družina je najpomembnejši dejavnik v procesu socializacije otrok, pozitivno družinsko okolje pa je nujno za dobro počutje in razvoj otrok, kjer se otroci lahko naučijo in razvijejo nekatere osnovne spretnosti, kot je razvoj občutka zdravega jaza, strategij spoprijemanja s stresom, kako uravnavati svoja čustva ter vstopati in ohranjati zdrave in zadovoljujoče intimne odnose (družinske, partnerske).

V zvezi s tem nas je v pričujoči raziskavi zanimalo, kakšna je ocena funkcionalnosti družinskega življenja v primarnih družinah OOA v primerjavi z osebami, ki niso OOA in kako se funkcionalni ter nefunkcionalni vidiki družinskega življenja povezujejo z nekaterimi vidiki funkcioniranja v odraslosti, kot je doživljanje individualnih problemov in moči, regulacija čustev, kvaliteta trenutnega družinskega življenja in zadovoljstvo s partnerskim odnosom.

Preverjali smo dve hipotezi:

1. OOA so v izvorni družini doživljali več nefunkcionalnosti kot osebe, ki niso OOA.

2. Bolj kot je nefunkcionalno družinsko življenje v izvorni družini, več je v odraslosti individualnih problemov in manj moči, več je težav v regulaciji čustev, slabša je kvaliteta trenutnega družinskega življenja in slabše je zadovoljstvo s partnerskim odnosom.

4 METODA

4.1 Udeleženci

V raziskavi je sodelovalo 431 udeležencev, od tega 187 (43,4 %) OOA in 244 (56,6 %) oseb, ki niso OOA. V skupini OOA je bilo 141 žensk in 46 moških, v skupini, ki niso OOA, pa 179 žensk in 65 moških. Povprečna starost vseh udeležencev je bila 36 let (min = 18 let; max = 74 let; SD = 14,73).

4.2 Pripomočki in postopek

Udeleženci so poleg splošnega vprašalnika o demografskih podatkih (spol, starost) izpolnjevali še naslednje vprašalnike:

1. Presejalni test otrok alkoholikov (Children of Alcoholics Screening test - CAST-6) [24, 25]. CAST-6 samoocenjevalni merski instrument, ki ocenjuje otrokove občutke, vedénje ter izkušnje, povezane z uporabo oziroma zlorabo alkohola s strani staršev in kaže, ali obstaja možnost, da je anketirani otrok alkoholika.

2. Lestvico izvorne družine (Family of Origin Scale - FOS), ki je del instrumenta STIC (Systemic Therapy Inventory of Change) [26]. Ocenjuje naslednja področja družinske funkcionalnosti: pozitivnost vzdušja v izvorni družini, negativnost vzdušja v izvorni družini, vzajemnost in jasnost pričakovanj v izvorni družini, prisotnost zlorabe v izvorni družini, vsiljivost in zlorabo substanc v izvorni družini. Višji rezultat na skupnem seštevku pomeni več funkcionalnosti v izvorni družini. Koeficient zanesljivosti (Cronbachov alfa) za celotni vprašalnik v naši raziskavi znaša α=0,938.

3. Lestvico individualni problemi in moči (Individual problems and strenghts - IPS), ki je del instrumenta STIC (Systemic Therapy Inventory of Change) [26]. Uporablja se za oceno posameznikovih problematičnih in močnih področij. V skupino problemov se uvrščajo dimenzije: izraženost negativnih afektov, odsotnost inhibicije močnih impulzov, fleksibilnost/odpornost, nerazumevanje samega sebe, zloraba substanc. Višji kot so rezultati na teh lestvicah, več težav oz. individualnih problemov imajo posamezniki. V skupino osebnih moči se uvrščajo dimenzije: življenjska funkcionalnost, odprtost samoizražanja, samosprejemanje. Višji kot so rezultati na teh lestvicah, več individualnih moči imajo posamezniki. Koeficient zanesljivosti (Cronbachov alfa) za lestvico posameznikovih problemov v naši raziskavi je sprejemljiv in znaša α=0,682, za dimenzijo posameznikovih moči pa znaša α=0,776.

4. Lestvico težav pri regulaciji čustev – krajša verzija (Difficulties in emotion regulation scale – Short form - DERS – SF), ki je kratek samoporočevalni instrument za oceno različnih vidikov čustvene disregulacije oz. neprimerne regulacije čustev [27, 28] na šestih področjih: nesprejemanje čustvenih odzivov, težave pri vedenju, usmerjenemu k določenemu cilju, težave pri kontroli impulzov, pomanjkanje čustvenega zavedanja, omejen dostop do strategij čustvene regulacije in pomanjkanje čustvene jasnosti. Višji rezultat kaže na večjo prisotnost problemov v čustveni regulaciji. Koeficient zanesljivosti (Cronbachov alfa) za celotni vprašalnik v naši raziskavi znaša α=0,823.

5. Lestvico sedanje družine (Family/Household Scale - FH)), ki je del instrumenta STIC (Systemic Therapy Inventory of Change) [26], s katero smo ocenjevali naslednje dimenzije družinske funkcionalnosti: pozitivno vzdušje v sedanji družini, negativno vzdušje v sedanji družini, fizično zlorabo v sedanji družini, odločanje v sedanji družini, jasnost mej v sedanji družini in občutenje nerazumevanja v sedanji družini. Višji rezultat na skupnem seštevku pomeni več funkcionalnosti v sedanji družini. Koeficient zanesljivosti (Cronbachov alfa) za celotni vprašalnik v naši raziskavi znaša α=0,866.

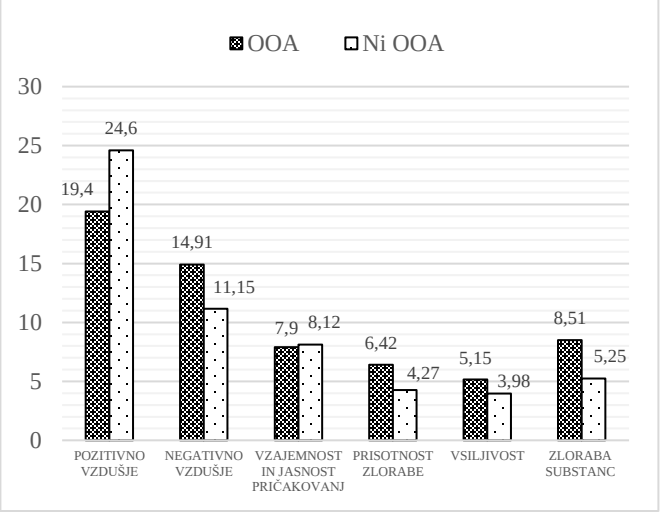
6. Kansaško lestvico zadovoljstva v zakonski zvezi (Kansas Marital Satisfaction Scale - KMSS) [29], ki je namenjena ocenjevanju zadovoljstva v zakonski/partnerski zvezi. Višji rezultat pomeni večje zadovoljstvo s partnerskim odnosom. Koeficient zanesljivosti (Cronbachov alfa) za vprašalnik v naši raziskavi znaša α=0,951.

Udeleženci so vprašalnik reševali v spletni obliki (povabilo za sodelovanje v raziskavi s povezavo do vprašalnika je bilo poslano na različne naslove in forume) in pisno (te udeležence smo pridobili na eni izmed klinik za zdravljenje alkoholizma). Anketiranje je potekalo od junija 2021 do maja 2022. Rezultate smo izračunali z uporabo programskega paketa SPSS 20.

5 REZULTATI

Hipoteza 1: OOA so v izvorni družini doživljali več nefunkcionalnosti kot osebe, ki niso OOA.

Primerjali smo podatke, ki se nanašajo na dimenzije funkcionalnosti družinskega življenja v izvorni družini glede na to, ali so udeleženci OOA, ali pa ne (razdelitev v ti dve skupini je bila narejena na osnovi vprašalnika CAST-6). Primerjava povprečnih vrednosti teh dimenzij pri OOA in osebah, ki niso OOA, so prikazane na Sliki 1.



Slika 1: Srednje vrednosti na posameznih dimenzijah funkcionalnosti družinskega življenja v izvornih družinah pri OOA in osebah, ki niso OOA.

Vidimo lahko, da so ocene povprečnih vrednosti pri vidikih funkcionalnosti družinskega življenja v izvorni družini pri OOA v primerjavi z udeleženci, ki niso OOA, višje pri nefunkcionalnih vidikih družinskega življenja (negativno vzdušje, prisotnost zlorabe, vsiljivost, zloraba substanc) in nižje pri funkcionalnih vidikih družinskega življenja (pozitivno vzdušje, vzajemnost in jasnost pričakovanj).

Statistično pomembnost razlik med skupinama smo zaradi nenormalne distribucije spremenljivk (ugotovljeno s Kolmogorov-Smirnov testom) preverili z Mann-Whitney U-testom za neodvisne vzorce. Rezultati so pokazali, da obstajajo statistično pomembne razlike med obema skupinama v vseh dimenzijah. OOA so v izvornih družinah doživljali statistično pomembno manj funkcionalno družinsko življenje kot osebe, ki niso OOA (U=9986,500; p=0,000). Pri OOA je v primerjavi z osebami, ki niso OOA, bilo v izvornih družinah prisotnega statistično pomembno manj pozitivnega vzdušja (U=12020,000; p=0,000), več negativnega vzdušja (U=12899,000; p=0,000), manj vzajemnosti in jasnosti pričakovanj (U=15616,500; p=0,000), več zlorabe (U=13660,000; p=0,000), več vsiljivosti (U=15385,000; p=0,000) in več zlorabe substanc (U=6452,500; p=0,00).

Hipoteza 2: Bolj kot je nefunkcionalno družinsko življenje v izvorni družini, več je v odraslosti individualnih problemov in manj moči, več je težav v regulaciji čustev, slabša je kvaliteta trenutnega družinskega življenja in slabše je zadovoljstvo s partnerskim odnosom.

Nadalje smo na celotnem vzorcu preverjali, kako se funkcionalnost družinskega življenja v izvorni družini (skupna dimenzija) pri posameznikih v odraslosti povezuje s posameznimi vidiki funkcionalnosti (individualni problemi in moči, težave v regulaciji čustev, kvaliteta trenutnega družinskega življenja in zadovoljstvo s partnerskim odnosom). Zaradi nenormalne distribucije spremenljivk (ugotovljeno s Kolmogorov-Smirnov testom) smo za ugotavljanje povezanosti uporabili Spearmanov korelacijski koeficient. Iz rezultatov (Tabela 1) je razvidno, da obstaja trend, da bolj kot je bilo funkcionalno družinsko življenje v izvorni družini, več je pri posameznikih v odraslosti prisotnih osebnih moči (večji so življenjska funkcionalnost, odprtost samoizražanja, samosprejemanje) in manj je osebnih problemov (manj je izraženosti negativnih afektov, odsotnosti inhibicije močnih impulzov, fleksibilnosti/odpornosti, nerazumevanja

samega sebe, zlorabe substanc). Obstaja tudi trend, da več kot je funkcionalnosti v izvorni družini, v manjši meri imajo osebe težave v regulaciji čustev (razen pri dimenziji pomanjkanje čustvenega zavedanja, kjer korelacija ni statistično pomembna). Višja funkcionalnost izvorne družine je statistično pomembno negativno povezana z vidiki nefunkcionalnosti v sedanji družini (negativno vzdušje, fizična zloraba, nerazumevanje) in pozitivno z vidiki funkcionalnosti v sedanji družini (pozitivno vzdušje, vključenost v odločanje, jasnost mej) ter zadovoljstvom s partnerskim odnosom.

Tabela 1: Korelacijski koeficienti (Spearmanov rho) med funkcionalnostjo družinskega življenja v izvorni družini in individualnim problemi ter močmi, težavami v regulaciji čustev, funkcionalnostjo trenutnega družinskega življenja in zadovoljstvom v partnerskem odnosu (N = 431).

	FOS-SKUPAJ
IPS-moči	,303**
IPS-problemi	-,326**
DERS-nesprejemanje čustvenih odzivov	-,241**
DERS-težave pri usmerjenosti k cilju	-,213**
DERS-težave pri kontroli impulzov	-,254**
DERS-pomanjkanje čustvenega zavedanja	-0,061
DERS-omejene strategije čustvene regulacije	-,256**
DERS-pomanjkanje čustvene jasnosti	-,256**
DERS-SKUPAJ	-,300**
FH-pozitivno vzdušje	,495**
FH-negativno vzdušje	-,419**
FH-fizična zloraba	-,265**
FH-vključenost v odločanje	,264**
FH-jasnost mej	,225**
FH-nerazumevanje	-,438**
FH-SKUPAJ	,484**
KMSS	,275**

*Opombe: FOS – Lestvica izvorne družine; IPS – Lestvica individualni problemi in moči; DERS – Lestvica težav pri regulaciji čustev; FH – Lestvica sedanje družine; KMSS – Kansaška lestvica zadovoljstva v zakonski zvezi; ** – statistično pomemben rezultat na nivoju 1 % tveganja.*

6 RAZPRAVA IN SKLEP

Rezultati potrjujejo, da alkoholizem staršev globoko negativno zaznamuje delovanje družinskega sistema, saj OOA, ki so odraščali ob starših alkoholikih, poročajo o manj funkcionalnem družinskem sistemu kot osebe, ki so odraščale v družinah brez alkoholizma staršev. V družinah alkoholikov je tako po retrospektivni oceni njihovih odraslih otrok v splošnem zaznati manj pozitivnosti in več negativnosti vzdušja, kar potrjujejo tudi druge raziskave [30, 31]. V družinah z alkoholizmom staršev je tudi manj jasnosti glede tega, kaj družinski člani pričakujejo drug od drugega, prav tako je manj vzajemnosti pri skupnem odločanju. Več pa je vsiljivosti s strani staršev in drugih družinskih članov. Vse to nakazuje na porušene in neprimerne razmejitve v družinah, kjer je prisoten alkoholizem staršev. Alkoholične družine so namreč mnogokrat slabo diferencirane. Zaradi velike napetosti so posamezniki stalno zaskrbljeni, prilagajajo se in reagirajo na vedenje alkoholika, v družini ni možnosti za avtonomni razvoj posameznika, njegova samopodoba je izrazito negativna [32]. Kot poročajo tudi druge raziskave [3, 33], je tudi po naših rezultatih v družinah z alkoholizmom staršev prisotnega več zlorabljajočega vedenja, ki ga spremlja tudi višja stopnja zlorabe substanc pri družinskih članih. Izrazita raba alkohola pri staršu npr. pomembno povečuje tveganje, da bo do otroka na nek način zlorabljajoč. Več kot je v družini članov, ki zlorabljajo ali so odvisni od alkohola, bolj bo verjetno, da bodo otroci v družini zlorabljeni ali zanemarjeni [7].

Vse te družinske okoliščine predstavljajo dejavnik tveganja za zdrav razvoj otrok, ki so izrazito ranljivi na vzdušje v družinski klimi. Družina z dinamiko odnosov je namreč temeljno okolje njihovega psihosocialnega razvoja [34]. Aktivnosti in dinamike v družinah, kjer je prisoten alkoholizem staršev, so podrejene odvisniškemu vedenju. S podrejenostjo odvisnosti je zaznamovana celotna družinska klima. Starševska drža odvisnih staršev je običajno nefunkcionalna, nekonsistentna in kaotična, kar za otroke pomeni živeti v nenehni napetosti in strahu, saj nikoli ne vedo, kaj lahko pričakujejo iz trenutka v trenutek. V teh primerih imajo tudi neprestano občutek, da karkoli naredijo, ni prav, na osnovi tega pa se oblikuje občutek, da je nekaj narobe z njimi [6]. Otroci so čustveno zasedeni in podrejeni vzdušju v družini. Tipičen odraz tega je prevzemanje različnih vlog v družini (npr. postaršenje), za katere otroci čustveno niso dozoreli [16]. V prilagajanju družinskemu stanju poskušajo otroci na svojo škodo narediti vse, da ohranjajo ravnovesje v družini in njeno delovanje [35].

Ti otroci te izkušnje in dojemanje družinskih pravil nosijo s seboj v najstništvo in odraslost in verjetneje zgradijo izkrivljene temelje, na katerih delujejo naprej. Kot otroci so se namreč naučili obnašati na različne načine, ki so jim omogočali preživeti. To vedenje se lahko giblje od kljubovanja avtoriteti do zatiranja lastnih potreb in pretirane pozornosti na potrebe drugih [6]. Nefunkcionalna družinska klima (tudi v družinskem sistemu, kjer ni alkoholizma) tako odmeva v odraslosti, kar potrjujejo tudi rezultati naše raziskave. Obstaja namreč trend, da več kot je bilo disfunkcionalnosti družinskega življenja v družinah, kjer so posamezniki odraščali, več težav imajo na različnih področjih funkcioniranja v odraslosti (na področju osebnih problemov in moči, pri regulaciji čustev, pri doživljanju kvalitete življenja v trenutnem družinskem okolju in doživljanju zadovoljstva v partnerskem odnosu).

Čeprav vsi otroci alkoholikov ne odrastejo v odrasle, ki bi ne bili funkcionalni, z našo raziskavo, ki se pridružuje tudi drugim obstoječim raziskavam tega področja, izpostavljamo vidno in nevidno tveganje, ki so mu izpostavljeni otroci alkoholikov v svojih primarnih družinah, posledice pa so vidne tudi v odrasli dobi. Rečemo lahko, da so OOA (skrite) žrtve alkoholizma staršev in zato je utemeljena potreba po psihosocialni in terapevtski podpori tudi takrat, ko so že zapustili svoje primarno družinsko okolje in ustvarili novega.

REFERENCE

[1] Nacionalni inštitut za javno zdravje. (2018). *Alkoholna politika v sloveniji priložnosti za zmanjševanje škode in stroškov ter neenakosti med prebivalci.* Ljubljana: NIJZ.

[2] Nacionalni inštitut za javno zdravje. (2019). *Pandemija covid-19 v Sloveniji.* https://www.nijz.si/sites/www.nijz.si/files/uploaded/panda_porocilo_po_18._valu_koncno_0.pdf.

[3] Solis, J. M., Shadur, J. M., Burns, A. R., in Hussong, A. M. (2012). Understanding the diverse needs of children whose parents abuse substances. *Current Drug Abuse Reviews, 5*(2), 135–147. https://doi.org/10.2174%2F1874473711205020135

[4] Rangarajan S., in Kelly L. (2006). Family communication patterns, family environment, and the impact of parental alcoholism on offspring self-esteem. *Journal of Social and Personal Relationships, 23*(4), 655–671. https://psycnet.apa.org/doi/10.1177/0265407506065990

[5] Vernig, P. M. (2011). Family roles in homes with alcohol-dependent parents: An evidence-based review. *Substance Use & Misuse*, *46*(4), 535–542. https://doi.org/10.3109/10826084.2010.501676

[6] Ruben, D. H. (2001). *Treating adult children of alcoholics: A behavioral approach.* San Diego: Academic Press.

[7] Gold, M. S., in Adamec, C. (2010). *The encyclopedia of alcoholism and alcohol abuse.* New York: Infobase Publishing.

[8] Caan, W. (2013). Alcohol and the family. *Contemporary Social Science, 8*(1), 8–17. https://doi.org/10.1080/21582041.2012.745594

[9] McLaughlin, K. A., Gadermann, A. M., Hwang, I., Sampson, N. A., Al-Hamzawi, A., Andrade, L. A., Angermeyer, M. C., Benjet, C., Bromet, E. J., Bruffaerts, R., Caldas-de-Almeida, J. M., de Girolamo, G., de Graaf, R., Florescu, S., Gureje, O., Haro, J. M., Hinkov, H. R., Horiguchi, I., Hu, C., Karam, A. N., Kovess-Masfety, V., Lee, S., Murphy, S. D., Nizamie, S. H., Posada-Villa, J., Williams, D. R., in Kessler, R. C. (2012). Parent psychopathology and offspring mental disorders: Results from the WHO World Mental Health Surveys. *British Journal of Psychiatry, 200*(4), 290–299. https://doi.org/10.1192/bjp.bp.111.101253

[10] Ashenberg Straussner, S. L. (2011). Children of substance-abusing parents: An overview. V S. L. Ashenberg Straussner, in C. Huff Fewell (Ur.), *Children of substance-abusing parents* (str. 1–27). New York: Springer.

[11] Hall, C. W., in Webster, R. E. (2007). Risk factors among adult children of alcoholics. *International Journal of Behavioral Consultation and Therapy, 3*(4), 494–511. https://doi.org/10.1037/h0100819

[12] Pasternak, A., in Schier, K. (2012). The role reversal in the families of Adult Children of Alcoholics. *Archieves of Psychiatry and Psychotherapy, 14*(3), 51–57. http://w.archivespp.pl/uploads/images/2012_14_3/Pasternak51_ArchivesPP_3_2012.pdf

[13] Burnett, G., Jones, R. A., Bliwise, N. G., in Ross, L. T. (2006). Family unpredictability, parental alcoholism, and the development of parentification.

[14] *The American Journal of Family Therapy, 34*(3), 181–189. https://psycnet.apa.org/doi/10.1080/01926180600550437

[15] Haverfield, M. C., Theiss, J. A., in Leustek, J. (2016). Characteristics of communication in families of alcoholics. *Journal of Family Communication, 16*(2), 111–127. https://doi.org/10.1080/15267431.2016.1146284

[16] Earley, L., in Cushway, D. (2002). The parentified child. *Clinical Child Psychology and Psychiatry, 7*(2), 163−178. https://doi.org/10.1177/1359104502007002005

[17] Kearney, P., Levin, E., in Rosen, G. (2000). *Alcohol, drug and mental health problems: Working with families.* London: National Institute for Social Work.

[18] Dayton, T. (2011). Treatment issues and psychodrama interventions with adults who grew up with substance-abusing Parents. V S. L. Ashenberg Straussner, in C. Huff Fewell (Ur.), *Children of substance-abusing parents* (str. 153–170). New York: Springer.

[19] Şen-Aslan, H. (2021). A family problem: The effects of parental alcohol on children. *Nesne, 9*(19), 127–138. https://dx.doi.org/10.7816/nesne-09-19-10

[20] Hart, K. E., Fiissel, D. L., in McAleer, M. (2003). Do adult offspring of alcoholics suffer from poor medical health? A three-group comparison controlling for self-report bias. *The Canadian Journal of Nursing Research, 35*(1), 53–72.

[21] Harter, S. L. (2000). Psychosocial adjustment of adult children of alcoholicss: A review of the recent empirical literature. *Clinical Psychology Review, 20*(3), 311–337. https://doi.org/10.1016/s0272-7358(98)00084-1

[22] Collins, G. R. (2007). *Christian Counselling.* Nashville: Thomas Nelson.

[23] Kelley, M. L., Cash, T. F., Grant, A. R., Miles, D. L., in Santos, M. T. (2004). Parental alcoholism: Relationships to adult attachment in college women and men. *Addictive behaviors, 29*(8), 1633–1636. https://doi.org/10.1016/j.addbeh.2004.02.064

[24] Sorocco, K. H., Carnes, N., C., Cohoon, A. J., Vincent, A. S., in Lovallo, W. R. (2015). Risk factors for alcoholism in the Oklahoma Family Health Patterns project: Impact of early life adversity and family history on affect regulation and personality, drug and alcohol dependence. *Drug and Alcohol Dependence, 150*, 38–45. https://doi.org/10.1016/j.drugalcdep.2015.02.001

[25] Hodgins, D. C., Maticka-Tyndale, E., El-Guebaly, N., in West, M. (1993). The cast-6: development of a short-form of the Children of alcoholics screening test. *Addictive Behaviours*, *18*(3), 337– 345. https://doi.org/10.1016/0306-4603(93)90035-8

[26] Pilat, J. M., in Jones, J. W. (1984). Identification of children of alcoholics: Two empirical studies. *Alcohol Health and Research World, 9*(2), 27–36.

[27] Pinsof, W. M., Zinbarg, R. E., Shimokawa, K., Latta, T. A., Goldsmith, J. Z., Knobloch-Fedders, L. M., Chambers, A. L., in Lebow, J. L. (2015). Confirming, validating, and norming the factor structure of Systemic Therapy Inventory of Change initial and intersession. *Family Process, 54*(3), 464–484. https://doi.org/10.1111/famp.12159

[28] Gratz, K. L., in Roemer, E. (2004). Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54. https://psycnet.apa.org/doi/10.1023/B:JOBA.0000007455.08539.94

[29] Kaufman, E. A., Xia, M., Fosco, G., Yaptangco, M., Skidmore, C. R., in Crowell, S. E. (2016). The difficulties in emotion regulation scale short form (DERS-SF): Validation and replication in adolescent and adult samples. *Journal of Psychopathology and Behavioral Assessment*, *38*(3), 443–455. https://psycnet.apa.org/doi/10.1007/s10862-015-9529-3

[30] Schumm, W. R., Paff-Bergen, L. A., Hatch, R. C., Obiorah, F. C., Copeland, J. M., Meens, L. D., in Bugaighis, M. A. (1986). Concurrent and discriminant validity of the Kansas Marital Satisfaction Scale. *Journal of Marriage and the Family, 48*)2), 381–387. https://psycnet.apa.org/doi/10.2307/352405

[31] Johnson, P. (2001). Dimensions of functioning in alcoholics and nonalcoholics families. *Journal of Mental Health Counseling, 23*(2), 127–136.

[32] Schroeder, V. M., in Kelley, M. L. (2008). The influence of family factors on the executive functioning of adult children of alcoholics in college. *Family Relations, 57*(3), 404–414. https://doi.org/10.1111/j.1741-3729.2008.00509.x

[33] Crespi, T. D., in Rueckert, Q. H. (2006). Family therapy and children of alcoholics: Implications for continuing education and certification in substance abuse practice. *Journal of Child & Adolescent Substance Abuse, 15*(3), 33–44. https://doi.org/10.1300/J029v15n03_03

[34] Lander, L., Howsare, J., in Byrne, M. (2013). The impact of substance use disorders on families and children: from theory to practice. *Social Work in Public Health, 28*(3-4), 194–205. https://doi.org/10.1080%2F19371918.2013.759005

[35] Wong, W. P. L. (2012). Underestimated impact of family climate on young adult: Mediation and moderation effects of psychosocial maturity on well-being discovery. *SS Student E-Journal, 1*(1), 60–90. http://ssweb.cityu.edu.hk/download/RS/E-Journal/journal4.pdf

[36] Hooper, L. M., in Wallace, S. A. (2010). Evaluating the parentification questionnaire: psychometric properties and psychopathology correlates. *Contemporary Family Therapy, 32*(1), 52–68. https://psycnet.apa.org/doi/10.1007/s10591-009-9103-9

Nevrobiološko ozadje težav v čustveni regulaciji in tveganje za odvisnost od alkohola

Neurobiological background of difficulties in emotion regulation and the risk of alcohol dependence

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POVZETEK[1]

Odvisnost od alkohola in njegova tvegana raba je pogosto povezana z manj funkcionalno regulacijo čustvenih odzivov [1]. Alkoholizem pa predstavlja velik družbeni in zdravstveni problem. Ko ima oseba funkcionalne sposobnosti čustvene regulacije, lahko prepoznava čustva in lahko kontrolira njihovo izražanje. Nasprotno, oseba z nefunkcionalnimi veščinami čustvene regulacije se svojih čustev ne zaveda, zato so njihova dejanja lahko zelo impulzivna. Nefunkcionalno regulirani čustveni odzivi povzročajo v telesu neobvladljivo stisko, saj vznemirijo celoten hormonski sistem (hipotalamus-hipofizo-nadledvično (HPA) os). Kadar posameznik nima funkcionalnih veščin čustvene regulacije, nezavedno poskuša nadomestiti pomanjkanje funkcionalne regulacije z obliko nefunkcionalne regulacijske oblike. Naša raziskava statistično pomembno kaže, da je ena od oblik nefunkcionalne regulacije čustvenega stanja posameznika tvegana raba alkohola.

V našem prispevku predstavljamo rezultate raziskave, ki kaže na statistično pomembne povezave med različnimi dimenzijami nefunkcionalne čustvene regulacije in tvegano rabo alkohola. V raziskavi je sodelovalo 478 odraslih posameznikov. Še posebej močna je korelacija med posamezniki, ki se čustev manj zavedajo (DERS dimenzija zavedanje čustev) in tvegano rabo alkohola.

Prikazani rezultati kažejo na potrebo po psihoterapevtski obravnavi saj le-ta lahko omogoči posameznikom, da se soočijo s težavami v čustveni regulaciji in bolj funkcionalno regulirajo svoja čustva ter se manj zatekajo k tvegani rabi alkohola.

KLJUČNE BESEDE

čustvena regulacija, nevrobiološko ozadje, zloraba alkohola

ABSTRACT

Alcohol dependence and its risky use are often associated with less functional regulation of emotional responses [1]. Alcoholism is a major social and health problem. When a person has functional emotional regulation skills, they can recognize emotions and can control their expression. Conversely, a person with dysfunctional emotional regulation skills is not aware of their emotions, so their actions can be very impulsive. Dysfunctional regulated emotional responses cause uncontrollable distress in the body, as they upset the entire hormonal system. Because individual lacks functional emotional regulation skills, they often tried to compensate for the lack of functional regulation with a form of dysfunctional regulation. Our research statistically significantly shows that one of the forms of dysfunctional regulation of an individual's emotional state is the risky use of alcohol.

In our paper, we present the results of the research, which show statistically significant connections between different dimensions of dysfunctional emotional regulation and risky alcohol use. 478 adults participated in the research. The correlation between individuals who are less aware of emotions (DERS emotional awareness dimension) and risky alcohol use is particularly strong.

The results shown indicate the need for psychotherapeutic treatment, as it could enable individuals to face problems in emotional regulation and regulate their emotions more functionally and resort less to the risky use of alcohol.

KEYWORDS

emotional regulation, neurobiological background, alcohol abuse

1 NEVROBIOLOŠKO OZADJE TEŽAV V ČUSTVENI REGULACIJI

Raziskovalci [2] ugotavljajo povezavo med čustveno kontrolo in HPA (hipotalamus-hipofiza-nadledvična žleza) osjo. HPA os je nevroendokrini sistem, ki se aktivira ob stresu. Ob travmatičnih izkušnjah in stresnih situacijah pride v delovanju HPA osi do funkcionalnih sprememb, ki se kažejo kot hipo ali hiperaktivnost določenih hormonov v centralnem živčnem sistemu [2, 3], z namenom da se telesno stanje pripravi na boj ali beg. Iz tega se da sklepati, da je disregulirana HPA os, zaradi akutnih ali dolgoročnih sprememb, bolj ranljiva in vpliva na slabše telesne in posledično čustvene odzive na stresna stanja [2, 4, 5], kar lahko prepoznamo kot težave pri čustveni regulaciji.

Motnje pri delovanju HPA osi kažejo na težave v čustveni regulaciji, saj so, med drugim, povezane z razvojem depresije ali PTSM, ter so obenem povezane z večjo verjetnostjo uživanja alkohola, kar kažejo ugotovitve avtorjev [2, 6]. PTSM je povezana z

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zmanjšano reaktivnostjo HPA osi, vključno s hipokortizolizmom , medtem ko je za depresijo značilna povečana reaktivnost HPA osi, vključno s hiperkortizolizmom [3]. Bolj natančno povezanost med uživanjem alkohola in mehanizmi HPA osi še vedno raziskujejo, vendar nekatere ugotovitve kažejo, da oslabljena aktivnost adrenokortikotropnega hormona (ACTH) in kortizola lahko predstavlja ranljivost za uživanje alkohola [2] Čustvena stanja v posamezniku se namreč prevajajo v jezik kortizola, digitalni signali misli in čustev se v posameznikovem telesu prevedejo na analogno in enostavno raven kortizola, ki jo izražamo v številkah.

V prisotnosti akutnega stresa (pretirana vročina, mraz, poškodbe, infekcije, stres, močna čustva), aktivirana HPA os vpliva na sproščanje povečane ravni sprostilnega hormona kortikotropina (CRH) iz hipotalamusa, ki je stimulator za izločanje hormona kortikotropina - adrenokortikotropnega hormona (ACTH), ki se izloča iz srednjega dela hipofize. ACTH spodbuja izločanje glukokortikoidov, vključno s kortizolom (pri ljudeh), da prepreči odziv na stres v predelih, kot sta hipotalamus, kot tudi hipokampus, prefrontalni korteks in hipofize preko negativne povratne zveze [2,14]

V raziskavi se je pokazalo, da imajo npr. posamezniki s PTSM oslabljen ACTH ob stresu [7]. Obenem je neka druga raziskava pokazala, ob kratkotrajni abstinenci pri posameznikih odvisnih od alkohola, oslabljeno aktivnost HPA osi ob izpostavljenosti stresu [8] in nižjim ACTH, zaradi česar so bolj ranljivi za ponovno uporabo alkohola, kot posamezniki z visokim odzivom ACTH. [9].

Ugotovitve kažejo, da lahko zmanjšana ACTH in kortizol pomenita ranljivost za uporabo alkohola pri posameznikih s PTSM. Kar zadeva depresijo, je uživanje alkohola povezano s povečanimi ravnmi ACTH in kortizola pri ljudeh in živalskih modelih [8, 10,11]. Disregulirano stanje HPA osi in hormonsko neravnovesje namreč kažeta na težave pri čustveni regulaciji.

2 TVEGANA RABA ALKOHOLA V POVEZAVI S TEŽAVAMI PRI ČUSTVENI REGULACIJI

Zmanjšana zavestna kontrola emocionalnih stanj poveča občutljivost za težave pri uravnavanju čustev in s tem se poveča verjetnost, da bodo ti posamezniki uživali alkohol do opojnih stanj z namenom doseči kratkotrajno regulacijo čustev. Raziskave so namreč pokazale, da je konzumacija alkohola pri lajšanju negativnih občutkov najbolj učinkovita, ko so bile zaužite doze alkohola, ki imajo omamen učinek [12].

Uživanje alkohola kot kratkoročni mehanizem za uravnavanje čustev je dobro dokumentirano; alkohol namreč lahko ponudi "priložnost za obvladovanje" za posameznike, pri katerih je zaznati težave na področju zavestne kontrole čustvenega stanja [12].
Fiziološki učinki alkohola vplivajo na povečanje aktivnosti dopaminogeničnih, noradrenalinih in opioidih peptidov ter s tem lahko pozitivno okrepijo afektivna stanja. Obenem pa lahko negativno okrepijo afektivna stanja ko delujejo na receptorje gama-aminomaslene kisline (GABAA) v hipokampusu in kortikalnih regijah. Avtorji [12, 2] kot eno od fizioloških posledic alkohola opisujejo tudi zmanjšanje negativnih čustev, kot so anksioznost, jeza in strah; zmanjša pa se tudi čustveno vzburjenje.

Alkohol namreč, kot mnoge druge vrste drog, sproži sproščanje dopamina iz ventralnega tegmentalnega področja (VTA), ki vpliva na mezolimbične možganske strukture, kot npr. medialni prefrontalni korteks (mPFC), nucleus accumbens (NAcc) bazolateralna amigdala in različni prefrontalni predeli [22]. Ta vpliv dopamina pri posamezniku povzroči občutek sreče in pomiritve.

Dopamin igra pomembno vlogo pri razvoju odvisnosti (posameznik želi več alkohola, droge). Občutki, da posameznik uživa v alkoholu ali drogi pa so v telesu vzpostavljeni s striatnim opioidergičnim nevrotransmiterjem oziroma endorfinom, ki se ob uživanju alkohola prav tako sprošča [23].

Stres in alkohol namreč delujeta po isti poti, oba povečata reaktivnost HPA osi, povišane ravni hormonov HPA pa spodbujajo sproščanje endorfina, ki je povezan z drugimi možganskimi področji (npr. ventralno tegmentalno območje) in ojačevalnimi učinki alkohola oziroma drog [13, 15]. Z večjimi količinami zaužitega alkohola se poveča reaktivnost HPA osi, vključno z ACTH in kortizolom ter se dosežejo želeni učinki krepitve v sistemu, ki pa ima za posledico povečano aktivnost ACTH in kortizola.

Kot rečeno mnoge študije kažejo na povezanost težav pri uravnavanju in delovanju čustev ter uživanjem alkohola in težavami povezanimi s tem [16, 12]. Raziskava je pokazala, da je bila visoka stopnja negativnih emocij in pa impulzivnosti, kot odziva na negativne emocije, v pozitivni korelaciji z rizično uporabo alkohola in pitjem do popolne omamljenosti [17]. Tudi čustvena nestabilnost je bila povezana z nevarno rabo alkohola [18]. Opredeljeni so bili namreč trije indikatorji čustvenega funkcioniranja in sicer: impulzivnost, čustvena (ne)stabilnosti in toleranca na stres. Raziskovalci so ugotovili, da je višja stopnja odpornosti na stres in bolj pozitivno afektivno stanje posameznika v negativni korelaciji z uporabo alkohola in je lahko neke vrsta zaščita pred tvegano rabo alkohola [17].

3 OPREDELITEV PROBLEMA IN HIPOTEZE

Težave pri čustvenem funkcioniranju pogosto vodijo v manj zadovoljivo vsakdanje življenje. Poleg tega, da lahko negativno vplivajo na medosebne odnose, težave v čustveni regulaciji zelo močno obremenjujejo posameznika samega. Kot smo videli v uvodnem delu, so mnoge študije [2,3,4, 8,11, 16] neregulirane emocije povezale z večjo ranljivostjo nevrobiološkega odziva telesa, še posebej HPA osi, ki se odziva in uravnava stres pri posamezniku. Ker taka ranljivost na stresne situacije lahko v telesu povzroči veliko neobvladljivih emocij in telesnih občutkov, pogosto posamezniki nezavedno

poskušajo to stanje uravnati s pomočjo alkohola [22,12,23]..

Glede na to nas je v konkretni raziskavi zanimala povezanost med težavami pri čustveni regulaciji, na različnih dimenzijah ter tvegano uporabo alkohola.

Preverjali smo naslednjo hipotezo:

Hipoteza 1: Posamezniki z več težavami pri čustveni regulaciji bolj tvegano uživajo alkohol

4 METODA

4.1 Udeleženci

V raziskavi je sodelovalo 476 udeležencev, od tega 348 (73,1 %) žensk in 128 (26,9 %) moških. Povprečna starost vseh udeležencev je bila 35 let (SD=14,5).

4.2 Pripomočki in postopek

Udeleženci so poleg splošnega vprašalnika o demografskih podatkih (spol, starost) izpolnjevali še naslednje vprašalnike:

1. Lestvico težav pri regulaciji čustev – krajša verzija (Difficulties in emotion regulation scale – Short form - DERS – SF), ki je kratek samoporočevalni instrument za oceno različnih vidikov čustvene disregulacije oz. neprimerne regulacije čustev [19, 20] na šestih področjih: nesprejemanje čustvenih odzivov, težave pri vedenju, usmerjenemu k določenemu cilju, težave pri kontroli impulzov, pomanjkanje čustvenega zavedanja, omejen dostop do strategij čustvene regulacije in pomanjkanje čustvene jasnosti. Višji rezultat kaže na večjo prisotnost problemov v čustveni regulaciji. Koeficient zanesljivosti (Cronbachov alfa) za celotni vprašalnik v naši raziskavi znaša α=0,823.

2. Vprašalnik o stopnji tveganosti rabe alkohola AUDIT (The Alcohol Use Disorders Identification Test AUDIT (WHO) je test, ki omogoča prepoznati trenutne težave s pitjem alkohola (npr. škodljivo rabo alkohola, zlorabo alkohola in odvisnost od alkohola) [21]. Meri tri vidike zlorabe alkohola: tvegano uživanje alkohola (količina in pogostost), simptome odvisnosti od alkohola (toleranca, sposobnost kontrole) in z uživanjem alkohola povezane probleme. Višji rezultat kaže na bolj tvegano rabo alkohola. Koeficient zanesljivosti (Cronbachov alfa) za celotni vprašalnik v naši raziskavi znaša α=0,935.

Udeleženci so vprašalnik reševali v spletni obliki (povabilo za sodelovanje v raziskavi s povezavo do vprašalnika je bilo poslano na različne naslove in forume) in pisno (te udeležence smo pridobili na eni izmed klinik za zdravljenje alkoholizma). Anketiranje je potekalo od junija 2021 do maja 2022. Rezultate smo izračunali z uporabo programskega paketa SPSS 20.

5 REZULTATI

Hipoteza 1: Posamezniki z več težavami pri čustveni regulaciji bolj tvegano uživajo alkohol.

Na našem vzorcu smo preverjali, kako se težave pri čustveni regulaciji v šestih dimenzijah ter skupni dimenziji pri posameznikih povezujejo s tvegano uporabo alkohola na treh dimenzijah ter skupni dimenziji. Ker so naši podatki nenormalno distribuirani (test Kolmogorov-Smirnov), smo za ugotavljanje povezanosti uporabili Spearmanov korelacijski koeficient.

Rezultati (Tabela 1) kažejo, da obstaja statistično pomembna povezava med posamezniki z več težavami pri čustvenem regulaciji in bolj tvegana uporaba alkohola.

Na našem vzorcu smo preverjali kako se tvegana raba alkohola (skupna dimenzija) povezuje z različnimi vidiki težav pri čustveni regulaciji, ki smo jih merili na šestih dimenzijah ter skupno dimenzijo (nesprejemanje čustvenih odzivov, težave pri usmerjenosti k cilju, težave pri kontroli impulzov, pomanjkanje čustvenega zavedanja, omejene strategije čustvene regulacije, pomanjkanje čustvene jasnosti in skupna dimenzija)

Iz tabele 1 je razvidno da se tvegana raba alkohola statistično pomembno pozitivno povezuje z vsemi dimenzijami težav pri čustvenem funkcioniranju. Obstaja trend, da več kot je pri posamezniku nesprejemanja čustvenih odzivov, težav pri usmerjenosti k cilju, težav pri kontroli impulzov ter omejene strategije čustvene regulacije, več je tvegane rabe alkohola. Še posebej statistično pomembna pozitivna povezava obstaja med dimenzijo pomanjkanje čustvenega zavedanja in tvegano rabo alkohola (rho =.173**, p = .000) . Statistično pomembna je tudi povezava med dimenzijo pomanjkanje čustvene jasnosti in tvegano rabo alkohola, vendar na nivoju 5% tveganja.

Tabela 1: Korelacijski koeficienti (Spearmanov rho) med težavami pri regulaciji čustev (vse dimenzije) in tvegano rabo alkohola (skupna dimenzije) (N = 476).

		AUDIT SKUPAJ
DERS - nesprejemanje_čust_odzivov	r_{ho}	.134**
	p	**.003**
DERS - cilji	r_{ho}	.134**
	p	**.003**
DERS - impulzi	r_{ho}	.154**
	p	**.001**
DERS - Pomanjkanje čustevenega zavedanja	r_{ho}	.173**
	p	**.000**
DERS - omejene_strategije_regulacije	r_{ho}	.149**
	p	**.001**
DERS - čustvena_jasnost	r_{ho}	.107*
	p	**.016**
DERS	r_{ho}	.164**

SKUPAJ	p	**.000**

*Opombe: DERS – Lestvica težav pri regulaciji čustev; AUDIT - Vprašalnik o stopnji tveganosti rabe alkohola; ** – statistično pomemben rezultat na nivoju 1 % tveganja. * – statistično pomemben rezultat na nivoju 5 % tveganja.*

6 RAZPRAVA IN SKLEP

Rezultati potrjujejo, da so posamezniki s težavami pri čustveni regulaciji bolj nagnjeni k tvegani rabi alkohola. Težave v čustveni regulaciji imajo zapleteno nevrobiološko ozadje, ki povzroči disharmonično telesno stanje. Ob različnih stresnih situacijah, kjer se kažejo težave pri čustveni regulaciji, prihaja do vzburjene HPA osi. Posameznik nezavedno išče čim hitrejše načine regulacije, kjer se pogosto sreča z alkoholom kot enim od možnih načinov hitre pomiritve telesnega neravnovesja [1].

In kot lahko vidimo iz naših rezultatov (tabela 1), je pri posameznikih s težavami pri čustveni regulaciji statistično pomembna povezanost s tvegano rabo alkohola. Še posebej je to opazno pri dimenziji Pomanjkanje čustvenega zavedanja. Pri tej dimenziji težav pri čustveni regulaciji obstaja statistično pomembna pozitivna povezava. Posamezniki, ki se svojih čustev ne zavedajo, jih pogosto disocirajo. Disocirana ali potlačena čustva pa v telesu povzročajo neravnovesje, kar se kaže preko treh indikatorjev čustvenega funkcioniranja in sicer: impulzivnosti, čustvene (ne)stabilnosti in tolerance na stres [18].

Ker alkoholizem predstavlja velik javnozdravstveni in družbeni problem, je pomembno razumeti, da so težave pri čustveni regulaciji povezane s tvegano rabo alkohola. Ravno zaradi tega vedenja je lahko več zavestnih družbenih akcij usmerjenih v preventivno delovanje na področju bolj funkcionalne regulacije čustev, kot je npr. psihoedukacija, psihoterapija ali katera druga oblika ozaveščanja čustvenega stanja pri posamezniku [16]. S tovrstnim preventivnim delovanjem je mogoče ponuditi eno od poti za zmanjšanje posledic povezanih z alkoholom.

Naše ugotovitve podpirajo prejšnje raziskave, ki kažejo, da so težave z uravnavanjem čustev pogosto povezane s posledicami, povezanimi z alkoholom.

REFERENCE

[1] Khantzian E. J., Albanese M. J. (2008). *Understanding Addiction as Self-Medication: Finding Hope Behind the Pain.* London, New York: Rowman & Littlefield;

[2] Klanecky, A. K., & McChargue, D. E. (2012). Vulnerability to alcohol use disorders following early sexual abuse: The role of effortful control. *Addiction Research & Theory, 21(2), 160–180.* doi:10.3109/16066359.2012.703269

[3] Heim, C., Newport, J., Wagner, D., Wilcox, M.M., Miller, A.H. in Nemeroff, C.B. (2002). The role of early adverse experience and adulthood stress in the prediction of neuroendocrine stress reactivity in women: A multiple regression analysis. *Depression & Anxiety*, 15, 117–125;

[4] Majewska, M.D. (2002). HPA axis and stimulant dependence: An enigmatic relationship. *Psychoneuroendocrinology*, 27, 5–12.

[5] Alexander, N., Kuepper, Y., Schmitz, A., Osinsky, R., Kozyra, E. in Hennig, J. (2009). Gene-environment interactions predict cortisol responses after acute stress: Implications for the etiology of depression. *Psychoneuroendocrinology*, 34, 1294–1303.

[6] Hein, D., Cohen, L. in Campbell, A. (2005). Is traumatic stress a vulnerability factor for women with substance use disorders? *Clinical Psychology Review*, 25, 813–823.

[7] Santa Ana, E.J., Saladin, M.E., Back, S.E., Waldrop, A.E., Spratt, E.G., McRae, A.L. in Brady, K.T. (2006). PTSD and the HPA axis: Differences in response to the cold pressor task among individual with child vs adult trauma. *Psychoneuroendocrinology*, 31, 501–509.

[8] Lovallo, W.R. (2006). Cortisol secretion patterns in addiction and addiction risk. *International Journal of Psychophysiology*, 59, 195–202.

[9] Brady, K.T., Back, S.E., Waldrop, A.E., McRae, A.L., Anton, R.F., Upadhyaya, H.P. in Randall, P.K. (2006). Cold pressor task reactivity: Predictors of alcohol use among alcohol-dependent individuals with and without comorbid posttraumatic stress disorder. *Alcoholism: Clinical and Experimental Research*, 30, 938–946.

[10] Przybycien-Szymanska, M.M., Rao, Y.S. in Pak, T.R. (2010). Binge-pattern alcohol exposure during puberty induces sexually dimorphic changes in genes regulating the HPA axis. *American Journal of Physiology – Endocrinology and Metabolism*, 298, E320–E328.

[11] Adinoff, B., Iranmaneshi, A., Veldhuis, J. in Fisher, L. (1998). Disturbances of the stress response. *Alcohol Health & Research World*, 22, 67–72.

[12] Sher, K.J. in Grekin, E.R. (2007). *Alcohol and affect regulation*. V J.J. Gross (Ur.), Handbook of emotion regulation (pp. 560–580). New York, NY: Guilford Press.

[13] Gianoulakis, C. (1998). Alcohol-seeking behavior: The roles of the hypothalamic-pituitary-adrenal axis and the endogenous opioid system. *Alcohol Health & Research World*, 22, 202–210.

[14] Lupien SJ, McEwen BS, Gunnar MR, Heim C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nat. Rev. Neurosci.;* 10:434–445.

[15] Milivojevic, V., H. C. Fox in Rajita Sinha. (2015) *Neural Mechanisms Associated with Stress-Induced Drug Craving.* V S.J.Wilson (Ur.) The Wiley Handbook on the Cognitive Neuroscience of Addiction. 240-265.

[16] Dvorak, R. D., Sargent, E. M., Kilwein, T. M., Stevenson, B. L., Kuvaas, N. J. in Williams, T. J. (2014). Alcohol use and alcohol-related consequences: associations with emotion regulation difficulties. *The American Journal of Drug and Alcohol Abuse, 40(2), 125–130.* doi:10.3109/00952990.2013.877920

[17] Wray T.B., Simons J.S., Dvorak R.D., Gaher R.M. (2012) Trait-based affective processes in alcohol-involved ''risk behaviors''. *Addict Behav*; 37:1230–1239

[18] Simons J.S., Carey K.B., Wills T.A. (2009). Alcohol abuse and dependence symptoms: a multidimensional model of common and specific etiology. *Psychol Addict Behav*; 23:415–427.

[19] Kaufman, E. A., M. Xia, G. Fosco, M. Yaptangco, C. R. Skidmore in S. E. Crowell. (2016). The difficulties in emotion regulation scale short form (DERS-SF): Validation and replication in adolescent and adult samples. *Journal of Psychopathology and Behavioral Assessment*, 38(3), 443–455.

[20] Gratz, K. L. in Roemer, E. (2004). Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, 26(1), 41–54.
https://psycnet.apa.org/doi/10.1023/B:JOBA.0000007455.08539.94

[21] Saunders, J.B., Aasland, O.G., Babor, T.F., de la Fuente, J.R. in Grant, M. Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption. II. Addiction, 88, 791-804, 1993.

[22] Morel, C., Montgomery, S., & Han, M.-H. (2018). Nicotine and alcohol: the role of midbrain dopaminergic neurons in drug reinforcement. *European Journal of Neuroscience.* doi:10.1111/ejn.14160

[23] Robinson, M.J.F., Fischer, A.M., Ahuja, A., Lesser, E.N., Maniates, H. (2015). *Roles of "Wanting" and "Liking" in Motivating Behavior: Gambling, Food, and Drug Addictions*. V: Simpson, E., Balsam, P. (eds) Behavioral Neuroscience of Motivation. Current Topics in Behavioral Neurosciences, vol 27. Springer, Cham. https://doi.org/10.1007/7854_2015_387

Zbornik 25. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2022

Zvezek G

Proceedings of the 25th International Multiconference

INFORMATION SOCIETY – IS 2022

Volume G

Vzgoja in izobraževanje v informacijski družbi
Education in Information Society

Urednika / Editors

Uroš Rajkovič, Borut Batagelj

http://is.ijs.si

14. oktober 2022 / 14 October 2022
Ljubljana, Slovenija

PREDGOVOR

Letošnja konferenca Vzgoja in izobraževanje v informacijski družbi je že 25., kar pomeni, da se odvija vsako leto v okviru multikonference Informacijska družba. Že četrt stoletja iščemo sinergijo med človekom in informacijsko tehnologijo v procesih vzgoje in izobraževanja.

Vsako leto je posebno in tudi letošnje ni izjema. Zakorakali smo v novo šolsko leto brez posebnim zdravstvenih omejitev, ki so veljale v preteklih letih, hkrati pa smo bogatejši za izkušnje, ki smo jih pridobili pri izobraževanju na daljavo. Ostalo je še veliko neodgovorjenih vprašanj, predvsem v povezavi s hibridnimi načini poučevanja.

Vabimo vas, da se udeležite letošnje konference, na kateri se bomo učili ob deljenju naših izkušenj.

Uredniški odbor

FOREWORD

This year's conference Education in Information Society is the 25th, which means that it takes place every year as a part of the Information Society Multi-Conference. For a quarter of a century, we have been seeking synergies between people and information technology in the processes of education.

Every year is special and this year is no exception. We have entered a new school year without any special health restrictions of previous years, and at the same time, we are richer for the experience we have gained in distance learning. There are still many unanswered questions, especially in relation to hybrid teaching methods.

We invite you to attend this year's conference, where we will learn while sharing our experiences.

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Sistem za spremljanje stresa preko prevodnosti kože med reševanjem testa

System for Monitoring Stress Through Skin Conductance During an Exam

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POVZETEK

V prispevku nas je zanimalo kaj se dogaja z dijaki med reševanjem testa. Vsako preverjanje znanja predstavlja za dijake stresno situacijo. Poiskati smo želeli način kako bi spremljali nivo stresa med reševanjem testa. Verjetno vsi vemo, da se nam, ko smo v stresni situaciji, običajno začnejo potiti roke. Gre za avtonomni odziv živčnega sistema, ki ob stresni situaciji aktivira žleze znojnice. Zato lahko preko merjenja prevodnosti kože spremljamo gibanje nivoja stresa.

V prispevku je opisana izdelava sistema, ki nam omogoča merjenje prevodnosti kože, preko katere lahko spremljamo nivo stresa, ki mu je dijak izpostavljen med reševanjem testa. Merilni sistem sestavljata elektrodi, ki se med testom dotikata prstov ter ostali elektronski elementi. V programskem okolju Labview je bila razvita tudi aplikacija, ki omogoča izbiro pravilnega odgovora, medtem ko beleži gibanje prevodnosti kože.

V zadnjem delu so prikazani tudi rezultati nekaj meritev in ugotovitve. Podana so tudi izhodišča za nadaljnje delo, ki se predvsem nanašajo na načrtovanje eksperimentov in analizo rezultatov.

Tovrstna uporaba področja psihofiziologije odpira vrata v razvoj adaptivnih metod učenja, ki bodo vključevala spremljanje fizioloških parametrov in preko povratne zanke pomagala učečemu pri bolj učinkovitem učenju.

KLJUČNE BESEDE

Stres, prevodnost kože, psihofiziologija, test, Labview aplikacija, elektrode

ABSTRACT

In the article, we were interested in what happens to the students while solving the test. Each knowledge test represents a stressful situation for students. We wanted to find a way to monitor the stress level during the test. We probably all know that when we are in a stressful situation, our hands usually start to sweat. It is an autonomous response of the nervous system, which activates the sweat glands in stressful situations. Therefore, we can monitor the movement of the stress level by measuring skin conductivity.

The paper describes the creation of a system that allows us to measure the conductivity of the skin, through which we can monitor the level of stress that the student is exposed to while solving the test. The measuring system consists of electrodes that touch the fingers during the test and other electronic elements. An application was also developed in the Labview software environment, which allows choosing the correct answer while recording the movement of skin conductance.

The last part also shows the results of some measurements and findings. The starting points for further work are also given, which mainly relate to the design of experiments and the analysis of results.

This kind of use of the field of psychophysiology opens the door to the development of adaptive learning methods, which will include the monitoring of physiological parameters and through a feedback loop help the learner to learn more effectively

KEYWORDS

Stress, conductivity of the skin, psychophysiology, test, Labview application, electrodes

1 UVOD

Vsako preverjanje znanja predstavlja za dijake določeno stopnjo stresa. Dijaki so pod časovnim pritiskom saj imajo za reševanje omejeno količino časa. Včasih se nepravilni odgovori celo točkujejo z negativnimi točkami in tako še povečajo pritisk.

Zanimalo nas je kaj se dogaja z dijaki med reševanjem testa. S tem namenom je bil razvit sistem, ki nam omogoča spremljanje prevodnosti kože, preko katere zaznavamo stopnjo stresa, ki ga doživlja dijak. V nadaljevanju bo predstavljena zasnova sistema, ki vsebuje aplikacijo, ki je bila razvita v programskem okolju Labview, ter merilno vezje z elektrodami. Na koncu pa bomo podali primer uporabe sistema med reševanjem testa z vprašanji izbirnega tipa.

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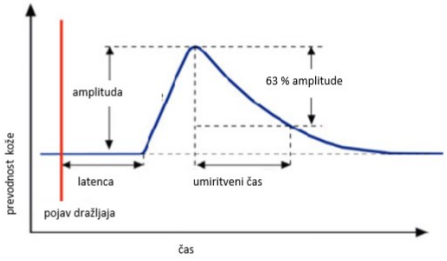
2 PREVODNOST KOŽE

Vsak se je že kdaj nahajal v situaciji, kjer se nam je zaradi stresa povečal srčni utrip, začeli smo hitreje dihati, krvni tlak nam je narastel in začele so se nam potiti roke. Področje, ki se ukvarja s tem, kako naše telo reagira na različne psihološke dražljaje imenujemo psihofiziologija [1]. Eden izmed parametrov, ki ga lahko spremljamo med stresno situacijo je prevodnost kože [2, 3]. Ob nastopu dražljaja bodo naši možgani poslali signal, ki aktivira žleze znojnice. Tega procesa ne moremo kontrolirati, saj se zgodi samodejno. Oglejmo si kako izgleda tipičen signal prevodnosti kože SCR (skin conductance response) (Slika 1). Vidimo lahko, da po pojavu dražljaja običajno traja od ene do treh sekund, da se žleze znojnice aktivirajo. Ta čas imenujemo latenca. Signal nato doseže najvišjo točko in se potem začne postopoma spuščati na predhodno raven. Prednost spremljanja signala prevodnosti kože je ta, da lahko relativno hitro zaznamo vpliv dražljaja. Ravno zaradi tega razloga smo se odločili, da bomo spremljali nivo stresa preko prevodnosti kože.

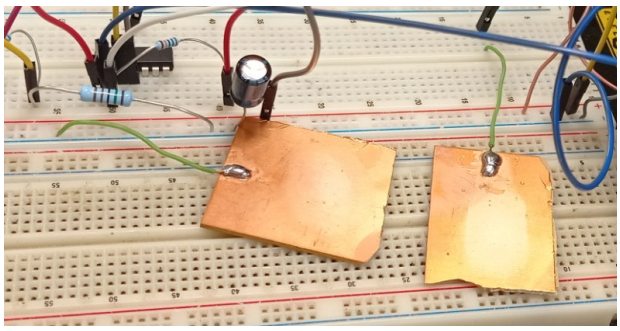


Slika 1: Signal prevodnosti kože

3 SISTEM ZA MERJENJE PREVODNOSTI KOŽE

3.1 Merilni sistem

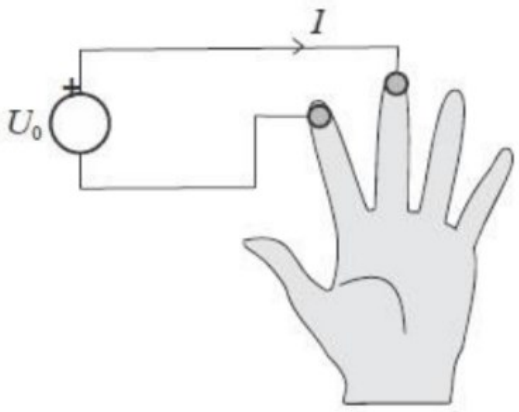
Oglejmo si preprost merilnik prevodnosti kože. Osnovno vezje za merjenje prevodnosti kože vsebuje elektrode (Slika 2). Odločili smo se za baker, saj le-ta dovolj dobro prevaja električni tok.



Slika 2: Bakrene elektrode

Elektrode priključimo na šibko napetost (0.64 V). Preko kazalca in sredinca bo stekel električni tok, ki je sorazmeren prevodnosti kože, kar lahko enostavno izračunamo preko spodnje enačbe. (Slika 3)

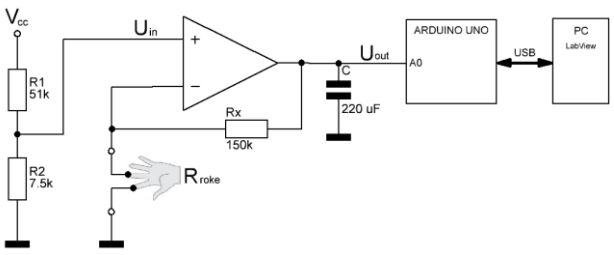
$$G = \frac{I}{U} \tag{1}$$



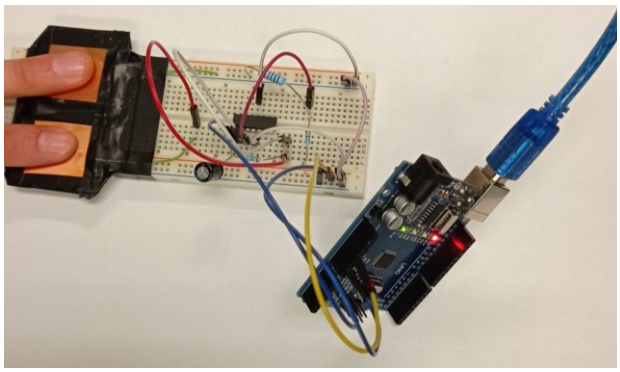
Slika 3: Koncept merjenja prevodnosti kože

Poleg elektrod potrebujemo še nekaj komponent, ki so prikazane na Sliki 4 in Sliki 5. Merilno vezje vsebuje operacijski ojačevalnik, ki poskrbi, da šibak napetostni signal ojačamo. V vezje je dodan tudi kondenzator, ki odpravlja visokofrekvenčne motnje. Izhod operacijskega ojačevalnika je povezan na analogni vhod (A0) mikrokrmilnika, ki se nahaja na razvojni plošči Arduino UNO.

Vrednost prevodnosti kože se nato preko serijske povezave USB prenese do računalnika, kjer je nameščeno programsko okolje Labview oz. v njem razvita aplikacija.



Slika 4: Shema merilnega sistema

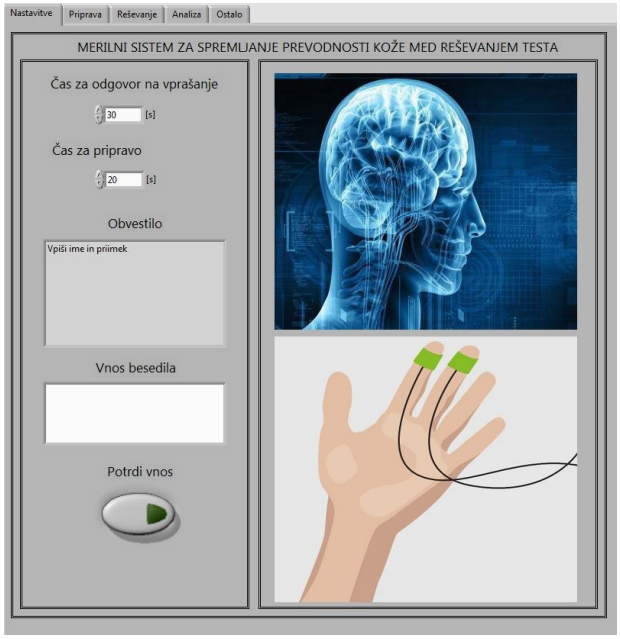


Slika 5: Merilni sistem

3.2 Programska aplikacija

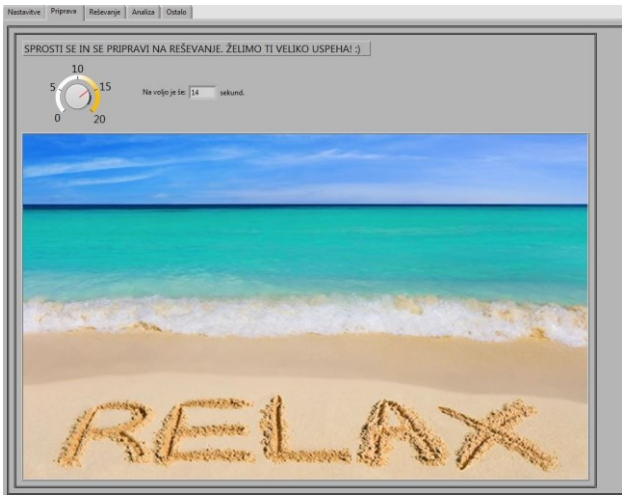
V programskem okolju Labview je bila razvita aplikacija, ki nam omogoča prikazovanje prevodnosti kože med reševanjem testa z vprašanji izbirnega tipa.

Najprej testiranec vpiše svoje podatke in opredeli trenutno počutje (Slika 6).



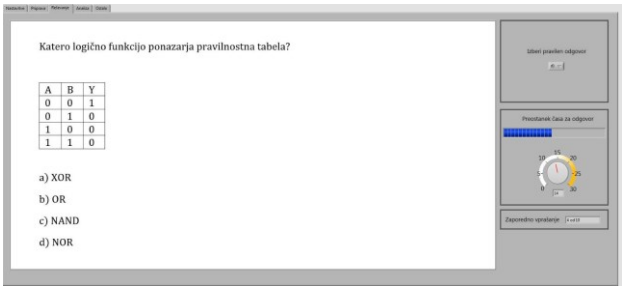
Slika 6: Nastavitev parametrov in vnos podatkov

Nato sledi približno minuta umirjanja, da se prevodnost kože stabilizira (Slika 7).



Slika 7: Sproščanje in priprava na reševanje

V nadaljevanju se zaporedoma prikaže 10 vprašanj. Pri vsakem vprašanju je na voljo 30 sekund časa za izbiro odgovora. Odgovor je možno izbirati preko spustnega seznama. Testirancu se prikazuje tudi čas, ki ga ima še na voljo, da izbere ustrezen odgovor ter zaporedna številka vprašanja (Slika 8). Na koncu se pokaže uspešnost reševanja testa in gibanje prevodnosti kože. Tako lahko vidimo pri katerem vprašanju se je zgodila opaznejša sprememba prevodnosti kože in odgovori na katera vprašanja so bili pravilni.

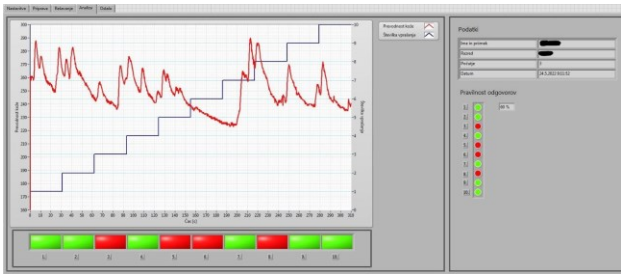


Slika 8: Reševanje testa

3.3 Rezultati testiranja

Merilni sistem smo zaradi časovne stiske uspeli preizkusiti le na manjšem vzorcu dijakov (N=5). Prav tako je bil naš namen zgolj preizkusiti delovanje sistema, ne pa poglobljeno načrtovanje eksperimenta in analiza rezultatov.

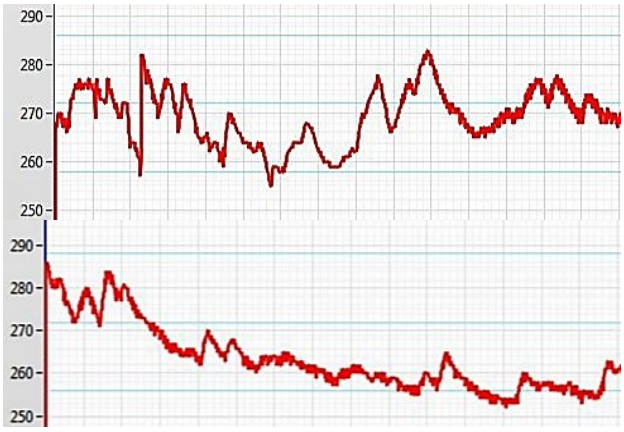
Poglejmo si primer dijaka, ki je reševal test (Slika 9).



Slika 9: Rezultat testiranja

Na grafu je z modro barvo prikazana zaporedna številka vprašanja, rdeča barva pa prikazuje potek prevodnosti kože. V spodnjem delu okna je rdeč oz. zelen indikator, ki nam pokaže pravilnost odgovora. Prav tako vidimo kakšna je bila uspešnost v %. Pri primeru na Sliki 9 vidimo, da so bili med reševanjem stalno prisotni skoki prevodnosti, kar nakazuje, da je bil dijak stalno pod stresom. Opaznejši premik opazimo pri sedmem vprašanju, ko ob iztekanju časa prevodnost izrazito naraste. Dijak je na to vprašanje sicer odgovoril pravilno. Če bi želeli dobiti več informacij, bi morali pogledati na katero vprašanje konkretno je odgovarjal. Lahko bi se tudi na koncu z dijakom pogovorili in tako dobili še večji vpogled kaj se je dogajalo in zakaj je reagiral tako kot je.

Za primerjavo si poglejmo dva grafa, ki prikazujeta gibanje prevodnosti kože. V enem primeru je dijak ves čas sproščen, v drugem pa rešuje test (Slika 10). Pri aktivnem stanju je nivo prevodnosti višji. Prav tako je opaziti več skokov oz. sprememb v prevodnosti. Pri umirjanju pa nivo prevodnosti ves čas upada s sicer manjšimi skoki.



Slika 10: Primerjava umirjenega (spodaj) in aktivnega (zgoraj) stanja

Iz analize več grafov lahko podamo nekaj zaključkov oz. opažanj. Pri iztekanju časa za posamezen odgovor bo prevodnost kože običajno naredila skok, saj se bo dijak trudil izbrati pravilen odgovor preden se mu izteče čas. Nivo je med reševanjem testa višji kot pri umirjenem stanju. Znotraj povišanega nivoja prevodnosti se pojavljajo skoki, ki so posledica reakcij na posamezna vprašanja.

4 ZAKLJUČEK

S trenutnimi rezultati dela smo lahko zadovoljni, saj nam je uspelo narediti delujoč sistem, ki nam omogoča spremljanje stresa med reševanjem testa. Z izvedbo nekaj testiranj na dijakih smo dobili povratno informacijo o delovanju sistema. Celotna aplikacija je dovolj robustna in modularna, da omogoča prilagajanje časa za odgovor, rotacijo in izbiro različnih vprašanj, izvoz grafov v program, kjer lahko delamo analize signalov.

Kljub temu pa imamo še veliko možnosti za izboljšave. Sam merilni sistem lahko vgradimo v ohišje, ki je natisnjeno s 3D tiskalnikom ter izdelamo tiskano vezje. Dodati je možno tudi povratno zanko, ki nam omogoča, da lahko glede na gibanje prevodnosti prilagajamo težavnost vprašanj oz. čas za odgovor. Na ta način lahko dijaku omogočimo, da bolje izkoristi svoje potenciale pri reševanju in mu omejimo stres, ki ga reševanje testa povzroča. Nižji nivo stresa namreč poveča učinkovitost učenja [4].

Ključno pri nadaljnjem delu pa je načrtovanje in izvedba eksperimentov, kjer na večjem številu dijakov preizkusimo različno težavnost vprašanj in časovne omejitve. Pri interpretaciji rezultatov in načrtovanju eksperimentov bo vsekakor potrebna interdisciplinarnost in s tem vključitev psihologa.

Z razvojem in preizkusom našega sistema smo naredili prve korake v smeri povezovanja psihofiziologije in procesa učenja. Menimo, da ima adaptivno učenje z uporabo psihofiziologije v prihodnosti še veliko potenciala.

LITERATURA IN VIRI

[1] Psihofiziologija. Dostopno na naslovu https://en.wikipedia.org/wiki/Psychophysiology (27. 7. 2022)

[2] George I. Christopoulos, Marilyn A. Uy, Wei Jie Yap, 2016. The Body and the Brain: Measuring Skin Conductance Responses to Understand the Emotional Experience. DOI: https://doi.org/10.1177/1094428116681073

[3] Gregor Geršak. 2013. Enostavni nizkocenovni merilniki prevodnosti kože. Dostopno na naslovu https://ev.fe.uni-lj.si/1-2-2013/Gersak.pdf (27. 7. 2022)

[4] Tacy L. Holliday, Sukhaynah H. Said. Psychophysiological Measures of Learning Comfort: Study Groups' Learning Styles and Pulse Changes. Dostopno na naslovu https://files.eric.ed.gov/fulltext/EJ818223.pdf (27. 7. 2022)

Vizualizacija sinteze 2D abstraktnih teksturnih vzorcev z naključnostjo

Visualization of the Synthesis of 2D Abstract Textural Patterns With Randomness

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POVZETEK

V prispevku bomo orisali konceptualno uporabo naključnosti za ustvarjanje zaporednih in ponavljajočih se vsebinskih struktur digitalnih vizualnih podobotvorij znotraj digitalne generativne umetnosti, v nadaljevanju pa računalniško generirano naključnost in njeno vlogo v sodobni umetniški praksi v medijski produkciji. Programiranje, še posebej kreativno kodiranje v kontekstu umetnosti in oblikovanja, je proces usklajevanja in prehajanja med individualno ustvarjalno mislijo in togimi konceptualnimi modeli kode. Zato smo posebej oblikovali učne oblike, metode in aktivnosti pri seznanjanju dijakov z matematičnim modelom naključnosti. Tudi brez upoštevanja teh teoretičnih idej nam psevdonaključnost in generatorji proceduralnih števil, kot je Perlinov šum, nudijo preproste, a zmogljive načine za ustvarjanje učinkovitih in raznolikih vizualnih rezultatov. Pričakuje se, da bodo kakršni koli zaključki, ki izhajajo iz tega prispevka, vodili k boljšemu razumevanju ustvarjalnega procesa v kontekstu vizualnega dela, ki temelji na kodi, saj večinoma vizualni rezultati kreativnega kodiranja niso neposredno predvidljivi vnaprej.

KLJUČNE BESEDE

Proceduralna pismenost, algoritmično mišljenje, naključnost, naključna števila, šum, digitalni generativni sistem

ABSTRACT

In this paper, we will outline the conceptual use of randomness for the creation of sequential and repetitive content structures of digital visual sub-creations within digital generative art, and in the following, computer-generated randomness and its role in contemporary artistic practice in media production. Programming, especially creative coding in the context of art and design, is a process of matching and transitioning between individual creative thought and rigid conceptual models of code. That is why we have specially designed learning forms, methods and activities to familiarize students with the mathematical model of randomness. Even without considering these theoretical ideas, pseudorandomness and procedural number generators such as Perlin noise provide us with simple yet powerful ways to produce effective and varied visual results. Any conclusions drawn from this paper are expected to lead to a better understanding of the creative process in the context of code-based visual work, since for the most part the visual outcomes of creative coding are not directly predictable in advance.

KEYWORDS

Procedural literacy, algorithmic thinking, randomness, random numbers, noise, digital generative system

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1 UVOD

Uporaba različnih analognih tehnik spreminjanja naključnosti in negotovosti v opredeljujoča dejavnika v procesih umetniškega ustvarjanja na likovnem področju sega v začetke dvajsetega stoletja in je bistvena upodobitvena značilnost dadaistov[1] in konceptualistov[2]. S pojavom računalnikov in različnih računalniških platform se je izražanje ustvarjalne subjektivnosti skozi programsko kodo preneslo v umetniško prakso in vizualno raziskovanje uporabe stohastičnosti na področju digitalne generativne umetnosti, tako na konceptualni kot tehnični ravni. Ob tem seveda velja poudariti, da obstaja temeljna razlika med naključnostjo znotraj dadaistične umetnosti in kasnejše računalniške umetnosti. Medtem, ko se naključnost v dadaizmu nanaša na čisto naključje, se naključnost v računalniški umetnosti uporablja kot psevdonaključnost, kjer je v smislu digitalne logike naključje delno nadzorovano.

Uporaba računalniških metod v digitalni generativni umetnosti se namreč odvija v nizu ustvarjalnih metodologij za zavestno interakcijo vnaprej določenih sistemov z različnimi dejavniki nepredvidljivosti skozi konceptualizacijo, produkcijo in predstavitvijo umetniškega dela. Kreativno kodiranje [1] kot programiranje v kontekstu računalniške umetnosti in digitalnega oblikovanja je proces usklajevanja in prehajanja med individualno ustvarjalno mislijo in konceptualnimi modeli programske kode. S prevajanjem abstraktnih idej v konkretne vizualne rezultate s pomočjo preprostih algoritmov in programske kode je mogoče ustvariti ogromno vizualnih računalniških interpretacij, ki omogočajo razcvet novih

[1] Dadaizem, oblika umetniške anarhije, ki je izzivala družbene, politične in kulturne vrednote tistega časa.

[2] Konceptualizem je umetniško gibanje, pri katerem je ideja (ali koncept) v ozadju dela pomembnejša od končnega umetniškega objekta.

vizualnosti, s čimer se formalizira neobvladljivost ustvarjalnega procesa, a hkrati poudarja in estetizira kontekstualna narava računalniške umetnosti. Za doseganje estetskih rezultatov v produkciji likovnih form znotraj računalniško generiranih dvorazsežnih podob ustvarjalci posegajo po kombiniranju strogo načrtovane strukturne in likovne logike ter metod matematične naključnosti programskega okolja. To jim omogoča razumevanje inherentne generativnosti vsakega ustvarjalnega procesa, ki ga narekujejo naključni pojavi, in eksplicitnega generativnega pristopa, ki ceni in razvija umetniško delo kot dinamičen dogodek, navdihnjen z radovednostjo, dovzeten za naključje in odprt za spremembe. Logično-numerična transpozicija generiranih grafičnih podatkov v vizualni prostor, včasih s ponavljajočimi se geometrijskimi vzorci, včasih z zlomljenimi strukturami, včasih izoliranimi snopi tokovnic ali gručami točk.

Ustvarjalne metodologije, ki temeljijo na algoritemskih procesih, implementirajo estetske zmožnosti naključnosti v proces ustvarjanja digitalne postopkovne generativne grafike, pri kateri nastanejo različni vizualni rezultati z odstopanjem od nadzora ustvarjalca v omejenem okviru. Različni dejavniki naključnost kot konstitutivni faktorji predstavljajo vhodne parametre v algoritmu pri vizualizaciji strukturiranega grafičnega sistema in s tem neposredno vplivajo na kakovost njegovih vizualnih rezultatov, ki ne premorejo predvidljivih vzorcev. Iz tega izhaja, da uporaba naključnosti spremeni ustvarjalni proces iz popolnoma načrtovanega v bolj naključnega. Ustvarjalcem omogoča, da nekatere svoje intuitivne, subjektivne odločitve, prenesejo na ustvarjalni proces, ki ga ne morejo v celoti nadzorovati. Stopnja naključja je odločitev ustvarjalca. Uvajanje naključnosti in negotovosti v vizualno vsebino digitalne postopkovne generativne grafike kaže na dva vidika njene umetniške produkcije. Sprva se lahko izvor umetniške prakse premakne od rezultatov povsem načrtovanega koncepta k bolj naključnim in celo lažje dostopnim rezultatom znotraj produkcijskega procesa. Po drugi strani pa ta vrsta naključnosti izzove opazovalca, da spremeni točko gledišča s tehnično-tehnološkega pristopa v ustvarjalnem procesu na bolj intelektualne ravni dojemanja vsebin njegove realizacije. Prav tako je v umetniški produkciji digitalne postopkovne generativne grafike naključnost povezana z zaporednostjo in ponavljanjem. Generativni proces skupaj z ogromnimi možnostmi kombinatorike rezultira v razredu grafik namesto posamezne grafike. Potreba po izbiri med vsemi možnimi rezultati vključuje naključnost na veliko različnih načinov. Nepredvidljivost, variacije, ponavljanje, kaos, šum, napetost med redom in neredom so koncepti, povezani z naključnostjo. Digitalna generativna umetnost vključuje te koncepte z velikim naborom matematičnih tehnik in metod ter predstavlja umetno vrsto, ki je sposobna ustvariti neskončno zaporedje posameznih dogodkov, od katerih je vsak drugačen, edinstven in neponovljiv, vendar pripada isti prepoznavni oblikovalski ideji in estetski formaciji.

Velik del generativne umetnosti uporablja naključna števila prek računalniških generatorjev psevdonaključnih števil. Računalniški generatorji psevdonaključnih števil so oblikovani, da se izognejo pomanjkljivostim pravih naključnih števil. Ti generatorji proizvajajo zaporedja števil, ki približujejo neodvisne enakomerno porazdeljene naključne spremenljivke. Poleg tega so dobljena zaporedja ustvarjena deterministično. Ustvarjeno zaporedje števil je pogosto definirano rekurzivno z začetno vrednostjo, ki se običajno imenuje *seme*. To pomeni, da so naslednje vrednosti v zaporedju ponovljive, če je začetno seme znano. Poleg tega je zaradi preproste rekurzivne definicije zaporedja mogoče učinkovito generirati psevdonaključna števila. Enakomerno porazdeljena zaporedja se lahko v razširitvi uporabijo za generiranje števil iz poljubnih porazdelitev. Generatorji premorejo lastnosti determinizma in učinkovitosti, zato imajo prednost pred pravimi naključnimi števili.

Da bi izkoristili prednost naključnosti, je treba v generativni sistem uvesti funkcije za vzorčenje hitro spreminjajočih se podatkov. S preprostim dodajanjem naključnih števil vizualnim parametrom so lahko izhodni rezultati nenaravni in vizualno togi, vendar običajno pričakujemo bolj gladek prehod v teksturnih vzorcih kot razpoložljivo možnost v grajenju vizualne estetike.

2 METODA DELA

2.1 Razvijanje algoritmičnega mišljenja in proceduralne pismenosti

Težnja po prekrivanju znanosti in umetnosti je aktualna tudi v izobraževanju. Določen učni sklop pri kreativnem kodiranju je bil zato posvečen vprašanju simbioze znanosti in umetnosti v izobraževalnem kontekstu. Poleg teoretičnih obravnav sorodnih vprašanj (načini preseganja dihotomije znanstvenega in umetniškega pristopa k svetu, vloga učitelja v tem procesu, ustvarjalno povezovanje izoliranih izobraževalnih vsebin) tudi ponuja konkretne primere izvedenih kratkih izobraževalnih projektov. Skupna lastnost teh projektov je povezovanje izobraževalnih vsebin različnih študijskih področij (tako umetniških kot naravoslovnih).

Generativna umetnost obravnava proceduralnost kot osrednji koncept znotraj umetniških performativnih praks, pri čemer obravnava vlogo in pomen človeškega izvajalca pri uprizarjanju algoritemskih umetniških del. Kot zmožnost izvajanja pravil, ki izhaja iz opisa procesov v formalna navodila (kot so algoritmi), lahko proceduralnost konceptualno zajema tako računalnike kot ljudi kot entitete, ki izvajajo ta pravila. V likovni umetnosti je bil ta pojem uvožen iz glasbe (kot ena od njenih inherentnih lastnosti), konceptualiziran in rekonceptualiziran znotraj širšega obsega performativnih praks, ki vključujejo postopke kot navodila za delovanje [2].

Pomemben del učnega procesa pri kreativnem kodiranju namenjamo preučevanju kognitivnih zahtev za učinkovito generativno ustvarjalnost. Obsegajo dva načina mišljenja: povezovanje algoritemskih in nepredvidljivih elementov v koherenten sistem ter konstrukcijo preprostih algoritmov kot večnamenskih orodij, ki zahtevajo proceduralno pismenost in veščine osnov programiranja za izdelavo enostavnih digitalnih generativnih projektov. K tem načinom smo pristopili sistematično, s poudarkom na kritičnih podrobnostih proceduralne pismenosti, kar nam je omogočilo branje in opisovanje procesov, vključitev proceduralne reprezentacije ter vizualne in računske estetike, neodvisno od tehnološkega okolja, v katerem so dijaki ustvarjali.

Proceduralno mišljenje vključuje tri osnovne korake: dematerializacijo določenega pojava v nabor objektov, ki ga ustrezno opisujejo, razrešitev tega nabora objektov v čisto sintakso (odstranitev semantične plasti) in prevajanje sintakse v niz operacij (elementi programskega jezika). Trivialnost osnovnih korakov zahteva niz kognitivnih sposobnosti: intuicijo

ali čut za prepoznavanje pojava, ki ga je mogoče algoritmizirati pod določenimi pogoji, domišljijo in prožnost sklepanja, razlikovanje med racionalnimi in iracionalnimi vidiki v mentalnih konceptih naravnih pojavov ter pozornost do obsega in neprilagodljivost algoritemskega (računalniškega) sistema. Proceduralno mišljenje se sooča z nekaterimi izzivi, zlasti pri kreativnem kodiranju. Konceptualne omejitve (sintakse) programskih jezikov in strojne arhitekture lahko vsilijo določene rešitve in nehote zavrtijo umetniški proces.

Med učnim procesom je bila razlaga in demonstracija konceptov programiranja podprta z uporabo vizualnih grafik, vsebinsko vezanih na naključnost. Na podlagi izkušenj, pridobljenih pri poučevanju kreativnega kodiranja, smo ugotovili, da uporaba tehnik vizualizacije posameznih programskih okolij in orodij pomaga pritegniti pozornost dijakov in podpira učenje ključnih konceptov programiranja. Primeri, ki so se demonstrirali v razredu, so služili kot vstopna točka za analizo računske in likovne logike, razgradnjo algoritmov ter odkrivanje vzorcev ali podobnosti znotraj programskih skicirk in njihovih vizualizacij. Praktične vaje so imele običajno navdih kot izhodišče, kjer so bili dijaki izzvani, da eksperimentirajo in ustvarijo nekaj novega, ali odpravljajo napake, da najdejo in popravijo napake, ali celo sodelujejo pri iskanju rešitve. Bistveni del vizualne forme in identitete tekstur je bil osredotočen na uporabo algoritmov, implementiranih v *p5.js* kot osnovnim programskim jezikom, saj je zaradi njegovih dinamičnih jezikovnih lastnosti ter zmožnosti združevanja funkcionalnih in objektno usmerjenih tehnik programiranja še posebej primeren za raziskovalno ustvarjalno prakso. Z uporabo poenostavljene sintakse in modela grafičnega programiranja nam je oblikovanje z algoritmi dalo skoraj neomejene variacije znotraj parametrov, ki smo jih določili na začetku ustvarjalnega procesa. Medtem ko smo lahko nadzorovali meje ustvarjenih vizualnih elementov, nismo imeli nadzora nad rezultati. Ta nepredvidljivost se je pokazala kot močna analogija za prihodnost tehnologije, ob tem pa se je izpostavilo vprašanje: kako nadzorujemo tisto, kar smo ustvarili?

Ustvarjanje množice različnih preprostih in zapletenih oblik iz matematičnih formul tako daje procesu oblikovanja znanstveni pridih, ki omogoča, da se oblikovanje predstavi kot rezultat strogega in objektivnega procesa. Med drugim smo skozi učni proces želeli izvedeti, kako lahko uporaba naključnosti kot generativnega načela medijskemu tehniku v vlogi oblikovalca digitalnega vizualnega podobotvorja ponudi kreativno oblikovalsko okolje.

2.2 Tehnike kreativnih in funkcionalnih pristopov v sintezi vzorcev

V prispevku bomo prikazali več tehnik, ki se uporabljajo v digitalni generativni umetnosti za ustvarjanje teksturnih vzorcev. Naslednje tehnike so le nekatere izmed mnogih različnih procesov, ki se uporabljajo v digitalni generativni umetnosti. Izbrali smo jih zato, da pokažemo na široko paleto digitalnega vizualnega podobotvorja, ki ga je mogoče ustvariti s preprostimi algoritmi. Nekatere izmed jih so prijazne dijakom začetnikom v kodiranju teksturnih vzorcev, druge, naprednejše, pa so namenjene dijakom, ki si izberejo teme iz kreativnega kodiranja za maturo.

Dijaki so skozi praktične vaje spoznavali razliko med rezultati grafičnih vsebin digitalnih vizualnih podobotvorij, ustvarjenimi z generatorji naključnih števil, katerih vrednosti so enakomerno porazdeljene skozi čas, in šuma, kjer vrednosti niso popolnoma naključne, ampak so vedno blizu tistim njihovih neposrednih sosedov. Dijaki so se seznanili z generatorjema naključnih števil v p5.js, funkcijama *random()* in *randomGaussian()*, kjer lahko prehodi med sosednjimi točkami divje nihajo, in funkcijo *noise()*, kjer je mogoče ustvariti gladke prehode v eni, dveh ali treh dimenzijah. Funkcija r*andom()* je generator naključnih števil, ki vrne psevdonaključno število ali zaporedje psevdonaključnih števil, praviloma enakomerno porazdeljenih na intervalu [0, 1). Funkcija *randomGaussian()* vrne psevdonaključne vrednosti, ki ustrezajo Gaussovi ali normalni porazdelitvi, za katero sta kot parameter navedena povprečje in standardni odklon. Z uporabo računalniško ustvarjenih naključnih funkcij lahko umetniki nadzorujejo količino naključnosti v celotnem proizvodnem procesu in lahko uporabljajo veliko bolj nekorelirano naključnost glede na njeno predvidljivost.

2.3 Naključni sprehajalec

Ena najpreprostejših tehnik, ki se uporablja v digitalni generativni umetnosti, je naključni sprehajalec. Naključni sprehajalec je model preprostega dinamičnega procesa, ki ga zlahka opredelimo kot sprehod z naključnimi koraki. Sled poti, ki jo geometrijski objekt zariše med sprehajanjem, je sestavljena iz odtisa njegovih številnih vmesnih stanj znotraj meja slikovne površine, določenih z uporabo generatorjev naključnih števil, v našem primeru funkcije *random()*. Vmesna stanja naključnega sprehajalca so običajno sestavljena iz njegove trenutne lege in funkcije, ki lahko to lego spremeni. Naključne sprehajalce je mogoče uporabiti na različne načine, kot je risanje črt ali oblik ali manipuliranje s podatki.

Najenostavnejši pristop za ustvarjanje naključnega sprehajalca je ustvarjanje naključne smeri premikanja objekta pri vsakem koraku, ki pa lahko ustvarja zelo zapletene likovne formacije z visoko stopnjo vizualnega šuma. V izogib visoki stopnji vizulanega šuma se opremo na bolj gladek pristop, ki temelji na ustvarjanju naključnega sprehajalca, ki sledi smeri zasuka v prejšnjem stanju. Novo smer ustvarimo tako, da prejšnji kot zasuka spremenimo z naključnim številom. Pri vsakem koraku naključnega sprehajalca se trenutni kot zasuka izračuna na podlagi prejšnjega kota zasuka in naključnega števila ter se nato premakne za določeno dolžino v smeri trenutnega kota. Razpon izbranega naključnega števila je mogoče zmanjšati ali povečati glede na količino želene variacije. Vsak pristop daje drugačen vizualni rezultat z različnimi lastnostmi. Številne parametre je mogoče prilagoditi, da s sprehajalci ustvarimo različne rezultate. Velikost koraka lahko povečujemo ali zmanjšujemo glede na velikost formata vizualnega polja umetniškega dela. Povečanje velikosti koraka lahko ustvari poti z ostrimi vogali na vsakem koraku, zmanjšanje velikosti koraka pa lahko ustvari pot z več krivuljami. Logični in algoritemski del naključnega sprehajalca je pomemben pri ustvarjanju vizualno zanimivih rezultatov. Vendar pa obstaja veliko stvari, ki niso logično ali algoritemsko zapletene in lahko prispevajo k generativnemu delu. Tako kot tradicionalna umetnost je tudi pri naključnih sprehajalcih pomembno uporabiti elemente umetnosti na učinkovit način.

2.4 Vrste šumov

Beli šum je zelo preprosta oblika šuma, pri kateri ima vsaka slikovna točka naključno izbrano vrednost med 1 in 0. Ker je beli šum nekoherenten šum, bi bil teren, ustvarjen z njim, videti preveč neraven in koničast, da bi bil podoben naravnemu terenu.

Perlinov šum [3], pogosto imenovan tudi klasični šum, je razvil Ken Perlin leta 1983. Perlin ga je prvotno ustvaril za film *TRON* (1982), vendar je hitro postal priljubljen algoritem za proceduralno generiranje, ki temelji na njegovi večnamenski uporabnosti in ker ni bilo patenta na njem. Leta 1996 je Perlin prejel oskarja za svoje delo z računalniško ustvarjenimi podobami v filmih. Perlinov šum dobro posnema naravne oblike in njegovo ponavljanje je težko zaznati. Idealen je za predstavitev kompleksnosti naravnih pojavov. Perlinov šum je mogoče implementirati v n številu dimenzij. Kar zadeva grafiko iger, se običajno uporabljajo samo 1-4 dimenzije. Vendar pa ima nekaj vizualno pomembnih smernih artefaktov. V nasprotju s standardno funkcijo naključnosti, random(), je Perlinov šum koherenten, kar pomeni, da bosta dve sosednji točki imeli podobno vrednost šuma. Zaradi tega so vse naključne variacije enakih velikosti in približno izotropne – videte bodo podobne v vseh smereh in legah.

Simpleksni šum je prav tako razvil Ken Perlin leta 2001 kot naslednika Perlinovega šuma, tokrat patentiranega. Rešuje težavo z vizualno pomembnimi smernimi artefakti šuma Perlin. Njegove druge prednosti so hitrejši čas obdelave in nižja računska kompleksnost, kar pride bolj do izraza pri višjih dimenzijah [3].

Worleyjev šum, imenovan tudi celični šum, je razvil Steven Worley leta 1996. To je funkcija, ki zapolni prostor z naključno razporejenimi točkami in poišče razdalje do najbližjih točk. Tako razdeli prostor v naključno zaporedje celic. Zaradi celične lastnosti se pogosto uporablja za simulacijo organskih stvari, kot so razpokan kamen, blato, voda ali biološke celice [4].

Voronojev šum je prilagoditev Worleyjevega hrupa in prav tako deluje tako, da točke naključno razporedi po prostoru, kar povzroči celicam podobne vzorce [5]. Kar zadeva računalniško zapletenost, je Voronojevo ustvarjanje nekoliko dražje od Worleyjevega šuma. Zagotavlja pa dodaten nadzor nad porazdelitvijo točk. Obstaja nekaj različic Voronojevega šuma z nekoliko drugačnimi formulami za izračun.

Fraktalni šum je izraz, ki se uporablja za opis kombinacije šumov. Če bi uporabili samo en šum, recimo Perlinov, bi dobili precej enakomerno gladek gorski teren. Tako je običajna praksa mešanja in kombiniranja različnih vrst šumov z različnimi lestvicami in ločljivostmi, da se doseže bolj zanimiva variacija. Uporaba fraktalnih šumov vodi do bolj naravnega videza terena.

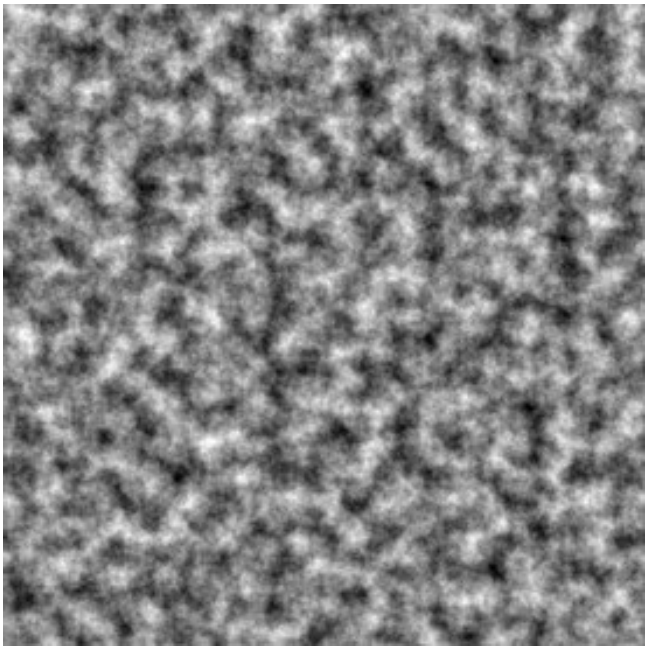
Konceptualna uporaba kreativnih in funkcionalnih pristopov naključnosti v sintezi abstraktnih vzorcev je prikazana na naslednjih slikah.

Slika 1 prikazuje eno izmed vizualizacij sinteze abstraktnega teksturnega vzorca s Perlinovim šumom.

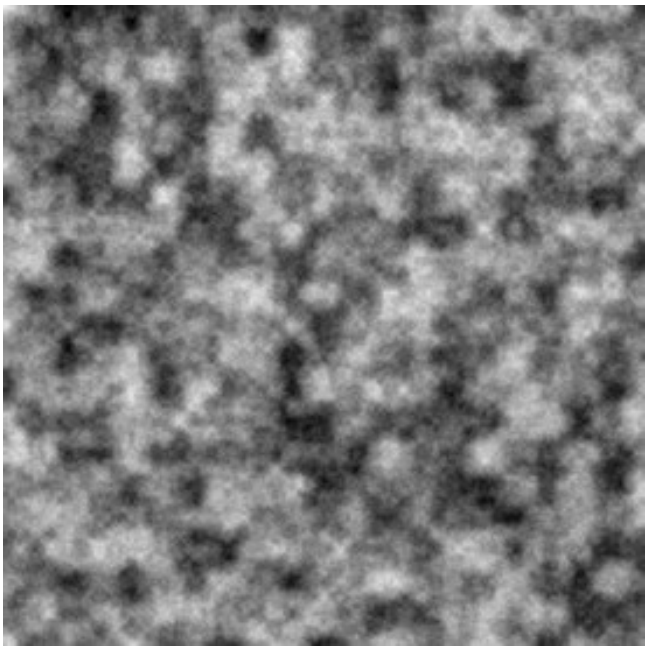
Slika 2 prikazuje eno izmed vizualizacij sinteze abstraktnega teksturnega vzorca s simpleksnim šumom.

Z dodajanjem različnih iteracij šuma (oktav), kjer zaporedoma povečujemo frekvence v zaporednih korakih (lakunarnost) in zmanjšujemo amplitude (ojačanje) šuma, lahko dosežemo boljšo zrnatost v vizualni strukturi šuma in s tem več finih podrobnosti same strukture abstraktnega vzorca. Takšno strukturo vzorca opazimo na Sliki 3 z vizualizacij sinteze abstraktnega teksturnega vzorca s Worleyevim šumom.

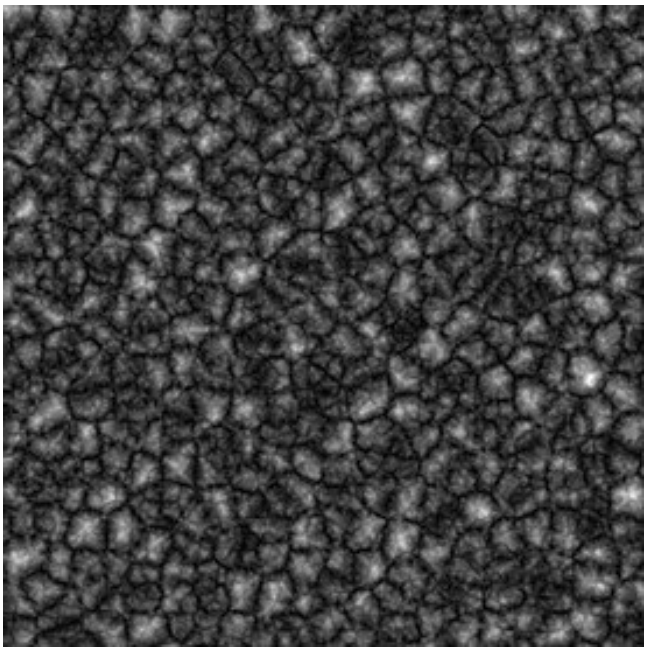
Slika 4 prikazuje eno izmed vizualizacij sinteze abstraktnega teksturnega vzorca s Voronoijevim šumom.



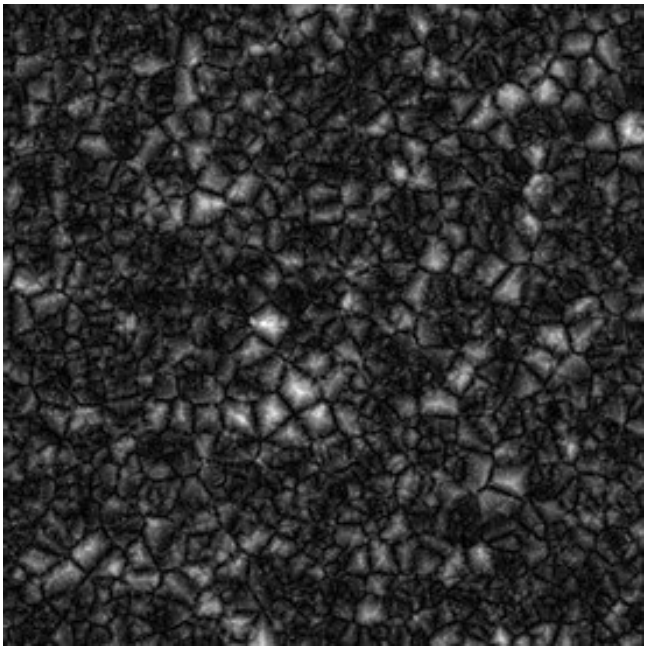
Slika 1: Vizualizacija sinteze abstraktnega teksturnega vzorca s Perlinovim šumom



Slika 2: Vizualizacija sinteze abstraktnega teksturnega vzorca s simpleksnim šumom



Slika 3: Vizualizacija sinteze abstraktnega teksturnega vzorca z Worleyevim šumom



Slika 4: Vizualizacija sinteze abstraktnega teksturnega vzorca z Voronoijevim šumom

3 REZULTATI IMPLEMETACIJE NAKLJUČNOSTI

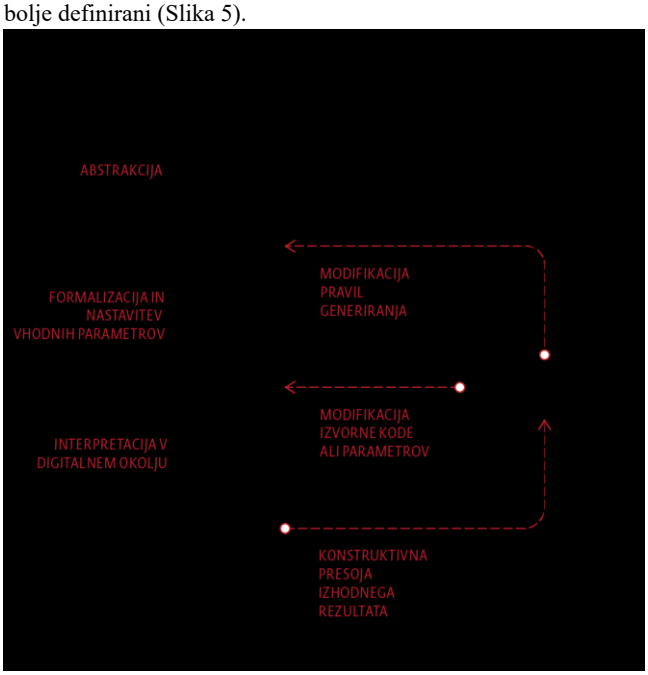
Sinteza vizualnih teksturnih 2D vzorcev je splošna tehnika, ki jo uporabljamo pri računalniško podprtem oblikovanju in ustvarjanju digitalnih vsebin. Teksturne vzorce lahko razumemo kot vizualne konfiguracije različnih geometrijskih struktur, ki kažejo na visoko stopnjo naključnosti katerih vizualna kakovost je določena s tem, kako zvesto poustvarijo izvorni vzorec.

Pri implementaciji naključnosti v digitalno vizualno podobotvorje so se dijaki osredotočali predvsem na raziskovanje generativne vizualne estetike, ki temelji na plastičnem eksperimentiranju s kodo. Njihova preprosta grafična dela raziskujejo potencial programiranja kot ekspresivnega jezika v okviru generativnosti in procesne umetnosti. Z eksperimentiranjem v kombiniranju različnih osnovnih geometrijskih oblik, linij in barv, so raziskovali možna razmerja med kaosom in redom, organskim in umetnim, naključnostjo in nadzorom, a hkrati pristopali k 5igitalin površini kot plastičnemu prostoru z uporabo kode kot umetniške materialnosti.

Določena mera naključja v postavitvi motiva slikovnih prvin znotraj neke, s formatom omejene digitalne postopkovno generirane grafike, prikazuje vizualno kompleksnost zapletenih geometrijskih vzorcev, sistemov delcev in drugih močnih programskih struktur (rekurzija) v neki strukturirani dinamični kompoziciji, ki je lahko geometrično organizirana ali pa organsko kaotična. Šum zagotavlja prilagodljiv, močan in estetski vir variacije, ki pogosto deluje bolje kot uporaba navadnega generatorja naključnih števil.

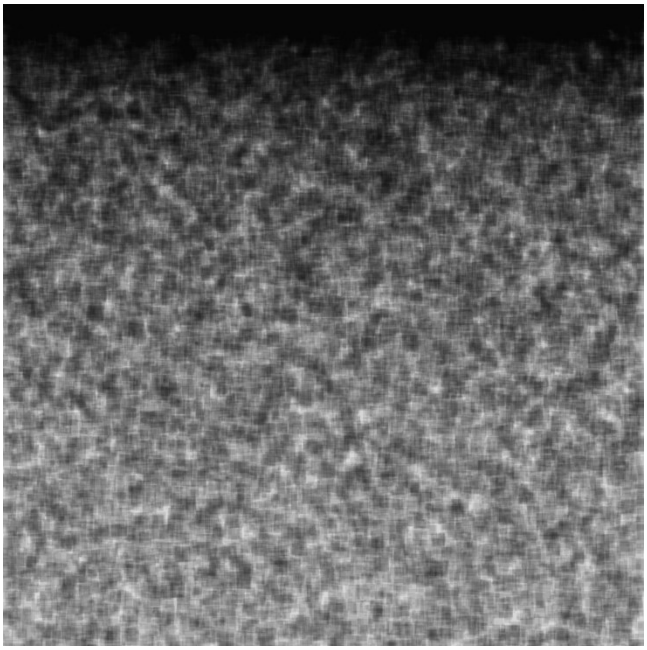
Obvladovanje psevdonaključnih funkcij je odločilni dejavnik stopnje predvidljivosti rezultatov pri vsaki njegovi ponovitvi ali celo med enkratno izvedbo, in to je v nekem smislu tisto, kar daje umetniškemu delu občutek, da je nekaj živo in živi znotraj same vsebine.

Ustvarjanje v polju digitalne generativne umetnosti je iterativni proces digitalnega načrtovanja z vključenim programskim okoljem, ki bo ustvarilo določeno število izhodov, ki ustrezajo določenim omejitvam, in ustvarjalca, ki bo natančno prilagodil izvedljivo območje digitalno ustvarjenega podobotvorja z izbiro določenega izhoda ali spreminjanjem vhodnih parametrov, razponov in porazdelitev. Ustvarjalec se nauči izboljšati program (običajno vključuje algoritme) z vsako ponovitvijo, ko njegovi načrtovalski cilji sčasoma postanejo bolje definirani (Slika 5).

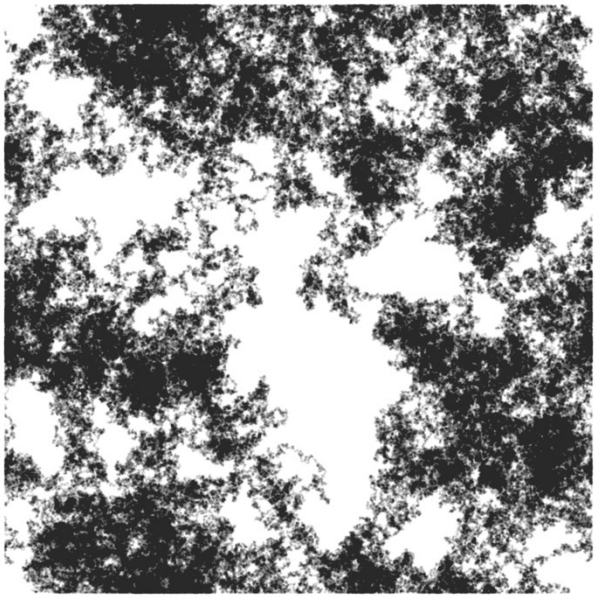


Slika 5: Proces načrtovanja v digitalni generativni umetnosti

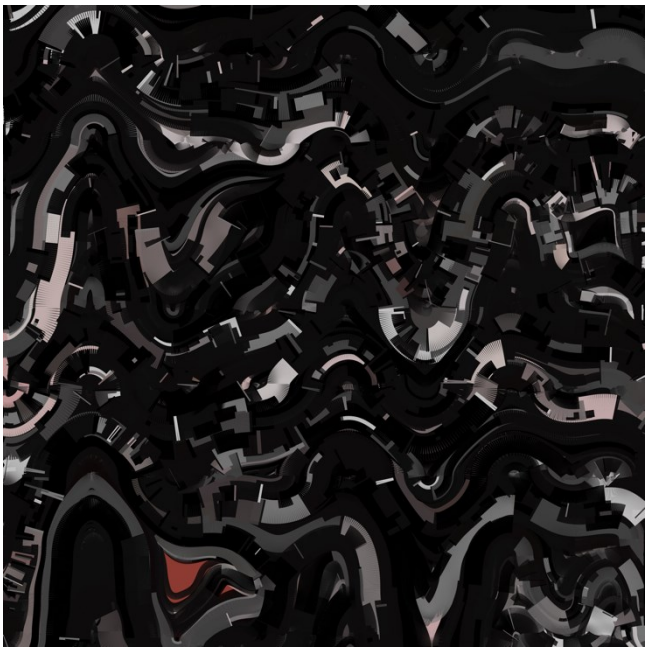
Na naslednjih slikah (Slika 6, 7, 8, 9 in 10) so prikazane digitalne grafike, ki praktično vizualizirajo sinteze abstraktnih teksturnih vzorcev z različnimi tehnikami, od preproste funkcije *random()* do različnih generirarnih šumov.



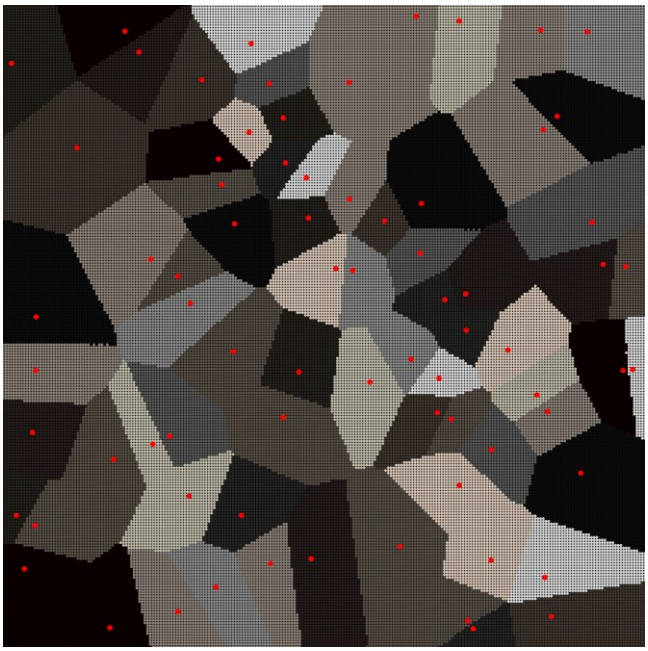
Slika 6: Vizualizacija sinteze abstraktnega teksturnega vzorca s funkcijo random()



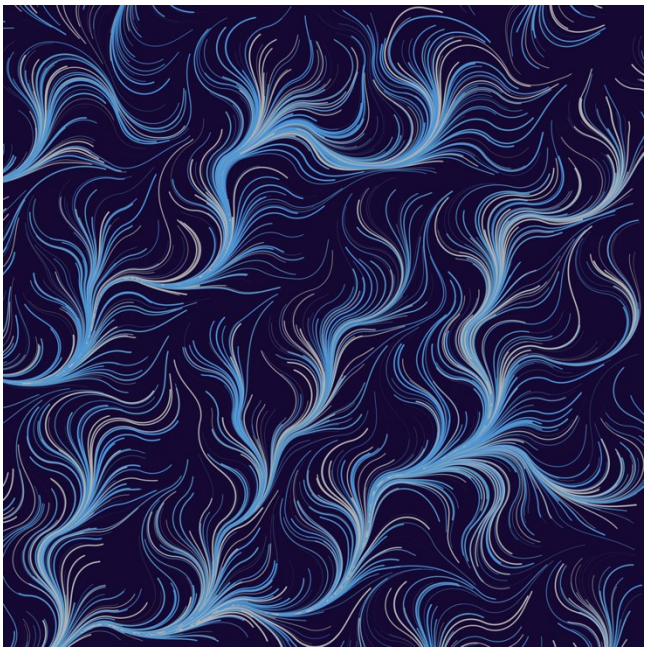
Slika 7: Vizualizacija sinteze abstraktnega teksturnega vzorca z naključnim sprehajalcem



Slika 8: Vizualizacija sinteze abstraktnega teksturnega vzorca z Worleyevim šumom



Slika 9: Vizualizacija sinteze abstraktnega teksturnega vzorca z Voronoijevim šumom



Slika 10: Vizualizacija sinteze abstraktnega teksturnega vzorca z Worleyevim šumom in sistemom delcev

4 ZAKLJUČEK

Proces generativne umetnosti kaže dualno naravo: po eni strani zahteva tako razvoj sistema, po drugi pa tudi razvoj metode vizualizacije za rezultat sistema. En sam sistem lahko povzroči zelo heterogene rezultate, če uporabljamo različne pristope vizualizacije. Mešanje in ujemanje obstoječih sistemov in metod vizualizacije ter razvoj novih skozi čas je temelj ustvarjanja v generativni umetnosti. Digitalna generativna umetnost ni nobena izjema. Vizualizacija lepote preprostih dinamičnih sistemov skozi preprosto programsko kodo, pri kateri cilj ni vnaprej določen, sam ustvarjalni proces pa temelji na odkrivanju, spreminjanju in raziskovanju večinoma nepričakovanih rezultatov, je tipičen primer uporabe naključnosti v računalniški umetnosti. Lahko potrdimo, da naključni faktor le omogoča umetnikom, da dobijo rezultate, ki bi jih z ročnim postopkom precej težko dosegli, kar se nanaša na ustvarjanje abstraktnih teksturnih vzorcev.

Implementacija naključnosti v digitalno podobotvorje je od dijakov zahtevala določeno mero spoznavanja in razumevanja dodoločenih matematičnih vsebin ter eksperimentiranja v različnih situacijah. Kreativno delo v parih in/ali skupinah je omogočalo razvijanje tako naravoslovne kot digitalne komunikacije. Interpretacija možnih konfiguracij abstraktnih tekstur in njihove morebitne napovedi so puščala dijakom veliko prostora za nova spoznanja. Ob izmenjevanju idej, situacij in razprav po opravljenih vizualizacijah se je krepile ustvarjalnost dijakov, kajti njihovo sodelovanje pri pripravi ustreznih programskih kod je delo na področju računalniške grafike naredilo še bolj zanimivo in raziskovalno. Ob tem so nenazadnje spoznali, da lahko vizualizacija tekstur s proceduralno generacijo ob pomoči nekaj ročno zapisanih pravil in računalniško generiranega naključja ustvarja neskončno množico podobnih, a vseeno še raznolikih konfiguracij, ki jo uporabijo kot samostojno podobotvorje ali pa konstruktivno vsebino za generacijo svetov v računalniških animacijah ali igricah. Izkušnje, pridobljene s pisanjem preprostih računalniških programov za generiranje abstraktnih teksturnih vzorcev, ali medsebojne izkušnje, ki so jih dijaki pridobili med razvijanjem naravoslovne in digitalne komunikacije, so pripomogle k razvoju digitalne pismenosti in razumevanju uporabe računalniških metod v ustvarjanju digitalne umetnosti.

5 VIRI

[1] Babič, D. (2019). Kreativno kodiranje v medijski produkciji. V U. Rajkovič, B. Batagelj (ur.), Zbornik 22. Mednarodne multikonference Informacijska družba. Zvezek J. Ljubljana: Institut »Jožef Stefan«. Pridobljeno na http://library.ijs.si/Stacks/Proceedings/InformationSociety/2019/IS2019_Volume_J%20-%20VIVID.pdf

[2] Kyunghyun K., Tek-Jin N. (2013). Designing Unique Products with Self-morphing Randomness. Department of Industrial Design, KAIST, Daejeon, Korea. Pridobljeno na http://aodr.org/xml/01482/01482.pdf

[3] Perlin, K. (2001). Standard for perlin noise. Pridobljeno na http://www.google.com/patents/US6867776

[4] Ebert, D., Musgrave, K., Peachey, D., Perlin, K., & Worley, S. (2003). Texturing & modeling: A procedural approach (3. ed.). San Francisco: Morgan Kaufman Publishers.

[5] Short, T. & Adams, T. (2017). Procedural generation in game design. Boca Raton: CRC Press, Taylor & Francis Group.

Malokodno programiranje in razvoj spletnih aplikacij

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POVZETEK

Malokodno programiranje in razvoj spletnih aplikacij je eden od načinov kako pospešiti digitalno poslovno transformacijo. Med zahtevami po hitrem razvoju zanesljivih in stroškovno sprejemljivih aplikacij ter zmogljivostjo razvijalskih kapacitet v sektorju IT zeva ogromen prepad. Za uspešno obvladovanje teh zahtev je potrebno usposobiti več domenskih strokovnjakov (specifične poslovne funkcije) za delo z novimi razvojnimi programskimi orodji. Ta tako njim kot tudi razvojnim specialistom s področja IT omogočajo nove, inovativne poslovne rešitve. Orodja za malokodno programiranje se od orodij za brezkodno programiranja ločijo po tem, da so slednja namenjena laičnim razvijalcem. Posledično so rešitve zamrznjene v okvir samega orodja. Malokodna orodja pa omogočajo tudi zelo detajlno prilagajanje z določenimi programskimi jeziki. Malokodno programiranje v primeru preprostih spletnih aplikacij ne zahteva poglobljenega znanja s področja modeliranja baz podatkov in uporabniškega vmesnika. Zato ga lahko kreativno uporablja širši krog ljudi. V okviru projekta Erasmus+ Better Employability for Everyone with APEX (BeeAPEX) bomo razvili elektronska gradiva, ki bodo študentom različnih usmeritev (družboslovje, tehnika, naravoslovje, medicina, itd.) in zainteresiranim posameznikom izven univerze (zaposlenim in nezaposlenim) omogočila: a) učenje malokodnega orodja za inovativno uporabo v procesih poslovne digitalne transformacije in b) povečati digitalne kompetence udeležencev.

KLJUČNE BESEDE

Malokodno programiranje, razvoj aplikacij, e-izobraževanje, zaposljivost

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ABSTRACT

Low-code programming and web application development is one of the modes to accelerate digital business transformation. There is a huge gap between the requirements for the rapid development of reliable and cost-effective applications and the capacity of development personel in the IT sector. To successfully manage these requirements, it is necessary to train several domain experts (specific business functions) to work with new development software tools. This enables new, innovative business solutions for both them and IT development specialists. Low-code programming tools differ from no-code programming tools in that the latter are intended for non-professional developers. As a result, solutions are frozen within the framework of the tool itself. On the contrary low-code tools also allow very detailed customization with specific programming languages. Low-code programming in the case of simple web applications does not require in-depth knowledge of database modeling and user interface. Therefore, it can be used creatively by a wider range of people. As part of the Erasmus+ Better Employability for Everyone with APEX (BeeAPEX) project, we will develop electronic materials that will enable students of various orientations (social sciences, engineering, natural sciences, medicine, etc.) and interested individuals outside the university (employed and unemployed) to: a) learn of a low-code tool for innovative use in business digital transformation processes and b) to increase the digital competences of the participants.

KEYWORDS

Low code programming, application development, e-education, employability

1 UVOD

Kot v svoji viziji in poti za digitalno preobrazbo Evrope do leta 2030 ugotavlja Evropska komisija, Evropa potrebuje večje

število IKT strokovnjakov, višjo stopnjo digitalnega znanja prebivalstva ter večjo uravnoteženost spolov na področju IKT [1]. Eden od pristopov, s katerim lahko v kratkem času razširimo znanje s področja razvoja aplikacij ter povečamo stopnjo digitalnega znanja prebivalstva, je vsekakor razvoj aplikacij s pristopom malokodnega programiranja. Zanimanje za platforme, ki omogočajo razvoj rešitev s pristopom malokodnega programiranja, narašča [2], saj s tovrstnim pristopom lahko z minimalnim znanjem programiranja razvijemo učinkovite poslovne spletne aplikacije.

V skladu s programom Evropske komisije za posodobitev evropskih visokošolskih sistemov [3] bi moralo visoko šolstvo okrepiti posameznikove potenciale ter opremiti diplomante z znanjem in temeljnimi prenosljivimi kompetencami, ki jih potrebujejo za da bi bili uspešni v poklicih, ki zahtevajo visoka znanja in spretnosti. V praksi imajo danes diplomanti EU težave pri iskanju kakovostne zaposlitve s polnim delovnim časom na svojem področju študija. Po drugi strani delodajalci ne morejo zadovoljiti potreb po visokokvalificiranem osebju, ki ima znanja s področja informatike ter praktične digitalne spretnosti. V programu Evropske komisije [3] je kot eden od izzivov navedeno tudi posodabljanje učnih načrtov glede na spreminjajoče se potrebe, pri čemer so problem predvsem počasni odzivi institucij. V okviru projekta BeeAPEX naslavljamo problem neskladja med znanjem diplomantov in IT veščinami, ki se zahtevajo na trgu dela, z vključevanjem delodajalcev (podjetje Oracle in lokalna MSP) pri oblikovanju in izvajanju tečajev s področja malokodnega programianja.

Glede na pozitivne predhodne izkušnje z okoljem za malokodno programiranje Oracle Application Express (APEX) [3, 4], smo se projektni partnerji iz 6 držav odločili, da v okviru Erasmus+ projekta Better Employability for Everyone With APEX (BeeAPEX), pripravimo elektronski učbenik, s katerim bi spodbudili uporabo ter razširili znanje malokodnega razvoja aplikacij tudi na kader, ki ni specializiran na področju informacijske tehnologije (IT). Kot kažejo podatki je v Sloveniji delež organizacij, ki uporabljajo pristope z malo ali nič programiranja zelo nizek [6], kar še dodatno nakazuje na potrebo po tovrstnem izobraževanju.

2 PREGLED LITERATURE

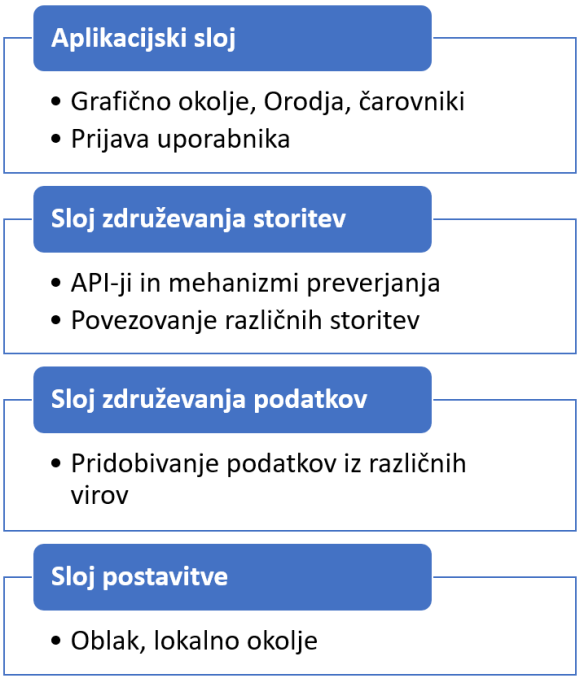
Malokodne razvojne platforme so enostavne za uporabo in jih večja tehnološka podjetja vedno bolj promovirajo, da bi omogočila posameznikom in organizacijam razvoj programskih rešitev z minimalnim znanjem programiranja [7]. Med bolj znanimi razvojnimi platformami tako lahko omenimo Mendix [8], Microsoft PowerApps [9], Google App Sheet [10] in Oracle APEX [11]. Čeprav pristop malokodnega programiranja še vedno zahteva nekaj osnovnega znanja programiranja, pa je tovrsten razvoj aplikacij hitrejši, cenejši, predvsem pa se ga lahko enostavneje naučimo. Gartner [12] ocenjuje, da bodo do leta 2024 večino poslovnih aplikacij razvijali strokovnjaki izven področja IT.

Kot ugotavljajo Rek, Beranič in Heričko [6], se orodja za razvoj aplikacij z malo ali nič programiranja uporabljajo v najrazličnejših industrijah. V literaturi zasledimo vedno več primerov aplikacij razvitih s pristopom malokodnega programiranja. Talesra in Nagaraja [2] v svojem prispevku predstavljata primer razvoja aplikacije automatizacijo dostopa v okolju Oracle APEX. Baggia, Leskovar in Rodič [4] predstavljajo pozitivne izkušnje z uvajanjem pristopa malokodnega programiranja v visokošolski izobraževalni sistem. Malokodni pristop so uporabili tudi za razvoj aplikacij za nadzor širjenja COVID-19, pri čemer je bil posebej izpostavljen izziv, da je potrebno aplikacijo razviti hitreje, kot pa se širi virus [13].

3 BOLJŠA ZAPOSLJIVOST Z ORACLE APEX

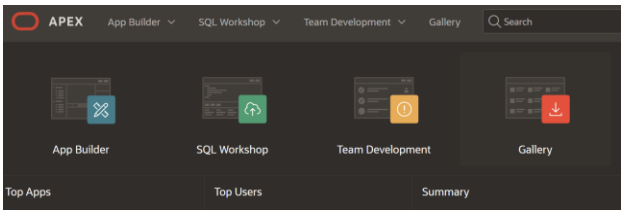
3.1 Malokodno programiranje in razvoj aplikacij

Pristop malokodnega programiranja najpogosteje uporabljamo za razvoj aplikacij v oblačnih storitvah [7]. Na ta način nam ponudniki omogočajo ne le razvoj z malo znanja programiranja, pač pa tudi možnost za razvoj aplikacij brez dodatne IKT opreme. Na sliki 1 so prikazani sloji tipične malokodne razvojne platforme.



Slika 1: Sloji malokodne razvojne platforme (povzeto po [7])

Komponente posameznih slojev malokodne razvojne platforme lahko razvrstimo v tri nivoje [7]. Na prvem nivoju imamo orodje za razvoj aplikacije, na drugem orodja za upravljanje strežniškega sistema, na tretjem pa orodja za upravljanje z zunanjimi storitvami integriranimi na platformo. Na sliki 2 je prikazano osnovo orodje za razvoj aplikacij v Oracle APEX.

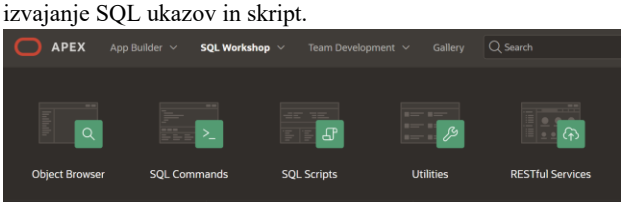


Slika 2: Izsek orodja za razvoj aplikacij v Oracle APEX

3.2 Oracle APEX

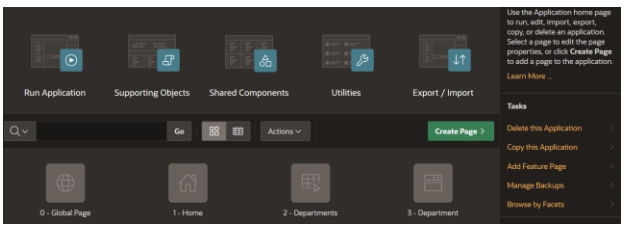
Oracle APEX je spletno razvojno okolje, ki ga je Oracle najprej ponudil kot dodatek k bazi podatkov, ki omogoča enostaven razvoj aplikacij na bazi podatkov [14]. Danes lahko Oracle APEX uporabljamo tudi kot oblačno storitev, za izobraževalne namene je možna brezplačna registracija delovnega prostora, v katerem lahko v omejenem obsegu ustvarjamo svojo bazo podatkov, določamo tabele, vnašamo podatke ter seveda razvijamo spletne aplikacije. Osnovna orodja, ki so na voljo v spletnem vmesniku vidimo na sliki 1. Uporabljamo lahko ***App Builder*** za izdelavo, uvoz in urejanje aplikacij, ***SQL Workshop*** za delo z bazo podatkov in objekti na bazi podatkov, ***Team Development*** za učinkovitejše delo v skupini ter ***Gallery***, v kateri si lahko ogledamo nekaj pred pripravljenih delov aplikacij.

V okviru projekta BeeAPEX bomo za udeležence izobraževanja pripravili elektronski učbenik in primere s katerimi se bodo lahko seznanili z nekaterimi od enostavnejših možnosti, ki jih ponuja Oracle APEX. V začetni fazi bo potrebno definirati ali pa uvoziti tabele v bazi podatkov in jih po potrebi napolniti s testnimi podatki. Na sliki 3 je prikazano okno ***SQL Workshop***, ki omogoča pregled objektov v bazi podatkov ter izvajanje SQL ukazov in skript.



Slika 3: Oracle APEX SQL Workshop

Eno ključnih orodij, ki jih bomo uporabili v okviru izobraževanja je tudi ***App Builder,*** v katerem izdelamo ali uvozimo aplikacijo, ter jo nato tudi urejamo. Na sliki 4 je prikazano okno za urejanje aplikacije.



Slika 4: Urejanje aplikacije v Oracle APEX

V malokodni razvojni platformi Oracle APEX imamo veliko možnosti za razvoj aplikacij, vendar se bomo zaradi potreb projekta BeeAPEX, ki katerega ciljna skupina so razvijalci z minimalnim znanjem s področja informacijske tehnologije, osredotočili samo na osnovna orodja. V nadaljevanju podrobneje predstavljamo aktivnosti, ki bodo izvedene v okviru projekta.

3.3 Aktivnosti v okviru projekta BeeAPEX

Znanje s področja malokodnega programiranja bomo v okviru projekta BeeAPEX širili na različne načine. V prvi vrsti bomo pripravili kratek spletni tečaj malokodnega programiranja v okolju Oracle APEX. Tečaj bo vključeval vsebine od oblikovanja in razvoja baze podatkov, do osnovnega razvoja aplikacij. V prvotni obliki bo tečaj razvit v angleškem jeziku, nato pa preveden v vseh 6 jezikov: slovenski, hrvaški, slovaški, nemški, poljski in grški. Vsebina tečaja bo prosto dostopna, hkrati pa jo bo mogoče uporabljati v okviru študijskega procesa sodelujočih institucij. Da bi informacijo o možnosti vključitve v tečaj razširili med študenti, izobraževalnimi institucijami in delodajalci, bomo pripravili 6 kratkih spletinarjev (angl. webinar), ki bodo prav tako prevedeni v vseh 6 jezikov. Poleg kratkega tečaja, bomo pripravili vsebino za napredni tečaj oziroma izbirni predmet v obsegu 75 ur oziroma 3 ECTS. Učni načrt predmeta bo vseboval tako predavanja, praktične vaje, naloge ter omogočal ocenjevanje dela študenta. Vključenih bo tudi 12 študij primerov, ki bodo razvite v sodelovanju s predstavniki poslovnega sektorja, da bodo odraz dejanskih rešitev v praksi. Predmet bo prosto dostopen, hkrati pa bodo sodelujoče ustanove pripravile dokumentacijo za priznanje izbirnega predmeta v posamezni državi. Pri obeh tečajih bomo vsebino testirali na pilotnih aktivnosti, ki se jih bodo udeležili srednješolci in študenti.

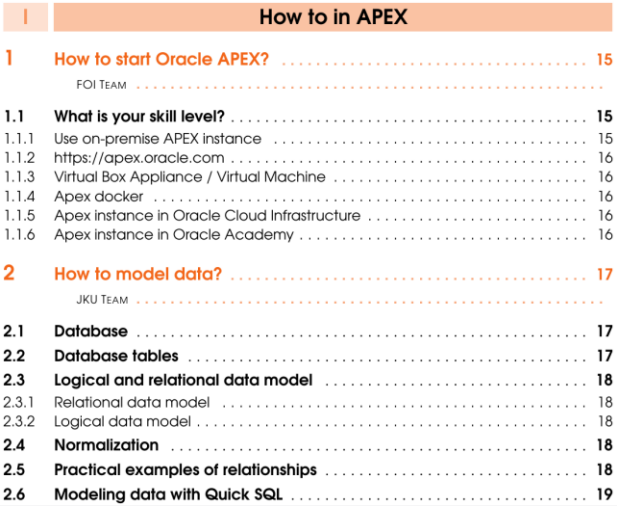
Poseben poudarek bomo v okviru projekta namenili tudi izobraževanju visokošolskih učiteljev. Na delavnico v obsegu 30 ur bomo povabili visokošolske učitelje iz 6 držav, prednostno učitelje s področja družboslovja, ter jim prikazali možnosti uporabe Oracle APEX za razvoj enostavnih aplikacij, ki jih bodo lahko uporabili v svojem študijskem procesu. Posebno pozornost bomo namenili tudi temu, da bo v delavnico vključenih tudi vsaj polovico učiteljic, saj je ženski spol na področju IT izobraževanja slabše zastopan.

V okviru promocijskih aktivnosti projekta, bomo naše rezultate predstavili tako srednješolskim ustanovam, visokošolskim ustanovam ter tudi delodajalcem.

3.4 Vsebina izobraževanja

Eden od ključnih rezultatov projekta BeeAPEX je tudi gradivo za izvedbo izbirnega predmeta oziroma kreditno ovrednotene obštudijske dejavnosti v obsegu 3 ECTS. Osnovno gradivo za samostojni študij študenta bo elektronski učbenik, ki bo poleg pisnega gradiva vključeval še skripte za pomoč pri gradnji modelov ter video posnetke s primeri.

Prvi del učbenika bo vseboval navodila s primeri, kako začnemo z Oracle APEX, kako modeliramo podatke, kako se orientiramo v razvojnem okolju, kako uvozimo podatke, oblikujemo prvi osnutek aplikacije, kakšna je razlika med obrazci in poročili, kako oblikujemo grafične prikaze, kako upravljamo z meniji. Udeležencem izobraževanja bodo prikazane tudi nekatere naprednejše teme ko je sodelovanje skupine v razvojnem okolju, kako si lahko pomagamo z galerijo predpripravljenih aplikacij in vtičnikov ter kako razvijemo aplikacijo v več jezikih. Na sliki 5 je prikazana delovna verzija kazala elektronskega učbenika.



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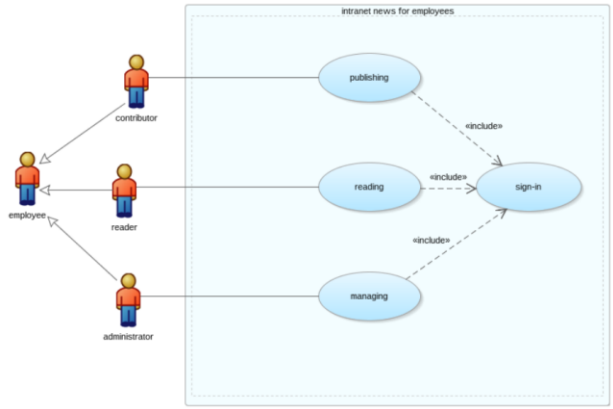
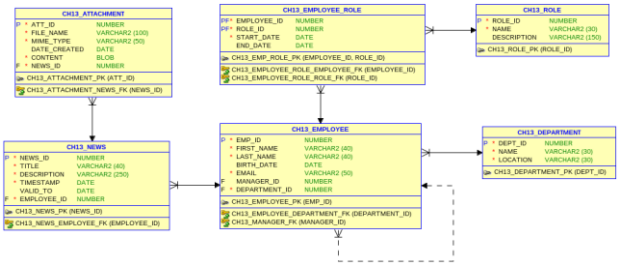
Slika 5: Delovna verzija kazala elektronskega učbenika

V drugem delu priročnika bomo udeležence izobraževanja seznanili z 12 različnimi primeri razvoja aplikacij. Vsebino primerov bomo oblikovali skupaj s poslovnimi partnerji, da bodo vključevali dejanske probleme iz prakse. Med predlogi primerov so tako intranet aplikacija za zaposlene, katalog rastlin, platforma za sodelovanje okoljske organizacije, sistem za prijavo inovacij, sistem za upravljanje dokumentov, spletna trgovina, sistem za razporejanje tečajev, oblikovanje kosovnice in stroškovnik, sistem za izposojo avtomobilov in podobno. Vsak primer bo na začetku opisan in predstavljen tudi v obliki diagrama primera uporabe. Na sliki 6 je prikazan diagram primera uporabe za intranet aplikacijo.



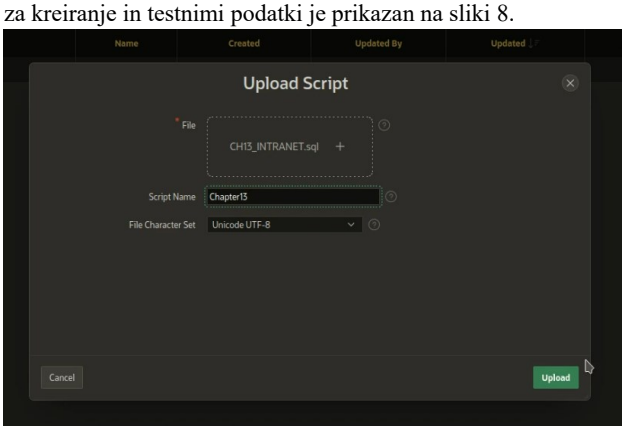
Slika 6: Diagram primera uporabe za intranet aplikacijo

Opisu primera bo sledila predstavitev baze podatkov, najprej v obliki logičnega modela, nato pa še v obliki relacijskega podatkovnega modela. Na sliki 7 je prikazan relacijski podatkovni model, ki služi kot osnova za razvoja intranetne aplikacije za zaposlene.



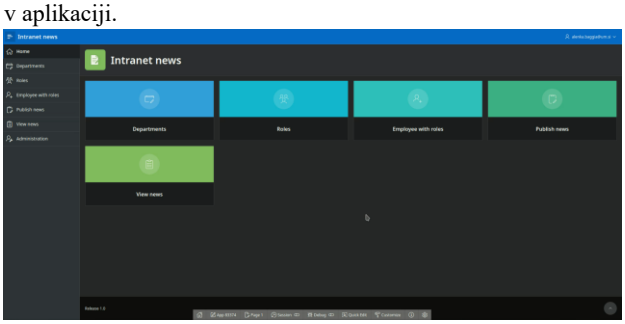
Slika 7: Primer relacijskega podatkovnega modela

Udeležencem izobraževanja bo na voljo skripta z ukazi za kreiranje tabel v bazi podatkov ter ukazi z osnovnimi testnimi podatki. Izsek videoposnetka z navodili za uvoz skripte z ukazi za kreiranje in testnimi podatki je prikazan na sliki 8.



Slika 8: Izsek posnetka za uvoz skripte v Oracle APEX

Posnetki, ki bodo prikazovali razvoj aplikacije v vsakem od 12 primerov bodo opremljeni z navodili, ki bodo prevedena v vseh 6 jezikov. Na sliki 9 je prikazana intranet aplikacija za zaposlene, v kateri so pravice vpogleda v posamezne obrazce določene glede na pravice uporabnika, ki se lahko razvrsti v eno od 3 skupin uporabnikov: upravljalec aplikacije, uporabnik s pravico objavljanja novic in običajni uporabnik s pravico pregledovanja intranetnih novic. Na sliki 9 je prikazan vpogled upravljalca aplikacije, ki ima dostop do vseh obrazcev in poročil v aplikaciji.



Slika 9: Intranet aplikacija za zaposlene

Na podoben način kot primer intranet aplikacije bodo predstavljeni tudi ostali primeri v elektronskem priročniku. V zaključku elektronskega priročnika bomo za izobraževalne ustanove pripravili tudi obrazce za akreditacijo učnih vsebin v državah partnerjev projekta BeeAPEX.

4 ZAKLJUČEK

Predlagani projekt bo podprl digitalno poslovno transformacijo visokošolskih institucij z razvojem digitalne pripravljenosti, odpornosti in zmogljivosti tako akademskega osebja kot tudi študentov. Pripeljal bo do posodobitve učnih načrtov in predmetov s področja informacijske tehnologije na področjih, malokodnega programiranja, oblikovanja aplikacij in baz podatkov. Takšen pristop bo študentom ne tehničnih smeri omogočil, da se izpopolnijo na področju IT, kar bo povečalo njihovo zaposljivost in zapolnilo vrzel med povpraševanjem in ponudbo razvijalcev IT.

Kot ugotavljajo [6], je delež organizacij, ki v Sloveniji uporabljajo pristope z malo ali nič programiranja, nizek, kar se razlikuje od globalne slike. V svetu je tovrstnih podjetij bistveno več (41 %). Predvidevamo, da bo tudi priprava učnih gradiv, ki bodo nastala v okviru Erasmus+ projekta Better Employability for Evernyone with APEX, spodbudila izobraževalne ustanove ter tudi posameznike k večji uporabi malokodnih razvojnih okolij ter s tem približala Slovenijo in ostale sodelujoče države globalnemu trendu na področju malokodnega razvoja aplikacij.

ZAHVALA

Prispevek je nastal ob podpori Evropske komisije z nepovratnimi sredstvi v okviru ključnega ukrepa 2: Sodelovanje med organizacijami in institucijami – Sodelovalna partnerstva za projekt KA220-HED-15/21 Better Employability for Everyone with APEX (BeeAPEX). Vsebina tega prispevka ne odraža nujno stališča ali mnenja Evropske komisije. Za izražena mnenja odgovarjajo samo avtorji in se zato ta ne morejo šteti za uradno stališče Evropske komisije.

LITERATURA IN VIRI

[1] Evropska komisija, “Evropska deklaracija o digitalnih pravicah in načelih za digitalno desetletje,” Bruselj, 2022.

[2] K. Talesra and G. S. Nagaraja, “Low-Code Platform for Application Development,” *Int. J. Appl. Eng. Res.*, vol. 16, no. 5, pp. 346–351, 2021.

[3] Evropska komisija, “Spodbujanje rasti in delovnih mest – program za posodobitev evropskih visokošolskih sistemov,” Bruselj, 2011.

[4] A. Baggia, R. Leskovar, and B. Rodič, “Low code programming with oracle APEX offers new opportunities in higher education,” in *3rd International Scientific Conference ITEMA Recent Advances in Information Technology, Tourism, Economics, Management and Agriculture*, 2019.

[5] A. Baggia, A. Mali, A. Grlica, and R. Leskovar, “Oracle APEX in Higher Education,” in *Proceedings of the 37th International Conference on Organizational Sciences Development*, 2018, pp. 27–38.

[6] P. Rek, T. Beranič, and M. Heričko, “Študija pričakovanj in uporabnosti orodij za razvoj aplikacij z malo ali nič programiranja,” *Uporab. Inform.*, no. SE-Znanstveni prispevki, Jul. 2022.

[7] A. Sahay, A. Indamutsa, D. Di Ruscio, and A. Pierantonio, “Supporting the understanding and comparison of low-code development platforms,” in *2020 46th Euromicro Conference on Software Engineering and Advanced Applications (SEAA)*, 2020, pp. 171–178.

[8] Mendix Technology BV, “No Title,” *Mendix: Go make it*, 2022. [Online]. Available: https://www.mendix.com/.

[9] Microsoft, “Power Apps,” *The world needs great solutions. Build yours faster.*, 2022. [Online]. Available: https://powerapps.microsoft.com/en-us/.

[10] Google, “AppSheet,” *The fastest way to build apps and automate work*, 2022. [Online]. Available: https://about.appsheet.com/home/.

[11] Oracle, “Oracle APEX,” *Build enterprise apps 20x faster with 100x less code*, 2022. [Online]. Available: https://apex.oracle.com/en/.

[12] Gartner Inc., “Gartner Says the Majority of Technology Products and Services Will Be Built by Professionals Outside of IT by 2024,” 2021. [Online]. Available: https://www.gartner.com/en/newsroom/press-releases/2021-06-10-gartner-says-the-majority-of-technology-products-and-services-will-be-built-by-professionals-outside-of-it-by-2024.

[13] J. Varajão, “Software Development in Disruptive Times: Creating a Software Solution with Fast Decision Capability, Agile Project Management, and Extreme Low-Code Technology,” *Queue*, vol. 19, no. 1, pp. 94–103, Feb. 2021.

[14] A. Geller and B. Spendolini, *Oracle Application Express: Build Powerful Data-Centric Web Apps with APEX 5*. New York: McGraw-Hill Education, 2017.

Pouk na daljavo: e-kulturni dan

Distance Learning: An E-Cultural Day

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POVZETEK

Dnevi dejavnosti so tisti del obveznega programa osnovne šole, ki medpredmetno povezujejo discipline in predmetna področja, vključena v predmetnik osnovne šole. Med dneve dejavnosti sodijo tudi kulturni dnevi, v sklopu katerih je priporočeno, da bi osnovnošolci vsaj enkrat letno obiskali kulturno-umetniško ustanovo (kino, gledališče, muzej, arhiv, galerija, koncertna dvorana …). Omenjene ustanove in njihove dejavnosti smo učencem s pomočjo IKT skušali približati tudi v času pouka na daljavo.

V prispevku je predstavljeno načrtovanje in izvedba kulturnega dne z naslovom Gledališke delavnice. Učenci od 6. do 9. razreda so si na spletni povezavi ogledali dramsko igro Kit na plaži, prirejeno po Möderndorferjevem mladinskem romanu. Po ogledu je sledilo izražanje vtisov in mnenja v obliki spletnega vprašalnika v spletni učilnici. Drugi del kulturnega dne je od učencev zahteval več aktivne udeležbe. Učenci 6. in 7. razreda so poustvarili dramski prizor, v obliki senčnih lutk izdelali književne osebe in domiselno oblikovali senčna gledališča. Prizor so odigrali in fotografije ter posnetke naložili v spletno učilnico kot dokaze aktivnega udejstvovanja na kulturnem dnevu. Učenci 8. in 9. razreda pa so svoje literarnovedno znanje dokazovali in nadgrajevali ob reševanju izzivov v spletni sobi pobega, ki smo jo oblikovali v spletnem orodju Google Forms. Za reševanje sobe pobega so bili precej motivirani. Podatke so iskali tudi na spletu in se povezali s sošolci. Kljub spletnemu okolju prilagojenim dejavnostim je bil kulturni dan učencem všeč, zato lahko povzamemo, da so bile metode in oblike dela ustrezno izbrane.

KLJUČNE BESEDE

Pouk na daljavo, kulturni dan, Google Forms, spletna soba pobega

ABSTRACT

Activity days are that part of the compulsory primary school program that cross-curricularly connects the disciplines and subject areas included in the primary school curriculum. Activity days also include cultural days, during which it is recommended that pupils visit a cultural and artistic institution (cinema, theater, museum, archive, gallery, concert hall, etc.) at least once a year. With the help of ICT, we tried to bring the aforementioned institutions and their activities closer to the pupils even during distance learning.

The article presents the planning and execution of a cultural day entitled Theater Workshops. Pupils from the 6th to the 9th grade watched the drama Kit on the Beach online, adapted from Möderndorfer's youth novel. Watching the drama was followed by the expression of impressions and opinions in the form of an online questionnaire in an online classroom. The second part of the cultural day required more active participation from the pupils. The 6th and 7th grade pupils recreated a dramatic scene, made literary characters in the form of shadow puppets and imaginatively designed shadow theaters. They acted out the scene and uploaded photos and videos to the online classroom as evidence of active participation in the cultural day. The 8th and 9th grade students demonstrated and improved their literary knowledge by solving challenges in the online escape room, which we designed using the Google Forms web tool. They were quite motivated to solve the escape room. They also looked for information online and connected with their classmates. Despite the activities adapted to the online environment, the students liked the cultural day, so we can summarize that the methods and forms of work were chosen accordingly.

KEYWORDS

Distance learning, cultural day, Google Forms, online escape room

1 UVOD

Dnevi dejavnosti vzpodbujajo vedoželjnost, ustvarjalnost in samoiniciativnost učenk in učencev, jih usposabljajo za samostojno opazovanje in pridobivanje izkušenj in znanja, za razvijanje spretnosti ter za samostojno reševanje problemov. Ob teh dejavnostih učenci in učenke znanje različnih področij med seboj povezujejo v celoto. Dnevi dejavnosti so namenjeni vsem učenkam in učencem, so vsebinsko pestri in smiselno razporejeni skozi vse šolsko leto. Vsebinsko se nadgrajujejo iz leta v leto oziroma iz triletja v triletje [1].V okviru pouka na daljavo je bilo za učitelje ali zunanje izvajalce pravi izziv pripraviti dan dejavnosti, ki bi bil učencem v izziv, v katerem bi bili aktivni in bi ob tem tudi uživali ter razvijali svoji vedoželjnost in sposobnost samostojnega reševanja problemov. Še posebej pri pripravi kulturnih dni je največ težav predstavljalo vprašanje,

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kakšne naloge oz. izdelke naj zahtevamo od učencev kot dokazilo o sodelovanju in učenju za namene spremljanja napredka učencev. Ker je Analiza izobraževanja na daljavo v času prvega vala epidemije covida-19 v Sloveniji pokazala [2], da so učitelji predmetnega pouka kot dokazilo o učenju in napredovanju od učencev zahtevali, naj jim posredujejo izpolnjene učne liste, rešene naloge v delovnem zvezku in ustne odgovore na zastavljena vprašanja prek videokonference; smo se v drugem valu izdatno trudili pridobivati raznolike dokaze o učenju in napredku, kot bi jih zbrali tudi realnem okolju (v učilnici).

Načrtovalci kulturnih dni smo se trudili upoštevati smernice in priporočila [1]: »Učenke in učenci spoznavajo različna jezikovna, družboslovna in umetnostna področja, naravne vrednote in vrednote človeške družbe ter jih med seboj povezujejo. V izvajanju kulturnih dni so učenke in učenci aktivni, to je dejavnosti načrtujejo ter sprejemajo, doživljajo in se izražajo. /…/ Razvijajo ustvarjalnost, sposobnost dojemanja spoznanj družboslovnih ved in jezikoslovja, doživljanje umetniške besede, barv, oblik, zvoka in giba ter prepoznavanje, razumevanje in vrednotenje pokrajine in njenih sestavnih delov.«

Odločili smo se, da učence od 6. do 9. razreda povabimo k ogledu gledališke predstave, ki je primerna za vse učence omenjenega starostnega razpona. Po ogledu so vsi učenci odgovarjali o svojem doživljanju gledališke predstave, izrazili so vtise in mnenja. Nato pa so učenci 6. in 7. razreda literarno in likovno poustvarjali, starejši učenci pa so se lotili zahtevnejšega spletnega izziva. Zavedali smo se namreč, da imajo starejši učenci že več znanja o gledališki umetnosti. V obzir smo vzeli usmeritve o zmernosti raznolikosti metod in dejavnosti, saj kljub temu, da raznolikost metod in aktivnosti prispeva k ohranjanju radovednosti učencev in njihovi notranji motiviranosti, pa v spletnih učnih okoljih ni dobro preveč eksperimentirati in vanje vnašati preveč novosti, saj lahko to sproži občutke tesnobe in napetosti pri učencih [3].

V nadaljevanju prispevka bo natančneje predstavljen potek kulturnega dneva na daljavo za učence od 6. do 9. razreda, ki smo ga poimenovali Gledališke delavnice. Natančneje bo prikazan postopek izdelave spletne sobe pobega z brezplačnim spletnim orodjem Google Forms.

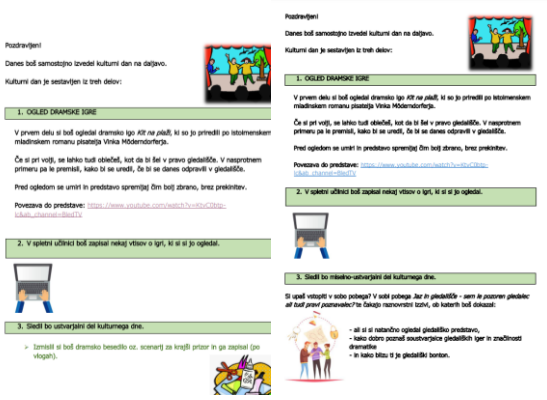
2 NAČRTOVANJE IN IZVEDBA KULTURNEGA DNE

2.1 Načrtovanje kulturnega dne

Dva dneva pred kulturnim dnevom so bili učenci preko spletne učilnice obveščeni, kdaj bo potekal kulturni dan in o temi le-tega.

Dan pred kulturnim dnevom so bila v spletno učilnico dodana navodila za izvedbo, natančno opisana po korakih (Sliki 1, 2).

Prvo navodilo je učencem razkrilo, da si bodo na spletu ogledali dramsko igro Kit na plaži, ki je prirejena po mladinskem romanu Vinka Möderndorferja in so jo odigrali dijaki Škofijske klasične gimnazije. Spodbujeni so bili, da se uredijo, kot bi bili v gledališču in si predstavo ogledajo zbrano, brez prekinitev.



Sliki 1, 2: Navodila za izvedbo kulturnega dne

Drugo navodilo je učence po ogledu igre usmerilo na vprašalnik o vtisih v spletni učilnici (Slika 3).

Slika 3: Vprašalnik o vtisih po ogledu dramske igre

Ustvarjalni del kulturnega dne je od učencev 6. in 7. razreda zahteval zapis kratkega dramskega prizora (poustvarjanje igre, ki so si jo ogledali, ali avtorski prizor), izdelavo senčnih lutk in preprostega senčnega gledališča. Nato so svoj prizor uprizorili in ob pomoči družinskih članov posneli. V spletno učilnico so naložili fotografije scenarija, izdelanih lutk in posnetke uprizorjenih dramskih prizorov (Sliki 4, 5).

Sliki 4, 5: Fotografiji senčnih lutk in scenarija

Učenci zadnjih dveh razredov tretje triade so se v tretjem delu kulturnega dne pomerili v miselno-ustvarjalnem izzivu – podali so se v spletno sobo pobega Jaz in gledališče – sem le pozoren gledalec ali tudi pravi poznavalec? Soba pobega (Slika

6) je bila oblikovana v spletnem orodju Google Form in je bila sestavljena iz različnih nalog, ki so preverjale:

- ali so si natančno ogledali gledališko predstavo,
- kako dobro poznajo soustvarjalce gledaliških iger in značilnosti dramatike
- in kako blizu jim je gledališki bonton.

Slika 6: Vstop v spletno sobo pobega

Učenci so imeli možnost, da si aktivnosti razporedijo skozi celoten dan in dokaze svojega kulturnega udejstvovanja učiteljem posredujejo do poznega večera.

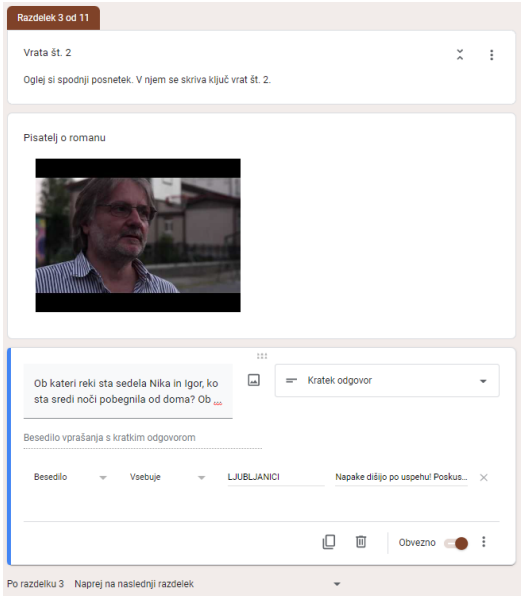
2.2 Spletna soba pobega

Soba pobega (angleško escape room) je igra, ki poteka v prostoru, v katerem je zaprta skupina ljudi, ki mora s pomočjo ugank, računov, namigov ter raznih drugih vrst pomoči poskusiti čimprej (navadno v 1 uri) priti na prostost. Njen nastanek so navdihnile tudi knjige, televizijski šovi in računalniške igre [4]. Igra je priljubljena po vsem svetu, saj udeleženci s kreativnim mišljenjem, iznajdljivostjo, raznolikimi strategijami reševanja problemov in sodelovanjem razrešijo vrsto nalog ter se prebijejo na prostost. Občutek brezizhodnosti in nezmožnost napredovanja brez najdene rešitve udeležence neverjetno notranje motivirata.

Nekatera spletna orodja, v našem primeru Google Forms, omogočajo, da znanje učne snovi ne preverjamo z običajnimi vprašanji ali kvizi, temveč vprašanje preoblikujemo v zanimivejšo obliko izziva, ki od udeleženca zahteva točno določeno rešitev ali ključ, ki odpira naslednji izziv in ob zaključku tudi končen izhod iz spletne sobe pobega. Spletno sobo pobega učencem enostavno posredujemo kot vse ostale google dokumente, v obliki spletne povezave.

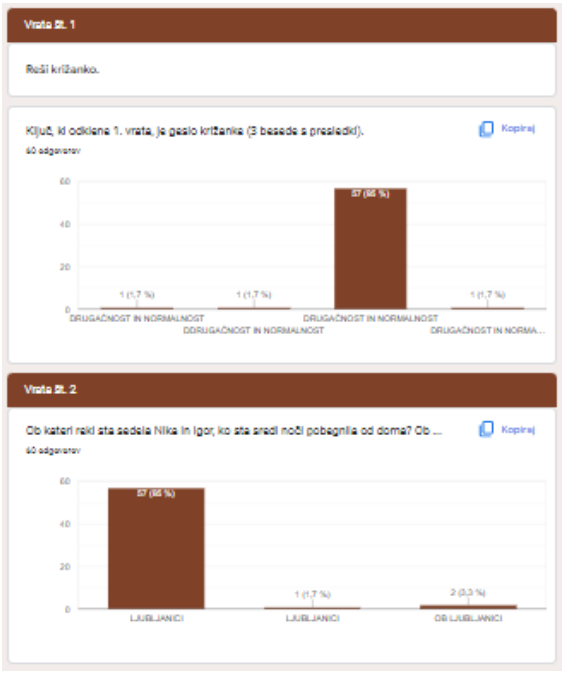
2.2.1 Oblikovanje točnega ključa. Snovalec sobe pobega (v našem primeru učitelj) pri vsaki nalogi oz. »vratih« nastavi naslednje nastavitve (Slika 7):

- kratek odgovor;
- besedilo (rešitev je besedilo);
- vsebuje (vsebuje točno tisto zaporedje črk, ki jih zapišemo na tretjo črto;
- na zadnjo črto lahko zapišemo, katero besedilo naj se pojavi, če se udeleženec pri zapisu rešite zmoti;
- ne pozabimo označiti, da je odgovor obvezen;
- novo nalogo oz. »sobo« pridobimo s kreiranjem novega razdelka.



Slika 7: Nastavitev točnega ključa vrat

2.2.2 Statistika. Prva naloga za učence v spletni sobi pobega je bil zapis imena, priimka in oddelka. Tako lahko učitelj v razdelku »Odzivi« sledi, kdo je uspešno razrešil vse izzive sobe pobega. Nekateri učenci so reševali v parih oz. skupinah. Sledi statistika ostalih rešitev (Slika 8). Orodje beleži tudi nepravilne rešitve (učenci so napačno odgovorili, zmotili so se v pravopisu ipd.)



Slika 8: Statistika rešitev

2.2.3 Odziv starejših učencev. Kulturni dan je bil organiziran aprila 2021, po velikonočnih praznikih, ko je bil za nekaj dni ponovno uveden pouk na daljavo, zato smo učitelji predvidevali, da starejši učenci pri izvajanju aktivnosti ne bodo najbolj odzivni. Učenci so nas pozitivno presenetili, saj se je skozi spletno sobo

pobega prebilo kar dve tretjini učencev. Zvedamo se, da so se med seboj obveščali o rešitvah nalog, vendar jih je spletna soba pobega kljub temu toliko pritegnila in motivirala, da so želeli priti do konca. Vsekakor pa so za visoko udeležno poskrbeli tudi elementi brezizhodnosti in tekmovalnosti.

3 REZULTATI

Učenci predmetne stopnje so si skoraj vsi ogledali gledališko igro, kar dokazujejo rešeni vprašalniki v spletni učilnici. Večini se je igra dopadla in so v veliki meri razbrali nekaj sporočil.
Učenci 6. in 7. razreda so bili nadvse ustvarjalni pri zapisu avtorskih dramskih prizorov in so ustvarili preproste, a domiselne senčne lutke in gledališča. Izkazali so se tudi pri snemanju prizorov z mobilnimi telefoni in posnetke uspešno naložili v spletne učilnice. Z dovoljenjem učencev smo nekaj najizvirnejših objavili na šolski spletni strani: https://www.youtube.com/watch?v=b6K9eewbtOI&t=5s&ab_channel=O%C5%A0TomaBrejca.

Osmošolci in devetošolci so morali za uspešno rešitev sobe pobega dobro poznati in razumeti vsebino dramske igre, natančno slediti navodilom, da so odkrili posamezne ključe, si pozorno ogledati nekaj posnetkov, ponoviti literarnovedne pojme, ki se navezujejo na dramatiko. Osvežili so tudi, kdo vse sodeluje pri uprizoritvi gledališke predstave in pravila kulturnega vedenja v gledališču. Marsikdo je bil pri reševanju nalog v sobi pobega aktivnejši, kot je navadno pri izkazovanju znanja v učilnici.

4 ZAKLJUČEK

V času pouka na daljavo je bilo smiselno in zaželeno, da smo izvedli tudi nekaj dni dejavnosti, ki so učence sprostili in ustvarjalno zaposlili z aktivnostmi, ki so se razlikovale od običajnih ur pouka na daljavo. Posegali smo po spletnih orodjih, ki učne vsebine popestrijo, medpredmetno povezujejo in učence spodbudijo k aktivni udeležbi.

Izkazalo se je, da so si učenci z veseljem ogledali dramsko igro, pa čeprav le preko spletne povezave.

Mlajši učenci so se odzvali z domiselnimi poustvarjalnimi rešitvami, ki so jih dokumentirali v obliki fotografij in videov.

Velik del starejših učencev je spletna soba pobega motivirala, da so razmišljali o literarnovednih pojmih, poklicih v gledališču in oliki. Nekateri izmed njih so se skozi naloge prebili s pomočjo

lastnega znanja, drugi pa so razvijali sposobnost iskanja podatkov v zapiskih, na spletu ali v pogovoru s sošolci.

Uporaba spletnega orodja Google Forms se je izkazala kot enostavna in učinkovita metoda za osvajanje, preverjanje in utrjevanje znanja, še bolj pa kot sredstvo za spodbujanje motivacije učencev in učenje na inovativen in igriv način.

5 LITERATURA IN VIRI

[1] *Dnevi dejavnosti.* Ministrstvo za znanost, izobraževanje in šport. Dostopno na naslovu https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/Drugi-konceptualni-dokumenti/Dnevi_dejavnosti.pdf (7. 8. 2022).

[2] dr. Tanja Rupnik Vec (ur.) 2020. *Analiza izobraževanja na daljavo v času prvega vala epidemije covida-19 v Sloveniji.* Ljubljana: Zavod Republike Slovenije za šolstvo. Dostopno na naslovu: https://www.zrss.si/pdf/izobrazevanje_na_daljavo_covid19.pdf (7. 8. 2022).

[3] Kastelic N., Kmetič E., Lazić T., Okretič L. 2021. *Kako motivirati učence pri poučevanju na daljavo?* Priročnik za učitelje. Ljubljana: Filozofska fakulteta, Oddelek za psihologijo. Dostopno na naslovu: https://resitve.sio.si/wp-content/uploads/sites/7/2021/12/Kako-motivirati-ucence.pdf (7. 8. 2022).

[4] Wikipedija: Soba pobega. Dostopno na naslovu: https://sl.wikipedia.org/wiki/Soba_pobega (7. 8. 2022).

Razvijanje digitalnih kompetenc po vertikali

Developing Digital Competencies Across Verticals

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POVZETEK

V povzetku je predstavljeno razvijanje digitalnih kompetenc učencev na Osnovni šoli Vide Pregarc.

Učitelji na Osnovni šoli Vide Pregarc skrbimo, da imajo vsi učenci možnost obiska računalniške učilnice in s tem uporabe računalniške opreme. Učitelji razredne stopnje se odločajo za uporabo matematičnih platform za utrjevanje znanja, uporabo programa Slikar, predmetni učitelji za iskanje informacij na spletu, ki jih učenci potrebujejo za pripravo projektnih nalog, reševanje interaktivnih nalog, uporabo slovarjev in še kaj bi se našlo.

Glede na to, da učenci vedno več uporabljajo digitalne vsebine tudi doma, se nam je zdelo smiselno, da razvijanje digitalnih kompetenc nekoliko bolj osmislimo, načrtujemo in kasneje lahko tudi ovrednotimo.

Učitelji so po strokovnih aktivih zapisali za katera digitalna znanja in spretnosti menijo, da bi jih učenci v posameznem razredu potrebovali in katere imajo namen v naslednjem letu razvijati. Na podlagi predlogov smo zapisali načrt razvijanja znanj po posameznih razredih oziroma predmetih in potrebno programsko opremo.

KLJUČNE BESEDE

Razvijanje digitalnih kompetenc, digitalna pismenost, informacijska tehnologija, poučevanje po vertikali

ABSTRACT

This summary presents the development of digital competences of pupils at the Vide Pregarc Primary School.

Teachers make sure that all pupils have the opportunity to visit the computer science classroom and use the computer equipment. Teachers are choosing to use maths platforms to consolidate their knowledge, using Painter, searching the web for the information students need to prepare project assignments, solve interactive tasks, use dictionaries and etc.

As students are increasingly using digital content at home, we thought it would make sense to make the development of digital competences a bit more meaningful, planned and later evaluable.

Teachers wrote down which digital skills they think pupils in each class need and which they intend to develop in the coming year.

Based on the suggestions, we wrote a plan to develop the skills by grade or subject, and the necessary software.

KEYWORDS

Developing digital competences, digital literacy, information technology, teaching across vertical

1 DIGITALNE KOMPETENCE

Digitalne kompetence so ena izmed ključnih življenjskih znanj med katera spadajo tudi pismenost, večjezičnost, matematična, naravoslovna, tehniška in inženirska kompetenca, osebnostna, državljanska, podjetnostna ter kulturna zavest in izražanje.

Digitalne kompetence združujejo samozavestno, kritično in odgovorno uporabo digitalnih tehnologij. V okvir digitalne kompetence lahko vključimo informacijsko in podatkovno pismenost, sporazumevanje, sodelovanje, izdelavo samostojnih digitalnih vsebin, varnost, avtorske pravice, reševanje problemov in seveda kritično mišljenje [1].

Številni avtorji imajo različna mnenje. Nekateri kompetence in pismenost enačijo, nekateri menijo, da ob usvojenih kompetencah postanemo pismeni, nekateri menijo, da je pismenost širše področje.

2 ZAČETKI

V želji, da učence čim bolj opolnomočimo z znanjem digitalnih vsebin, smo se na šoli odločili, da na šoli digitalne kompetence razvijamo in nadgrajujemo od 1. do 9. razreda.

Leta 2020, ko se je začelo nakazovati obdobje dela na daljavo in večina deležnikov na to ni bilo dovolj pripravljenih, smo lahko samo upali, da so naši učenci dovolj opolnomočeni za delo.

Do takrat so učenci med poukom redko prihajali v računalniško učilnico. Ko so prišli, so imeli jasna navodila za delo, naj preberejo, naj poiščejo, naj narišejo, naj napišejo. Smo se vprašali ali znajo?

Z namenom, da bo delo na daljavo čim bolje izpeljano, smo organizirano vabili učence v računalniško učilnico in jim poskušali olajšati delo. Nekaterim delo z računalnikom ni

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predstavljalo težav, potrebovali so le majhne napotke, drugim je predstavljal stres že prižig računalnika. Ugotovili smo, da vsi naši učenci niso pripravljeni na delo. Po odzivih jim je bilo v pomoč, da smo jim pripravili testno učilnico, kjer so lahko vadili objavljanje nalog, raziskovanje brez strahu, da se zgodi nekaj neprijetnega.

Šolsko leto s šolanjem na daljavo smo zaključili, še vedno pa nismo bili prepričani, če so učenci računalniško pismeni. Učenje računalniških veščin, kulturnega vedenja na spletu, varnosti, izdelavo digitalnih vsebin smo nadaljevali.

V preteklem šolskem letu smo se srečali z novim izzivom. Računalniško učilnico smo uporabljali tudi za pouk drugih predmetov in je bila večino ur zasedena. Prost so bile le 4 šolske ure. Z učitelji, ki so poučevali v njej, smo se dogovorili, da za potrebe računalniškega opismenjevanja, učilnice menjamo in tako lahko izvedemo ure digitalnih kompetenc.

3 UČITELJI

Ko smo začeli z načrtovanjem razvijanja digitalnih kompetenc, je nemalo učiteljev prišlo do dileme, če so usposobljeni za vodenje ur v računalniški učilnici. Ugotovili smo, da se vse kompetence ne razvijajo samo v računalniški učilnici ter da imamo učitelji dovolj znanja.

Učitelji lahko že ogromno naredimo, ko pri pouku naletimo na neznane pojme in jih s pomočjo spleta razložimo. Pri tem upoštevamo kritično razmišljanje glede veljavnosti podatkov in pravila varnega brskanja. Ko potrebujemo fotografijo za objavo na digitalnih predstavitvah, ne pozabimo na avtorske pravice. Strinjali smo se, da učitelji varne in kritične rabe tehnologije, ne moremo naučiti le z zgledom, ampak potrebujemo tudi specifične kompetence [2].

Slika 1: Digitalne kompetence za učitelje

Poskrbeli smo, da je pogovor o delu v računalniški učilnici stekel. Če sta v učilnici poučevala dva učitelja, sta se o delu dogovorila, si izmenjala ideje, mnenja kaj učenci znajo, kaj so delali preteklo leto, preteklo uro v računalniški učilnici, s koliko znanja prihajajo. Poskrbeli smo za dogovor o strokovnem znanju učitelja. Učitelj, ki se ne čuti sposobnega predati snov, je lahko čudovita podpora drugemu učitelju za pomoč učencem. Vsekakor pa je potrebno poskrbeti za stalno strokovno izpopolnjevanje učiteljev.

Na šoli smo v ta namen organizirali »Tržnice znanja«, kjer smo z učitelji poglabljali računalniška znanja. S tržnicami smo začeli med delom na daljavo in jih nadaljevali tudi v lanskem šolskem letu. Za tematike smo se dogovarjali sproti. Od osnovnih pisarniških programov do programov za urejanje fotografij, videoposnetkov in kasneje reševanjem izzivov na katere so naleteli med svojim delov.

V začetku šolskega leta smo se z učiteljicami uskladile kateri termini jim najbolj odgovarjajo in katere teme bi si želeli, da podpremo z digitalnim znanjem. Nekatere učiteljice so bile še vedno mnenja, da bodo bolj prepričane v delo, če bo pri delu v računalniški učilnici prisotna še učiteljica računalništva, kar smo ugodili.

4 UČENCI

Razvijanje veščin učencev je temeljilo na nadgradnji učne snovi posameznega razreda. V preteklem šolskem letu smo želeli, da vsak razred obišče računalniško učilnico vsaj dvakrat v letu. Žal nam to ni uspelo in bomo nadaljevali v letošnjem letu.

Z učenci prvega razreda smo prvo uro, ko so prišli v učilnico najprej spoznali učilnico, pravila dela v njej in spoznali temeljna informacijska znanja. Pogovorili smo se, če so že kdaj kaj delali z računalnikom. Večina digitalne naprave (računalnik, prenosni računalnik, tablice, telefone) uporablja dnevno. Uporabljajo jih predvsem za ogled video posnetkov in igranje igric. Na navodilo »prižgi računalnik« je imela večina učencev velike težave. V računalniški učilnici imamo stacionarne računalnike, v večini pa imajo doma prenosnike in so zato prižigali le monitorje in njihov odziv je bil, da računalnik ne dela. Zato je bila naša prva naloga, da se naučimo prižgati računalnik in ga kasneje po končanem delu tudi pravilno ugasniti.

Ure, ki so sledile so bile namenjene preprosti uporabi programa za utrjevanje matematičnega znanja. Poleg tega so usvojili še delo z miško (groba in fina motorika), nadgradili koordinacijo oko-roka, tipkanje (kar smo lahko medpredmetno povezali s poukom slovenščine).

V juniju, ko je bila učilnica več ur prosta, so učenci prvih razredov obiskali učilnico z namenom, da se naučijo programa Slikar. Z učiteljico smo se dogovorili, da program predstavi učiteljica računalništva, same zahteve kaj naj bo na njihovi risbi pa so se z učenci dogovorili že v razredu. Preden so končali delo, so risbo tudi shranili s svojim imenom. Risbe, ki so jih učenci narisali so natisnili in jih odnesli domov.

Učenci tretjega razreda že več let prihajajo v računalniško učilnico z namenom iskanja podatkov za pripravo govornega nastopa o slovenskem pesniku ali pisatelju.

Letos smo izkoristili še dodatno možnost in so pred to uro imeli še predavanje o varnosti na spletu. Obiskala jih je zunanja predavateljica in jim predstavila spletne pasti. Po tej uri so imeli pogovor z učiteljico računalništva, ki so ji lahko zastavili dileme in vprašanja o delu z računalnikom, varnosti, poukom. Zanimiv je bil pogovor z učencem, ki jo je želel prepričati, da mu dovoli na šolskem računalniku igrati spletno igrico. Učiteljici se je zdela ideja zanimiva in je dovolila. Učenec najbrž ni bil pripravljen, njihova razredničarka tudi ne in so bili nekoliko šokirani. Učiteljica računalništva in učenec sta se dogovorila, da igra 3 minute, igra ne sme biti strelska in igro lahko predvajamo na projektorju. Učenec se je usedel za računalnik, odtipkal povezavo, kliknil »ok« na vsa vprašanja in začel z igranjem igre. Po končani igri so izpeljali pogovor. Kaj je potrdil v začetku, kaj je pisalo, se je z vsem strinjal. Ugotovili smo, da učenec začetnega besedila ni razumel, a je vseeno potrdil, saj drugače ne bi mogel igrati. Uro je učiteljica izkoristila za poglobljen pogovor kakšne igre igramo, kaj klikamo in kaj ne, če ne razumemo vprašamo starejše, da nam obrazložijo, saj lahko hitro naletimo na težave.

Po tej uri so sledile ure v računalniški učilnici, kjer so učenci iskali podatke za pripravo govornega nastopa. Običajno so podatke poiskali in si naredili zapiske v njihove zvezke. Tokrat sta se njihova razredničarka in učiteljica računalništva dogovorili, da na računalniku naredijo mape, jih poimenujejo in vanje shranijo vse kar se jim bom zdelo uporabno (fotografije in Wordov dokument, kamor so zapisovali podatke).

Ker so se v šoli prvič srečali z urejevalnikom besedila Microsoft Word, jim ga je učiteljica računalništva predstavila. Naučili so se tudi dokument shraniti. Besedilo so nekoliko tudi oblikovali.

Učenci petega razreda prihajajo v računalniško učilnico z namenom učenja za kolesarski izpit in kasneje teoretičnega izpita. Pred tem večkrat poudarimo delo v spletnih učilnicah. Učitelji, ki poučujejo v petem razredu, uporabljajo spletne učilnice še pri rednem pouku za oddajo nalog, dodatne naloge pri utrjevanju znanja in utrjevanje znanja s pomočjo kvizov. Učiteljica računalništva je v zvezi z učitelji petega razreda in ure v računalniški učilnici so idealna priložnost, da se učenci naučijo nekaj novega in obnovijo znanje.

Učenci v petem razredu so ravno v starosti, ko začnejo uporabljati družbena omrežja in prav je, da takrat slišijo poglobljene vsebine o spletnem bontonu.

Učenci četrtega, petega in šestega razreda že lahko obiskujejo neobvezni izbirni predmet Računalništvo. Interes na naši šoli je kar velik. V okviru neobveznega predmeta se večino časa ukvarjamo z algoritmičnim načinom razmišljanja, ki ga kasneje zapeljemo v uvod v programiranja s programom Scratch. Učenci petih in šestih razredov za zaključno nalogo naredijo krajšo igro za mlajše učence (največkrat za prvo triletje).

S pomočjo programa Scratch hitro in uspešno razumejo in kasneje znajo uporabiti svoje znanje. Svoje izdelke in izdelke sošolce se naučijo kritično ovrednotiti.

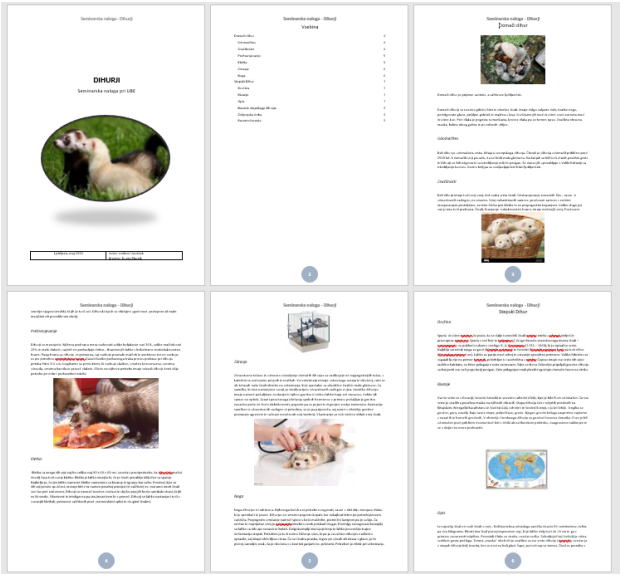
Slika 2: Zaključna naloga

Učenci predmetne stopnje obiskujejo računalniško učilnico predvsem v času dni dejavnosti, ur obveznih izbirnih predmetov in v času slovenščine, matematike, kemije ter tehnike in tehnologije.

Vsak izmed razredov ima matematični dan dejavnosti in takrat učiteljice matematike poskrbijo, da učenci spoznajo in se naučijo uporabljati program Microsoft Excel. V Excelu se učenci naučijo urejanje večje količine podatkov, uporabo osnovnih matematičnih in statističnih formul, uporabo in spreminjanje grafikonov, filtriranje podatkov in pripravo strani za tiskanje. Glede na učno snov jim predstavimo spletne aplikacije, ki jim olajšajo delo pri matematiki (MathLab, GeoGebra, spletne kvize), hkrati ponovimo tudi uporabo spletne učilnice, ki jo učiteljice matematike redno uporabljajo pri svojem delu.

V času ur slovenščine in angleščine je poudarek na iskanju in preverjanju informacij, ki jih najdemo na spletu in s tem kritično presojanje o verodostojnosti zapisanega. Naučijo se uporabe slovarjev in s tem pomoči pri vsakdanjem delu.

Med urami obveznih izbirnih predmetov s področja računalništva so ure namenjene poglabljanju splošnega računalniškega znanja. Učenci se naučijo oblikovanja besedila po lastni temi. Pri zapisovanju so potrebno tako kritično presojanje o vsebini, ki jo učenec najde na spletu. Podatke lahko poišče tudi doma, si jih shrani na zunanji disk ali oblačno storitev ali si jih pošlje preko elektronske pošte ter jih v šoli zna poiskati in jih uporabi v svojem dokumentu.



Slika 3: Urejanje besedil

Učenci se naučijo povezovanja z digitalno napravo (največkrat telefon) in si prenesejo fotografije, zvok ali video posnetke, v šoli jih obdelamo in izdelamo izdelke pri pouku multimedije. Urejene fotografije so velikokrat razstavljene na šolskih hodnikih, glasba pa predvajana na šolskem radiu.

Slika 4: Urejanje fotografij

5 ZAKLJUČEK

V današnjem času opažamo, da vedno bolj potrebujemo dobro razvite digitalne kompetence. Poleg ključnih kompetenc, ki jih učenci potrebujejo za razvoj, socialno vključenost, zdrav način življenja, so digitalne kompetence tiste, ki so v vedno bolj digitaliziranem svetu še kako zaželene.

Pri posredovanju znanj smo se osredotočali, da smo lahko sledili opisnikom digitalnih pismenosti [3] in ravnem, ki opisujejo doseganje kompetenc po standardu DigComp [4].

Pri delu je še vedno ogromno možnosti za izboljšave, zato smo si za letošnje šolsko leto zastavili celoletni šolski projekt opismenjevanja.

ZAHVALA

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LITERATURA IN VIRI

[1] Ključne kompetence za vseživljenjsko učenje. Dostopno na naslovu http://www.movit.si/fileadmin/movit/0ZAVOD/Publikacije/Tematske/2018_Kljucne_kompetence_za_vsezivljenjsko_ucenje.pdf (3. 8. 2022)

[2] Inovativna pedagogika. Dostopno na naslovu https://www.inovativna-sola.si/digitalne-kompetence-za-ucitelje-digcompedu/ (3. 8. 2022)

[3] Digitalna pismenost. Opisniki temeljne zmožnosti. Dostopno na naslovu https://pismenost.acs.si/wp-content/uploads/2018/09/Digitalna-pismenost-e-verzija.pdf (4. 8. 2022)

[4] ZRSŠ, DigCompEdu – Evropski okvir digitalnih kompetenc izobraževalcev. Dostopno na naslovu https://www.zrss.si/digitalna_bralnica/digcompedu-evropski-okvir-digitalnih-kompetenc-izobrazevalcev/ (3. 8. 2022)

Soba pobega pri pouku zgodovine

Escape Room in History Class

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POVZETEK

Učitelj zgodovine se vedno sprašuje, na kakšne načine učencem dvigniti motivacijo za aktivno spoznavanje preteklosti. Kot učiteljica imam med pripravo aktivnosti posameznega učnega sklopa, pred očmi generacijo učencev. Takrat razmišljam o dejavnostih, ki jih najbolj motivirajo in so pri pouku zgodovine najbolj aktivni. Šolsko leto 2020/21, v času pouka na daljavo, je od učitelja zahtevalo še več izvirnosti, saj so aktivnosti za učence morale biti zanimive, hkrati pa poučne.

V prispevku je predstavljena soba pobega, ki je bila oblikovana v Microsoftovem orodju OneNote. Za oblikovanje sobe pobega sem izbrala izbirno temo v 8. razredu osnovne šole kmečki upori, epidemije in naravne nesreče.

Priprava gradiva je zahtevala veliko časa, saj se je bilo najprej potrebno seznaniti z orodjem OneNote, nato je bilo potrebno raziskati prispevke, ki so obravnavali urejanje v orodju One Note, šele nato je bilo možno oblikovati gradivo, s katerim so učenci spoznavali novo učno vsebino.

OneNote je orodje, ki je zelo pregledno in ob večkratnem rokovanju z njim postane delo v njem zelo enostavno. V prispevku bo predstavljen način sestave sobe pobega in delo, ki so ga opravili učenci.

KLJUČNE BESEDE

Soba pobega, zgodovina, kmečki upori, One Note

ABSTRACT

A history teacher always wonders how to raise students' motivation to actively learn about the past. As a teacher, I have a generation of pupils in front of my eyes during the preparation of the learning activities. I think about the activities that motivate them the most and are most active in history lessons.

The 2020/21 school year, during distance learning, required even more originality from the teacher, as activities had to be interesting for pupils.

This article presents the escape room, which was created in Microsoft's One Note tool. To create an escape room, I chose an optional theme in the eighth grade of elementary school, rural riots, epidemics and natural disasters.

The preparation of the material took a long time, as it was first necessary to familiarise yourself with One Note, and then it was necessary to explore the contributions that dealt with editing in OneNote before it was possible to create material to enable students to learn about new learning content.

OneNote is a tool that is very transparent and, when you shake it over several, it becomes very easy to work in. The paper will show how the escape room was composition and the work done by the students.

KEYWORDS

Escape room, history, rural riots, One Note

1 UVOD

Učitelji se pred pripravo gradiva za obravnavo učnih enot vedno sprašujemo, na kakšen način pripraviti dejavnosti, da bomo za delo in učenje motiviral čim večje število učencev. V šolskem letu 2020/21 je bil to še posebno velik izziv za učitelje, saj smo zaradi epidemije izvajali pouk od doma. Znašli smo se v popolnoma novi situaciji, ki je od učiteljev in učencev zahtevala veliko notranje motivacije, da smo se zjutraj usedli pred računalnike in delali ali se učili.

Pouk zgodovine temelji na analiziranju raznoraznih zgodovinskih virov, saj želimo doseči, da učenci te vire spoznavajo, ob njih razvijajo kritično mišljenje in si ustvarjajo poglede na pretekle dogodke. V času dela na daljavo, smo uporabljali veliko avdio-vizualnih virov, zato sem se pri obravnavanju kmečkih uporov na Slovenskem odločila uporabiti tudi knjižne vire, ki sem jih vstavila v posamezne sobe. Moj cilj je bil ohranjati bralno razumevanje učencev.

V prispevku je predstavljeno, kako sem se kot učiteljica zgodovine soočila z iskanjem načinov, da bodo učne ure pestre, da bodo aktivirale učence za učenje in da bodo pripravljene tako, da bodo učenci od doma in samostojno lahko delo opravili. Drugi cilj, ki sem si ga postavila, je bil motivirati učence za aktivno učenje, saj je takrat njihovo pridobljeno znanje veliko trajnejše.

Kot učiteljica se zavedam vedno večjega pomena digitalnih kompetenc, ki jih v sodobnem svetu vedno bolj potrebujemo, zato je bil pri izbiri takšne učne ure moj cilj tudi razvijanje digitalnih kompetenc učencev, hkrati pa jim omogočiti sodelovanje z vrstniki, čeprav niso bili v skupnem prostoru.

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2 TEORETIČEN PREGLED

2.1 Motivacija za učenje

V času šolanja na daljavo sem se kot učiteljica srečala s popolnoma novim načinom poučevanja. Svojo vlogo sem videla kot osebo, ki učencem pripravlja gradivo, ki jih bo za delo od doma motiviralo, prav tako da se bodo naučili novih vsebin pri predmetu zgodovina ter da se seznanijo z različnimi načini uporabe računalnika, tablic in telefonov. Postavljena sem bila v novo vlogo, v kateri sem se tudi sama veliko naučila. Postati sem morala fleksibilna in radovedna. Pomembna veščina učitelja v sodobni šoli, mora biti tudi fleksibilnost. Prilagajati je potrebno poučevanje individualnim in skupinskim razlikam med učenci. Inovativnost učitelja omenja tudi M. Boekaerts, ki poudarja, da mora učitelj zavestno prilagajati svoje načrtovanje in poučevanje tako, da pripravi za učence zanimive didaktične dejavnosti, ki ustrezajo namenu in ki jih učenci z veseljem opravljajo. Tako učenje postane učinkovitejše. [1]

V sodobnem svetu so začeli prevladovati bolj celostni in integrirani modeli spodbujanja učne motivacije. Med najbolj znanimi je model TARGET. Po tem modelu učitelji spodbujajo učno motivacijo učencev, kot na primer lastnosti učnih nalog, organizacijo učnih dejavnosti, z odnosom med učiteljem in učenci, učiteljevimi pričakovanji, socialnimi interakcijami … Sodobnim konceptom je skupen cilj spodbuditi učence k učenju in obvladovanju ter da pri tem upoštevajo različne kontekstne dejavnike šolskega prostora. [2]

V povezavi s tem modelom lahko na tem mestu navedemo tudi osem načel, na katerih temelji motivacija za učenje:

- motivacija se izboljša, ko se učenci počutijo zmožne narediti tisto, kar se od njih pričakuje,
- učenci so bolj motivirani za učenje, ko zaznajo dosledno usklajenost med določenimi dejanji in dosežki,
- učenci so bolj motivirani za učenje, ko predmet cenijo in ko jim je jasen namen učenja,
- učenci so bolj motivirani za učenje, ko doživljajo pozitivna čustva v zvezi z didaktičnimi dejavnostmi,
- učence negativna čustva odvrnejo od učenja,
- učenci sprostijo svoje kognitivne potenciale za učenje takrat, ko imajo možnost vplivati na intenziteto, trajanje in izražanje svojih čustev,
- učenci so vztrajnejši pri učenju, ko lahko sami uravnavajo svoje potenciale in se znajo učinkovito spopadati z oviram in
- učenci so bolj motivirani za učenje in za uporabo strategij za uravnavanje motivacije, ko čutijo, da je okolje naklonjeno njihovemu učenju. [1]

Raziskave so pokazale, da učna motivacija ni v tako tesni zvezi z učnimi dosežki, kot z kognitivnimi in metakognitivnimi procesi in učenjem samim. Učna motivacija naj bi se izražala predvsem v odnosu do učenja in v različnosti pristopov k učenju. Zato se v sodobnih konceptih učenja in poučevanja motivacija definira kot mediatorsko (posredniško) spremenljivko učne uspešnosti. Kljub temu je ključna, saj se brez nje učenje sploh ne more zgoditi. [2]

2.2 Učenje s sodobno tehnologijo

Šolanje na daljavo je učitelje in učence potisnilo v novo obliko učenja in poučevanja. Tehnologija, kot so računalniki, tablice in internet so bili stalnica, ki jih v času pred epidemijo nismo tako pogosto vključevali v pouk. Takšno učenje je omogočilo v poučevanje vključevati več različnih digitalnih kompetenc in veščin, ki smo se jih tako učitelji kot učenci morali naučiti razvijati.

Pri poučevanju s tehnologijo moramo upoštevati naslednje:

- učno okolje moramo ohranjati čim bolj preprosto, z namenom, da zmanjšamo nepomembno procesiranje,
- učenje s tehnologijo se mora načrtovati tako, da s tehnologijo obvladujemo bistveno procesiranje,
- učenje s tehnologijo mora spodbujati generativno procesiranje,
- s tehnologijo moramo podpirati učenčevo aktivno kognitivno procesiranje med učenjem, ne da bi pri tem preobremenili njegovo spoznavno zmožnost. [3]

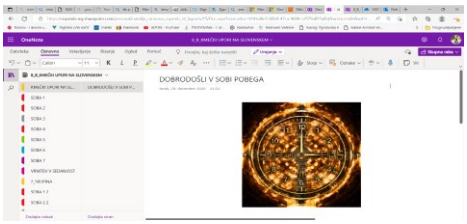
3 SOBA POBEGA – KMEČKI UPORI NA SLOVENSKEM

3.1 Microsoftov OneNote

Za izdelavo sobe pobega za učence 8. razredov sem se odločila uporabiti Microsoftovo orodje OneNote. V šolskem letu 2020/21 smo vsi zaposleni in vsi učenci prejeli uporabniški račun v Oblak 365, zaradi česar sem se odločila, da sobo pobega ustvarim v tem orodju. Prav tako sem z učenci pri pouku na daljavo že uporabljala OneNote za oblikovanje skupnih zapiskov.

Orodje OneNote je zelo preprost za uporabo, saj vizualno spominja na Microsoft Word, kar učenci že zelo dobro poznajo. Orodje pa ima tudi veliko prednosti:

- ustvariš lahko več strani, ki jih med seboj povežeš,
- vstavljaš datoteke, slike in spletne povezave,
- do dokumenta lahko dostopaš kadarkoli in iz različnih naprav in
- hkratno lahko v ustvarjen dokument vpisuje več učencev. [4]

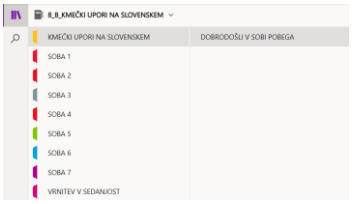


Slika 1: Uvodna stran skupnega zvezka v orodju One Note. (slika zaslona; lasten vir).

3.2 Potek priprave sobe pobega

Za izdelavo sobe pobega v OneNote sem si najprej pogledala posnetke na Youtube kanalu. Nato sem se lotila oblikovanja skupnega zvezka. V nadaljevanju v korakih predstavljam ustvarjanje sobe pobega:

1 Učence v oddelku sem razdelila v 6 skupin in ustvarila uvodno stran z osnovnimi informacijami.
2 Vsaki skupni sem ustvarila 7 sob z dodajanjem odsekov. Vsaka soba je bila posvečena enemu kmečkemu uporu, ki ga morajo osmošolci spoznati.
3 Nato sem se lotila oblikovanja vsebinskega dela vsake sobe posebej. Prednost orodja OneNote je, da lahko vse strani, ki so ustvarjene v odseku, kopiraš.
4 V vsaki sobi sem ustvarila nalogo, ki so jo učenci s sodelovanjem in predelavo učnega gradiva lahko rešili. Rešitev naloge je vodila do ključa s katerim so lahko odprli naslednjo sobo.
5 Ustvarjeno sobo pobega sem dala v skupno rabo in jo v Microsoft Teamsu delila z učenci pri uri zgodovine. Na pričetku učne ure sem učencem pojasnila, kako bo potekalo njihovo delo.



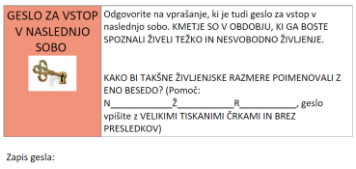
Slika 2: Osnovni pogled na sobo pobega v OneNote. (slika zaslona; lasten vir).

Pri izdelavi gradiva za učenje sem uporabila učbenik in različne spletne vire (Fran, puntarske pesmi na Youtube kanalu, zemljevide). Vsako sobo sem ustvarila malo drugače, da sem ohranila pozornost učencev. Učenci so ob nalogah urili tudi bralno razumevanje, saj so se rešitve nalog skrivale v besedilih, ki so se skrivala v sobah.

Slika 3: Primer posnetka v prvi sobi. (https://www.youtube.com/watch?v=zERbtzizRp0)

Slika 4: Primer odseka iz knjižnega vira, ki je bil zapisan v eni izmed sob (slika zaslona; lasten vir).

Slika 5: Primer naloge za ugotavljanje ključa, ki odpira naslednjo sobo. (slika zaslona; lasten vir).



Slika 6: Primer naloge za ugotavljanje ključa, ki odpira naslednjo sobo. (slika zaslona; lasten vir).

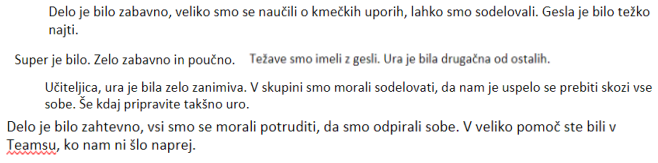
3.3 Izvedba učne ure in povratna informacija

V času pouka na daljavo smo imeli v 8. razredu 1 uro na teden zgodovine, preko videokonference v Teamsu. Pouk sem načrtovala tako, da so bili učenci čim bolj aktivni, velikokrat je delo potekalo v skupinah, ki smo jih oblikovali v Microsoft Teamsu. Učenci so skupaj obdelovali pripravljeno gradivo, jaz pa sem imela možnost obiskovati vsako skupino posebej in pregledovati njihove izdelke. Ob koncu ure smo se dobili v skupni sobi in takrat sem od učencev na različne načine pridobivala povratno informacijo, o pridobljenem znanju ali o načinu dela, ki so ga opravili. Svoje izdelke so morali še samostojno urediti in jih nato oddati v spletno učilnico.

Učni sklop kmečki upori na Slovenskem, ki smo ga obravnavali v sobi pobega, sem načrtovala za dve šolski uri. Prvo uro smo se dobili v Microsoft Teamsu, kjer sem učencem predstavila potek dela. Učenci so se sami razvrstili v šest skupin, izbiro sem jim prepustila, saj sem predvidevala, da bodo lažje delali v skupini, ki si jo sami izberejo. Učence sem seznanila z možnostjo klica na pomoč, kar je pomenilo, da so me lahko povabili v skupino, če so naleteli na težavo in sem jih usmerila pri reševanju naloge ali iskanju ključa za naslednjo sobo.

Učenci so delo opravljali z veliko zanimanja in interesa. Učenci so aktivno delali celotni dve uri, nekatere skupine so se dobile tudi po pouku, saj so želele čimprej poiskati izhod iz sobe pobega.

Ko so vse skupine z delom zaključile in našle izhod iz sobe pobega, so imeli v zadnji sobi učenci navodilo, da na kratko zapišejo povratno informacijo o načinu dela. Eden pomembnih elementov formativnega spremljanja je pridobiti odzive učencev o načinu dela, ki si ga pripravil za njih. Učenci so zapisali, da jim je bil takšen način dela zanimiv in da so imeli večjo motivacijo, da opravijo zastavljene naloge. Nekaj zapisov skupin je vidnih na sliki 7.



Slika 7: Povratne informacije učencev zapisne v OneNote. (slika zaslona; lasten vir).

4 ZAKLJUČEK

V prispevku sem predstavila obravnavo učnega sklopa pri predmetu zgodovina v času pouka na daljavo. Soba pobega, ki sem jo ustvarila v Microsoft OneNote je nastala z mislijo, da za učence, ki so zaradi epidemioloških razmer ostali doma, pripravim takšno učno uro, kjer bodo lahko sodelovali in s skupnimi močmi pridobivali nova znanja.

Ob zaključku sem ugotovila, da so učenci zaradi tako majhne spremembe načina pouka bili veliko bolj motivirani za učenje. Spoznali so kmečke upore na Slovenskem, si pri delu pomagali in sodelovali, razvijali pa so tudi digitalne kompetence, ki jih bodo v sodobnem svetu morali zelo dobro obvladati.

Soba pobega v orodju OneNote je preprosta za izdelavo in tudi uporabo, kar sem ugotovila s spremljanjem dela učencev, ki so mojo pomoč potrebovali predvsem pri vsebini in iskanju ključa za naslednjo sobo. Edina pomanjkljivost, ki jo lahko izpostavim je, da se sobe zaklenejo vedno znova, ko zapustimo OneNote, zato so učenci imeli navodilo, da geslo zapišejo na določeno mesto v že odklenjeni sobi in še na list papirja.

Organiziranje takšne učne ure od učitelja zahteva osnovna digitalna znanja in predvsem veliko volje, saj za pripravo takšnega zvezka potrebuješ več časa, kot za klasičen način pouka. Odziv učencev, ki so se aktivno vključili v pouk, čeprav so bili doma, pa dokazuje, da se je potrebno tudi učiteljem aktivno ukvarjati z dejavnostmi, ki jih pripravljajo za sodobne generacije.

ZAHVALA

Zahvaljujem se vodstvu šole, ki podpira in spodbuja vse moje ideje o vključevanju sodobnih konceptov poučevanja.

LITERATURA IN VIRI

[1] M. Boekaert. (2013). »Motivacija in čustva imajo ključno vlogo pri učenju.« V O naravi učenja: uporaba raziskav za navdih prakse. [Online]. Dosegljivo: 3_o naravi ucenja e-oblika.pdf (zrss.si) [5. 8. 2022].

[2] M. Jurševič, Motiviranje učencev v šoli, Ljubljana: Pedagoška fakulteta v Ljubljani, 2012.

[3] E. R. Mayer. (2013). »Učenje s tehnologijo.« V O naravi učenja: uporaba raziskav za navdih prakse. [Online]. Dosegljivo: 3_o naravi ucenja e-oblika.pdf (zrss.si) [5. 8. 2022].

[4] Microsoft One Note. Dostopno na naslovu: Microsoft OneNote – digitalna aplikacija za zapiske | Microsoft 365. [1. 8. 2022].

[5] OneNote Escape rooms! Dostopno na naslovu OneNote Escape Rooms! - YouTube [1. 8. 2022].

Poučevanje glasbene umetnosti na daljavo

Distance Learning Music

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POVZETEK

Čas epidemije je postavil šolski sistem na glavo. Dobesedno čez noč se je pouk iz učilnic preselil na splet. Učitelji smo iskali rešitve za kar najbolj kvalitetno izvedbo pouka in predstavitev učnih vsebin. V prispevku so predstavljeni praktični primeri poučevanja glasbene umetnosti na daljavo v času epidemije, ter njihove pomanjkljivosti in seveda tudi prednosti. Na koncu je predstavljena primerjava vseh idej po kriterijih, ki prikažejo njihovo uporabno vrednost. Za marsikatero rešitev se je na koncu namreč izkazalo, da ponuja še celo boljšo izvedbo učne teme in je primerna za uporabo tudi pri klasičnem pouku v učilnici, kar lahko bralcem služi kot izhodišče za nadgradnjo njihovih ur.

KLJUČNE BESEDE

Glasbena umetnost, šola na daljavo, spletna orodja

ABSTRACT

Restrictions in the time of the epidemic turned the school system upside down. Virtually overnight the teaching was moved to virtual online environments. Teachers had to find solutions that enabled us to continue teaching and delivering the high-quality contents to pupils. This article presents eight practical examples of distance learning music during the epidemic together with their advantages and disadvantages. They are then compared based on different criteria to present their usefulness. It turned out that many of the new teaching techniques, introduced during the pandemic actually bring added value for the pupils and therefore should be used even during the ordinary teaching in classroom. Readers are encouraged to implement presented ideas as part of their teaching.

KEYWORDS

Music, distance learning, online tools

1 UVOD

Glasba ima v vzgoji in izobraževanju velik pomen z vidika zdravja ter odnosov, saj glasba zdravi in nas povezuje. Zato so cilji glasbene vzgoje navduševati, sprostiti se s poslušanjem glasbe, ustvarjanjem … Vse to je bilo pomembno pri načrtovanju pouka glasbene umetnosti na daljavo. Didaktični napotki, ki vodijo k uspešnemu pouka glasbe na daljavo, so:

- realizacija le najnujnejših in elementarnih ciljev,
- dejavnostno naravnan pouk (poudarek je na ustvarjanju),
- učenje naj bo čim bolj življenjsko,
- naloge naj ne bodo predolge in prezahtevne [2].

Pri uresničevanju sodobnih učnih pristopov je pomembna tudi učna tehnologija, s pomočjo katere lahko dosegamo boljše učne rezultate. Takšen učni proces je dinamičen in za učence zanimivejši. Glavne značilnosti multimedijske tehnologije so, da je osnovana na računalniški tehnologiji, je interaktivna in komunikativna [1].

Seveda pa je treba paziti na smiselno vključevanje IKT v pouk, saj se lahko zelo hitro zgodi, da tak način postane prevladujoč. Ta oblika dela je le dopolnilo za ostale dejavnosti v okviru glasbenega pouka. Učenci imajo delo z računalnikom zelo radi, kljub temu pa to ne sme postati razlog za vključevanje računalnika v pouk. Pouk glasbene umetnosti je v prvi vrsti namenjena spodbujanju razvoja na glasbenem področju. IKT igra pri tem pomembno vlogo, saj predstavlja učni pripomoček, ki pomaga realizirati cilje glasbene vzgoje [4].

V času šolanja na daljavo smo bili k uporabi IKT tehnologije prisiljeni, kar pa se je na koncu pokazalo kot dobra spodbuda nam učiteljem, da svoje ideje za pouk v razreda prilagodimo ali celo nadgradimo.

2 IDEJE ZA POČEVANJE NA DALJAVO

Za uresničevanje učnih ciljev je bilo treba pri poučevanju na daljavo spremeniti načine poučevanja in izvedbe posameznih nalog. Spodaj je naštetih in opisanih nekaj idej za izvedbo pouka glasbene umetnosti na daljavo. Predstavljene so tudi njihove prednosti in slabosti.

2.1 Razlaga snovi preko video vsebin

Urnik učnih ur v živo je bil precej natrpan, zato sem ure v živo izvedla bolj redko. Termine sem raje prepustila predmetom, ki so za učence težji za razumevanje. Učencem sem tako razlago snov posredovala preko video posnetkov, ki sem jih ustvarila s pomočjo Power Pointa. Videi so vsebovali glasbene primere, slikovni material in mojo razlago. Videe sem naložila na spletno platformo Youtube, učencem pa povezavo posredovala preko spletne učilnice.

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2.1.1 Prednosti in slabosti. Slabost takšnega načina je, da učenci ob morebitnih vprašanjih o obravnavani temi le teh ne morajo postaviti takoj. Na drugi strani pa je tak način razlage snovi bil učencem všeč, saj so si lahko določen del o temi poslušali večkrat, predvsem pa so si sami izbrali, kdaj bodo snov poslušali.

2.2 Grafična tablica

Kot že omenjeno, sem v živo izvedla precej malo ur, če pa sem se že poslužila razlage v živo, sem si pri razlagi pomagala z grafično tablico. Ta se je izkazala kot res krasen pripomoček sploh pri učenju not. Učencem se ja tako na njihovih ekranih v živo risala tabelska slika.

2.2.1 Prednosti in slabosti. Uporaba grafične tablice se je izkazala kot zelo uporabna pri pouku na daljavo, saj je dajala možnost prikaza tabelske slike, ki so je učenci navajeni. Ta je bila še boljša kot v šoli, saj je branje s table iz zadnje vrste kdaj že prezahtevno. Uporaba grafične tablice pri pouku v razredu se dobro obnese predvsem zato, ker je pisanje na tablico učitelju precej bolj naravno, saj je razmerje zapisa na papirju in tabli različno. Prav tako je uporabno tam, kjer učilnica nima posebne table z notnimi črtami.

2.3 Rap o skladatelju

Učenci v 8. razredu spoznajo skladatelje iz obdobja klasicizma in romantike. Spoznavanja smo se lotili tako, da je vsak učenec predstavil skladatelja s pomočjo rapa. Podatke o njegovem življenju in delih so učenci poiskali preko spleta in nato rap zapisali v Wordu.

Ko je bil rap napisan, ga je bilo potrebno še izvesti. Na youtube so poiskali inštrumentalno spremljavo in nanjo izvedli rap ter posnetek objavili v spletni učilnici.

2.3.1 Prednosti in slabosti. Pri pouku za iskanje podatkov uporabljamo knjige in učbenike, pri delu na daljavo smo za vir imeli svetovni splet, kar je bilo učencem bolj všeč, kot pa listanje po knjigah. Za pouk v razredu se je na koncu kot najboljša opcija izkazala kar kombinacija obeh virov. Edina lastnost, ki je bila pri tej nalogi slaba, je bila izvedba. Pri pouku v šoli učenci rape izvedejo v živo pred sošolci. Na ta način lahko učenci krepijo tudi veščine nastopanja in se naučijo spopadanja s tremo, čemur pri snemanju posnetka doma niso izpostavljeni.

2.4 Grafična notacija in zvoki iz okolja

V 9. razredu učenci spoznavajo zgodovino glasbe 20. stoletja. V tistem času so skladatelji iskali nove načine za glasbeno izražanje.

Ena izmed značilnosti tistega časa je bila konkretna glasba, katere izhodišče so bili konkretni zvoki in šumi iz vsakdanjega življenja. Te zvoke so skladatelji uredili v smiselno celoto in nastale so skladbe (primer Pierre Schaeffer: Etuda z železnico) [3].

Druga novost tistega časa je bila uporaba grafične notacije, s katero so skladatelji s pomočjo slikovnih predlog podajali navodila za izvajanje.

Učenci so pri obravnavi te snovi izdelali praktično nalogo. Izmisliti so se morali svojo skladbo, tako da so uporabili obe novosti tistega časa. Skladbo so zapisali tako, da so za prikaz posameznih zvokov uporabili simbole, zvoke pa so v tem primeru predstavljali zvoki iz okolja. Zapis skladbe so morali tudi posneti na diktafone svojih mobilnih telefonov. Naloga je postala zanimiva ravno zaradi ustvarjanja zvočnega posnetka, ki so ga učenci ustvarili z mobilnim telefonom, ki jih učencem drugače ne dovolimo za uporabo pri pouku.

2.4.1 Prednosti in slabosti. Naloga je bila učencem všeč, saj je bila ustvarjalna, hkrati pa jim je dovolila uporabo mobilnih telefonov. Edina slabost te naloge je, da jo je v celoti težko izvesti pri pouku, saj učenci (tudi če bi jim dovolili uporabo telefona pri uri) ne bi mogli posneti skladb pri pouku. Tako bi morali ta del naloge še vedno opraviti doma.

2.5 Kulturni dan kot spletni koncert

Za čas epidemije so bili odpovedani vsi dnevi dejavnosti. Kulturni, športni, naravoslovni in tehnični dnevi učencem na drugačen, večkrat bolj praktičen način pokažejo različne teme, ki jih obravnavamo pri učnih urah. S področja glasbe si učenci največkrat ogledajo glasbeno predstavo (opero, balet, muzikal) ali prisluhnejo tematskemu koncertu. Žive izkušnje sicer ne mora nadomestiti noben posnetek, a kljub vsemu smo bili tako učitelji kot učenci zelo hvaležni, da so se marsikatere kulturne inštitucije v Sloveniji odločile, da omogočijo oglede posnetkov njihovih predstav in koncertov. Tako so si učenci en dan med šolanjem na daljavo ogledali posnetek koncerta in spoznali nove glasbene primere in zanimivosti iz zgodovine. Po ogledu koncerta so učenci rešili kviz preko Google obrazca, ki sem jim ga pripravila in s pomočjo Worda ustvarili koncertni list za ogledan koncert.

2.5.1 Prednosti in slabosti. Če otroke želimo navdušiti nad kulturnimi prireditvami, jih morajo učenci doživeti v živo v gledališču, operi, koncertni dvorani, tako da vse alternativne oblike niti približno ne dosegajo zahtevanega nivoja. Res pa je, da je ogled prireditve preko spleta na drugi strani cenovno ugoden, saj ne zahteva stroškov za prevoz do lokacije in vstopnice. Dobra stran ogleda prireditev preko spleta je tudi ta, da lahko s temi vsebinami nadgradimo pouk v razredu in s tem učencem pokažemo še več različnih umetniških projektov.

2.6 Proslava na daljavo

Ob dnevu šole in krajevnem prazniku na šoli vedno pripravimo prireditev. Ker izvedba v živo ni bila mogoča, smo se odločili, da prireditev posnamemo in jo na dan, ko bi prireditev potekala v živo, predvajamo preko spletne platforme. Učenci so točke za nastop in vnaprej pripravljeno vezno besedilo posneli doma, nato pa smo posnetke združili v prireditev. Odziv učencev, ki so želeli sodelovati na prireditvi, je bil zelo dober.

2.6.1 Prednosti in slabosti. Učencem je bil takšen način proslave všeč, saj se jim je zdelo, kot da snemajo film. Tisti, ki pa so za proslavo prispevali glasbene točke, so se na ta način srečali s tem, da lahko vnaprej posnete glasbene točke tudi popravijo v primeru napake, prav tako so na ta način dobili dober način, da svoj glasbeni nastop na podlagi posnetka analizirajo in tako napredujejo. Snemanje svoje izvedbe in analiza le-te pomaga glasbeniku k napredku. Vsekakor je ta metoda dobrodošla pri pripravi npr. pevskega zbora za nastop. Vsekakor pa je prireditev v živo nekaj povsem drugega, saj se učenci s tem krepijo v veščini nastopanja in urijo obnašanje na odru.

2.7 Zapis glasbe s pomočjo musescore

V času šolanja na daljavo smo se z nekaterimi učenci pripravljali na tekmovanje Glasbena olimpijada. Ena izmed nalog na

tekmovanju je tudi zapis lastne skladbe. V prejšnjih letih smo jih pisali na notni papir, na daljavo pa je bilo zaradi izmenjevanja skladbe med učenci in mano skladbo lažje pisati s pomočjo brezplačnega programa za notacijo Musescore. Poleg tega ta omogoča, da skladbo tudi zaigra. Ko smo bili v šoli, so mi namreč učenci svoje skladbe zaigrali na svoje inštrumente, tokrat pa to ni bilo mogoče.

2.7.1 Prednosti in slabosti. Čeprav je pri otrocih dobro spodbujati pisanje na roke in krepitev grafomotoričnih spretnosti, se je uporaba programa za zapisovanje not obnesla precej bolje kot pisanje na papir. S tem smo prihranili precej časa pri morebitnih popravah, saj not ni bilo potrebno ponovno prepisovati, zapis je bil precej bolj čitljiv, zaradi možnosti predvajanja zapisanega pa tudi bolj zanimiv pri odkrivanju različnih zvočnih barv.

2.8 Pevski zbor

Največji izziv pri poučevanju na daljavo je predstavljala izvedba ur otroškega in mladinskega pevskega zbora. Ure so za učitelja glasbe del njegove učne obveze, zato jih je bilo potrebno izvesti tudi na daljavo. Vaje preko spletnih učilnic niso prišle v poštev, saj je kakovost zvoka slaba, poleg tega prihaja do zakasnitev.

Učenje novih pesmi smo se lotili s pomočjo posnetkov. Učencem sem poslala dva posnetka. Na prvem sem skladbo zapela, drugi pa je bil posnetek klavirske spremljave, ob kateri so učenci lahko prepevali doma.

2.8.1 Prednosti in slabosti. Petje v zboru zahteva skupno muziciranje v živo in ga ne moramo nadomestiti na noben način. Učencem je bilo sicer všeč, da so pesmi lahko tudi doma peli ob spremljavi (na tak način jih prepevamo v šoli), vendar so tudi oni pogrešali skupinsko petje, ki je bistvo pevskega zbora.

3 PRIMEJAVA IDEJ

Predstavljene ideje so si vsebinsko precej različne in tudi zahtevajo različno raven angažiranosti učitelja. V tem razdelku predstavim primerjavo idej na podlagi različnih kriterijev, kar bralcu omogoča lažje odločanje, ali bo katero od idej vključil v svoj pouk. Kriteriji so določeni na način, da so ocenljivi in da so smiselni vse ideje.

Spodnja tabela (Tabela 1) prikazuje, kako se opisane ideje v članku obnesejo glede na določene kriterije:

- krepitev IKT znanj učencev,
- enakovredna ali boljša izkušnja kot v razredu,
- pozitiven odziv učencev,
- praktičnost izvedbe (ni potrebe po dodatnih pripomočkih, (pred)znanju) in
- smiselnost uporabe pri klasičnem pouku.

Kot je razvidno iz Tabele 1, so bile vse ideje dobro sprejete med učenci, večina pa omogoča enakovredno ali celo boljši izkušnjo kot v razredu. Dejavnosti, ki tega ne omogočajo so tiste, kjer gre za nastopanje učencev in skupinsko dejavnost oziroma ogled kulturnih prireditev.

Večina idej, kjer so učenci vključen kot ustvarjalci vsebin krepi njihove veščine IKT. Polovica idej je v celoti primerna za uporabo tudi pri pouku v razredu, saj gre za individualne naloge učencev z uporabo IKT. Te naloge so tudi za izvedbo precej enostavne saj ne potrebujejo drugih pripomočkov (npr. grafična tablica), ki jih navadno nimamo, niti ne zahtevajo dodatnega znanja (npr. znanje video montaže).

Posebej bi izpostavila rap o skladatelju in nalogo z uporabo grafične notacije, saj so zadostili vsem kriterijem in so zelo smiselni za redno vključitev v pouk. Poleg tega se je kot odlično izkazala uporaba programa Musescore, a žal je ta ideja omejena na uporabo v posebnih pogojih (npr. za Glasbeno olimpijado) in ni primerna za celoten razred.

Tabela 1: Primerjava idej glede na različne kriterije

	IKT	Boljša izkušnja	Odziv učencev	Praktičnost	Smiselnost
Razlaga snovi preko video vsebin	✓	✓	✓		
Grafična tablica		✓	✓		✓
Rap o skladatelju	✓	✓	✓	✓	✓
Grafična notacija in zvoki iz okolja	✓	✓	✓	✓	✓
Kulturni dan kot spletni koncert			✓		
Proslava na daljavo	✓		✓		
Zapis glasbe s pomočjo Musescore	✓	✓	✓	✓	✓
Pevski zbor			✓		

4 ZAKLJUČEK

Čeprav je bilo o šolanju na daljavo izrečenega in zapisanega veliko slabega, je meni dal veliko dobrega. Marsikatera od zgoraj opisanih rešitev se je namreč izkazala kot bolj učinkovita ali za učence bolj zanimiva kot običajna pot.

Tako smo z učenci pri pouku tudi letos (čeprav smo bili v šoli) ustvarjali skladbe z grafično notacijo in zvoki iz okolja ter pisali rap. S to razliko, da naloge učenci niso opravljali doma, temveč so naloge ustvarjali v računalniški učilnici med urami glasbene umetnosti. Učenci, ki so se udeležili tekmovanja, so za zapis skladbe posegali po programu za notacijo, saj jim je omogočal bolj enostavne popravke skladbe. Pevci pri pevskem zboru so si zaželeli posnetih spremljav tudi letos, saj so si skladbe želeli prepevati ob spremljavi tudi doma. Posneti koncerti in predstave pa nam krajšajo čas na kakšen dan, ko učenci niso pri volji za nič drugega.

Članek lahko služi kot ideja ali izhodišče ostalim pedagogom za uporabo pri pouku. V primeru, da se še kdaj ponovi šolanje na daljavo, lahko vse ideje služijo kot popestritev vsebin, sicer pa so določene uporabne tudi za vpeljavo v klasični pouk, saj dosegajo pozitiven odziv pri učencih.

LITERATURA IN VIRI

[1] Blatič, M. idr. (2003). Didaktika. Novo mesto: Visokošolsko središče, Inštitut za raziskovalno in razvojno delo

[2] Breznik, I. (2021). Pouk glasbe na daljavo. Glasba v šoli in vrtcu, 24, št. 1, str. 2-8.

[3] Čerič, J. in Šramel Vučina, U. (2008). Zgodovina glasbe II. Ljubljana: DZS.

[4] Lango, J. (2011). Poučevanje glasbene vzgoje z uporabo informacijsko komunikacijske tehnologije (Doktorska disertacija, Pedagoška fakulteta Ljubljana). Pridobljeno s http://pefprints.pef.uni-lj.si/535/1/Pou%C4%8Devanje_GVZ__z_IKT_Lango.pdf

Uporaba interaktivnih kvizov pri pouku angleščine

Using Interactive Quizzes in English Lessons

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POVZETEK

Sodobna tehnologija je postala del vsakdanjega življenja in pomemben del pouka pri mnogih predmetih. Učenci izven pouka uporabljajo različne spletne aplikacije, učitelji pa lahko tehnologijo uporabimo za poučevanje, tudi na otrokom privlačen način. V prispevku bom predstavila možnosti za uporabo interaktivnih kvizov pri pouku in prednosti njihove uporabe. Internet ponuja veliko različnih orodij za ustvarjanje kvizov. Najpogosteje uporabljano orodje je Kahoot!, na kratko pa bom opisala še dve zelo zanimivi platformi, Quizizz in Plickers, ki sta tudi prosto dostopni in sta se meni osebno izkazali za zelo priročni. Opisane bodo brezplačne funkcije in prednosti posameznega orodja, predstavljena pa bo tudi primerjava med njimi.

KLJUČNE BESEDE

Spletno učno orodje, interaktivni kviz, formativno spremljanje, Kahoot!, Quizizz, Plickers

ABSTRACT

Modern technology has become a vital part of our everyday life and an important part of lessons at school. While students use different online tools and applications in their free time, teachers can use technology for educational purposes, also in a fun way. The article aims to present different options for using interactive quizzes during lessons and the advantages they bring to the students and the teachers. There are a lot of different online tools for creating such quizzes. Besides Kahoot!, which is probably the most popular game-based learning platform, I will present two other free access platforms that are easy to use, Quizizz and Plickers. The basic (free) features of each online tool will be presented and a comparison of them will be shown.

KEYWORDS

Online learning tool, interactive quiz, formative assessment, Kahoot!, Quizizz, Plickers

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1 UVOD

S hitrim razvojem tehnologije se spreminjajo tudi generacije otrok. Sodobna tehnologija je postala del njihovega življenja in s pomočjo le-te lahko današnje učence bolj motiviramo za učenje in delo. Učenci s pomočjo IKT znanje sprejemajo po najmanj dveh kanalih, slušnem in vidnem, zato je delo učinkovitejše, informacije razumljivejše in znanje trajnejše.[1] Pri poučevanju tujih jezikov se nam ponuja veliko možnosti za popestritev pouka z uporabo različnih spletnih orodij. S tem lahko učencem pokažemo, da se je možno ob učenju tudi zabavati. Odličen način za dosego tega so interaktivni kvizi in igre.

2 UPORABA INTERAKTIVNIH KVIZOV

Kvize lahko uporabljamo pri kateremkoli predmetu in v katerikoli starostni skupini. Seveda jih ne uporabljamo vsako uro, ampak presodimo, kdaj je uporaba smiselna. Uporaba IKT orodij večinoma takoj pritegne pozornost učencev. Učenci so bolj motivirani, pozorni in ustvarjalni. Nad uporabo so večinoma navdušeni, saj so orodja pogosto tekmovalnega značaja, točkovanje pa vzdržuje napetost med igro.

Kvize lahko uporabljamo za uvodno motivacijo, za ugotavljanje predznanja učencev ali za predstavitev nove snovi. Z njimi lahko učence seznanimo s cilji določenega učnega sklopa in jim vzbudimo radovednost.

Ena izmed glavnih možnosti uporabe je po mojem mnenju formativno spremljanje. Spletna orodja so namreč odlična za preverjanje in utrjevanje znanja učencev. Namesto uporabe klasičnega preverjanja na papirju lahko znanje učencev preverimo na bolj zabaven način. Učenci dobijo takojšnjo povratno informacijo, učitelj pa dobi vpogled v njihovo znanje in napredek.

Učencem lahko celo zadamo nalogo, da ob koncu določenega učnega sklopa sestavijo vsak svoj kviz za utrjevanje snovi, se postavijo v vlogo učitelja in kviz v razredu tudi izpeljejo. Ob sestavljanju kviza spoznavajo, kaj znajo in česa še ne. [2]

Pri mnogih orodjih za izdelavo kvizov obstaja tudi možnost, da kviz učencem dodelimo kot domačo nalogo. Domača naloga lahko na tak način postane bolj privlačna za marsikaterega učenca, moramo pa se seveda prepričati, da imajo vsi učenci tudi doma dostop do interneta (preko računalnika ali pametnega telefona). Čeprav učenci kviz rešujejo samostojno doma, ima učitelj vseeno vpogled v odgovore in dosežke učencev. S tako povratno informacijo lažje načrtuje potek naslednje ure pouka.

3 INTERAKTIVNI KVIZI

Na spletu obstaja veliko orodij oz. aplikacij, ki omogočajo ustvarjanje interaktivnih kvizov in iger, s pomočjo katerih lahko popestrimo vsakodnevno rutino v razredu. Osnovni paket večine orodij je prosto dostopen in brezplačen, napredne funkcije pa so plačljive. Za uporabo je potrebna učiteljeva registracija, medtem ko učenci za igranje potrebujejo le kodo. Večina teh orodij omogoča oblikovanje lastnih kvizov ali pa uporabo že obstoječih, ki jih ustvarjalci delijo z drugimi uporabniki portala.

3.1 Kahoot!

Kahoot! je interaktivno digitalno orodje, ki je uporabno predvsem za izdelavo zanimivih spletnih kvizov in predstavitev. Gre za eno najbolj priljubljenih aplikacij med učenci in učitelji. Brezplačni paket učitelju omogoča ustvarjanje lastnega kviza ali uporabo in predelavo že obstoječih kvizov. V kviz lahko vstavimo vprašanja izbirnega tipa z največ 4 možnimi odgovori (slika 1) in vprašanja tipa 'prav/narobe'. Vprašanja lahko vsebujejo YouTube posnetke, slike (shranjene na računalniku), slike namesto odgovorov in matematične enačbe. Orodje nudi možnost časovne omejitve. Poleg pravilnosti odgovorov se točkuje tudi hitrost odgovarjanja. Učenci na svojih napravah načeloma vidijo samo znake za odgovore, ne pa tudi vprašanj in dejanskih odgovorov, ima pa učitelj možnost, da učencem omogoči pogled tudi z vprašanji.

Kviz lahko z učenci igramo v živo med poukom ali pa jim ga dodelimo kot domačo nalogo. Rezultate bomo videli v obeh primerih. V živo lahko učenci kviz igrajo individualno ali pa v skupinskem načinu. V skupinskem načinu obstajata dve možnosti: igranje na skupni napravi ali pa vsak udeleženec na svoji (do 5 skupin). Največje število igralcev v posameznem kvizu je 50. V Kahootu! lahko ustvarimo tudi razrede, v katere se učenci prijavijo, in jim na tak način dodelimo kvize.[3]

Kahoot! je dostopen preko povezave https://kahoot.com/, učenci pa do kviza dostopajo na https://kahoot.it/.

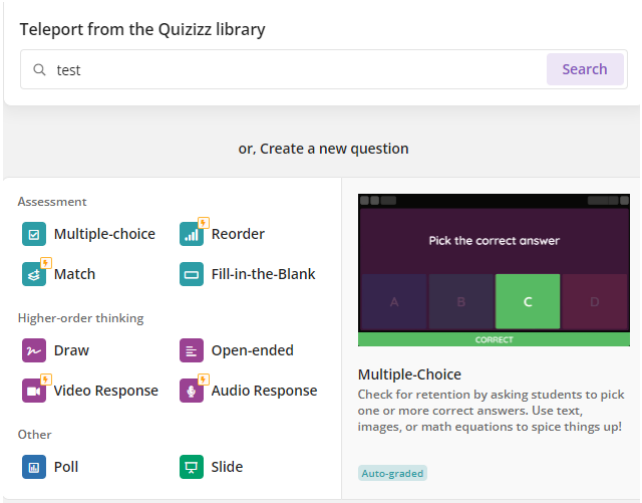
Slika 1. Primer vprašanja izbirnega tipa v orodju Kahoot! (VIR: https://www.monash.edu)

3.2 Quizizz

Quizizz je orodje za ustvarjanje kvizov in predstavitev. Z orodjem Quizizz lahko ustvarimo zelo podoben kviz kot z orodjem Kahoot!, le da Quizizz v osnovnem paketu omogoča vstavljanje več različnih tipov vprašanj (slika 2). Na voljo imamo vprašanja izbirnega tipa (dodamo lahko pet možnih odgovorov), kjer je lahko pravilen le en odgovor ali pa je pravilnih odgovorov več. Ustvarimo lahko tudi vprašanja, ki zahtevajo zapis manjkajočih besed. Orodje omogoča vključevanje ankete za pridobivanje mnenj in vprašanja odprtega tipa. V kviz lahko brezplačno vključimo 10 slik na dan, drsnice in matematične enačbe, žal pa v brezplačni verziji ni možno vstavljati avdio in video posnetkov. Pri vsakem vprašanju lahko določimo, koliko časa bo imel učenec za odgovor in s kolikšnim številom točk naj bo pravilen odgovor točkovan. Vidimo tudi prikaz vprašanja kot ga bodo videli učenci. Učenci na svojih napravah vidijo vprašanje in vse možne odgovore. Nastavitve omogočajo tudi, da orodje učencem vprašanje glasno prebere.

Kviz lahko z učenci igramo v živo med poukom ali pa jim ga dodelimo kot domačo nalogo. Rezultate bomo videli v obeh primerih. V živo je kviz možno igrati na klasičen način, kar pomeni, da učitelj vodi kviz, prestavlja vprašanja in po vsakem vprašanju poda razlago odgovora, lahko pa ga učenci igrajo vsak v svojem tempu. Tudi Quizizz ponuja skupinski način igranja. V kvizih lahko sodeluje največ 100 udeležencev, ki se prijavijo le s kodo, brez registracije. V Quizizzu je možno ustvariti tudi razrede, v katere se učenci prijavijo in jim na tak način dodelimo kvize. [4]

Orodje je dostopno na https://quizizz.com/, učenci pa se povežejo preko povezave https://quizizz.com/join.



Slika 2. Vrste vprašanj, ki jih omogoča Quizizz (VIR: lasten, zajem zaslonske slike)

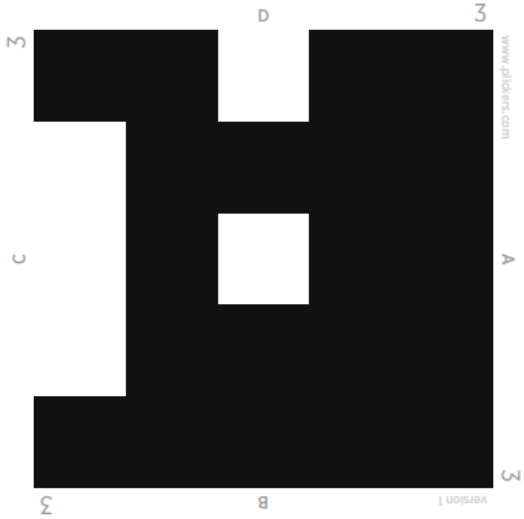
3.3 Plickers

Aplikacija Plickers ravno tako omogoča oblikovanje interaktivnih kvizov, vendar je nekoliko drugačna od preostalih orodij za formativno preverjanje znanja. Učitelj se mora za dostop registrirati in naložiti aplikacijo na pametni telefon. Pred uporabo je priporočljivo, da si v svojem računu ustvari razrede, vanje doda učence in vsakemu dodeli številko kartice. Učitelj nato pripravi kviz v spletnem orodju, ob igranju pa ga projicira na platno. Učenci za igranje ne potrebujejo računalnikov ali pametnih telefonov. Vse, kar potrebujejo, so plickers kartice, ki so dostopne na https://help.plickers.com/hc/en-us/articles/360008948034-Get-Plickers-Cards (slika 3). Učitelj kartice natisne, priporočljivo je, da jih tudi plastificira, saj se v nasprotnem primeru hitro uničijo. Vsak učenec v razredu dobi svojo kartico, zato jih je potrebno natisniti toliko, kolikor je učencev v razredu (obstaja 40 različnih kartic). Na karticah je edinstvena koda, na vsakem robu pa ena črka (A, B, C ali D). Na njej je natisnjena tudi zaporedna številka kartice/učenca. Učenec

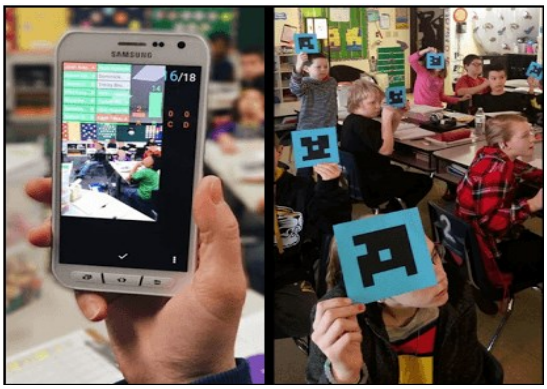
pri odgovarjanju na vprašanje kartico obrne tako, da je na vrhu črka odgovora, za katerega se je odločil. Preverjanje odgovorov poteka tako, da učitelj kartice optično prebere s svojim pametnim telefonom (slika 4). Ko s telefonom zajame kartico, se izpiše ime učenca, krogec, ki je ob imenu, pa se obarva rdeče (napačen odgovor) ali zeleno (pravilen odgovor). Ko vsi učenci odgovorijo, učitelj pokaže, kako je razred odgovarjal, nato pa razkrije tudi pravilen odgovor. Če želi, lahko ob koncu kviza učencem pokaže, kako uspešni so bili (v odstotkih).

Vsak kviz ima do največ 5 vprašanj. Izbiramo med dvema vrstama vprašanj: vprašanja izbirnega tipa in vprašanja tipa 'prav/narobe' ter anketo. Vprašanja izbirnega tipa dovoljujejo največ štiri možne odgovore. V vprašanja lahko vstavimo sliko, enačbo, avdio ali video posnetek, zvok iz knjižnice ali gif animacijo. Vse omenjene možnosti lahko vključimo tudi v odgovore. Časovne omejitve pri vprašanjih ni. Učitelj dobi povratno informacijo, učenec pa to informacijo dobi le, če mu jo učitelj pokaže. [5]

Ker ni časovne omejitve, učenci niso pod pritiskom, da morajo hitro odgovoriti, ampak lahko o svojem odgovoru malo premislijo. To orodje je primerno za vse razrede in vse predmete, še zlasti pa je uporabno pri mlajših učencih, ki večinoma nimajo svojih pametnih telefonov oz. v šolah s slabšim internetnim signalom. Orodje je dostopno na https://get.plickers.com/.



Slika 3. Primer Plickers kartice (VIR: lasten, zajem zaslonske slike)



Slika 4. Plickers kviz v razredu (VIR: https://lauracandler.com/innovative-strategies-for-plickers/)

3.4 Primerjava med kvizi

Opisana orodja za izdelavo kvizov so si v marsičem podobna, imajo pa tudi svoje posebnosti. Z aplikacijama Kahoot! in Quizizz lahko ustvarimo zelo podobne kvize, so pa vseeno manjše razlike med njima, medtem ko je Plickers precej drugačen. V spodnji tabeli so naštete najbolj pogoste funkcije, ki jih interaktivni kvizi omogočajo v brezplačnem paketu, ob tem pa je zapisano, ali za omenjena tri orodja ti kriteriji veljajo (Tabela 1).

Tabela 1: Primerjava orodij za izdelavo kvizov

	Kahoot!	Quizizz	Plickers
ustvarjanje lastnega kviza	DA	DA	DA
uporaba že obstoječih kvizov	DA	DA	omejeno
predelava obstoječih kvizov	DA	DA	omejeno
vprašanja izbirnega tipa	DA (4 možni odgovori, en pravilen odgovor)	DA (5 možnih odgovorov, en ali več pravilnih odgovorov)	DA (4 možni odgovori, en pravilen odgovor)
vprašanja 'prav/narobe'	DA	NE	DA
vprašanja, ki zahtevajo zapis manjkajoče besede	NE	DA	NE
vstavljanje slikovnega materiala	DA (le slike, ki so naložene na računalniku)	DA (10 slik na dan)	DA
vstavljanje YouTube posnetkov	DA	NE	DA
vstavljanje matematičnih enačb	DA	DA	DA
časovna omejitev pri odgovarjanju	DA	DA	NE
glasno branje vprašanja	NE	DA	NE
vpogled v rezultate učencev	DA	DA	DA
uporaba pametnih telefonov ali računalnikov	DA	DA	NE
individualno reševanje – učitelj vodi kviz	DA	DA	DA
individualno reševanje – prilagojeno posameznim učencem	NE	DA	NE
skupinsko reševanje	DA	DA	NE
igranje preko videokonferenčnega sistema	DA	DA	NE
samostojno reševanje doma	DA	DA	NE
učenci vidijo svoj dosežek	DA	DA	če jim učitelj to pokaže
tekmovanje s sošolci	DA	DA	NE
število sodelujočih učencev	do 50	do 100	do 40

4 ZAKLJUČEK

Spletni orodji Kahoot! in Quizizz sta si zelo podobni, saj učiteljem omogočata precej podobnih funkcij. Kahoot! je med

učitelji in učenci bolj poznan in posledično tudi bolj pogosto uporabljen pri pouku. Meni osebno pa se je pri pouku angleščine orodje Quizizz izkazalo za bolj uporabno kot Kahoot!. Eden izmed razlogov je, da v brezplačnem paketu nudi več različnih tipov vprašanj. Pri pouku angleščine opažam, da imajo učenci veliko težav s pravilnim zapisom besed, zato je zelo uporaben tip vprašanja, kjer morajo udeleženci dopisati ustrezno besedo. Na ta način učenci na zabaven način utrjujejo besedišče ter vadijo pravilen zapis. Učenci pred ocenjevanjem znanja zelo radi kvize uporabljajo tudi doma in s tem ponavljajo snov.

Quizizz večinoma uporabljam z učenci zadnje triade osnovne šole, kjer ima veliko učencev že svoje pametne telefone. V drugi triadi pa je situacija nekoliko drugačna, saj ima precej manj otrok v lasti pametno napravo. Pri šestošolcih se mi je zato pri pouku za najbolj uporabno orodje izkazal Plickers, saj učenci za igro ne potrebujejo računalnika ali telefona.

Orodij za ustvarjanje interaktivnih kvizov je veliko, zato učitelji brez težav najdemo orodja primerna starosti otrok, njihovi jezikovni ravni in digitalnim kompetencam.

LITERATURA IN VIRI

[1] K. Bučar. 2020. Uporaba digitalnih tehnologij pri angleščini v osnovni šoli. Zbornik Mednarodne strokovne konference Kreativna učna okolja (2020), 86-95

[2] P. Jelen. 2019. Uporaba aplikacije Kahoot! pri pouku in doma. Zbornik 22. mednarodne multikonference Informacijska družba. Vzgoja in izobraževanje v informacijski družbi (2019), 103-104

[3] Kahoot! https://kahoot.com/ (8. 8. 2022)

[4] Quizizz https://quizizz.com/ (8. 8. 2022)

[5] Plickers https://get.plickers.com/ (8. 8. 2022)

E-vzgojni vikend »Bod' na kavču!«

E-Educational Weekend “Bod’ Na Kavču!”

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POVZETEK

Dom Janeza Boska, v katerem sem zaposlena, deluje po preventivnem vzgojnem sistemu, ki ga je zasnoval veliki pedagog Janez Bosko. V prispevku želimo predstaviti primer dobre prakse dela z dijaki v času izobraževanja na daljavo, ki se je zgodilo v času epidemije COVID-19. Eden temeljnih elementov vzgoje v Domu Janeza Boska je vzgoja za skupnost.

Vzgojitelj v Domu Janeza Boska ima vlogo usmerjevalca celotnega vzgojnega procesa. Ena izmed njegovih vlog je tudi organizacija vzgojnega vikenda. Ta vikend je zelo pomemben za razvoj in povezovanje vzgojne skupine. To je bil razlog za odločitev, da organiziram e-vzgojni vikend tudi v času izobraževanja na daljavo.

Po koncu e-vzgojnega vikenda sem zbrala odzive dijakinj, samoinicativno pa se je oglasilo tudi nekaj staršev dijakinj, ki so bili prav tako navdušeni nad idejo in samo izvedbo vikenda.

KLJUČNE BESEDE

Don Boskov preventivni vzgojni sistem, vzgojitelj, vzgoja za skupnost, vzgojni vikend, e-vzgojni vikend

ABSTRACT

The Janez Bosko boarding school where I am employed operates within preventive educational system, which was founded by the great Janez Bosko himself. In this article I wish to present a case of a good case study when dealing with students that study remotely, that happened during the COVID-19 pandemic.

An educator at Janez Bosko boarding school controls an entire educational process. One of its roles is also to organise an educational weekend, which is important for the development and connectivity of the group. This was the main reason why I decided to organise it during the time of remote study.

After the online event I asked the students for some feedback. I have also received some positive feedback from the parents who were excited about the idea and execution of the online weekend event.

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KEYWORDS

Don Bosko preventive educational system, educator, education for community, educational weekend, e-educational weekend

1 UVOD

V strokovnem članku bomo predstavili don Boskov preventivni vzgojni sistem, sistem po katerem delujemo v Domu Janeza Boska. Dom Janeza Boska sestavljajo vzgojne skupine, ločeno dekliške in fantovske skupine.
Osredotočili se bom zlasti na področje vzgoje za skupnost. Ključni elementi, s katerimi ustvarjamo skupnost so: gradnja identitete vzgojne skupine preko vsakodnevnih pobud, večerna srečanja, vzgojni vikend in pozornost na vsakega posameznika preko osebnega spremljanja mladostnika. Na koncu bomo predstavili primer dobre prakse dela na daljavo, ki smo ga poimenovala e-vzgojni vikend “Bod’ na kavču!”. Odločitev za izvedbo le tega je padla v letu 2020, ko so se vrata izobraževalnih ustanov v Sloveniji zaprla, z namenom preprečevanja širjenja virusa Covid-19. Na odpoved izobraževalnega procesa, ki se je zgodil v letu 2020 zaradi pandemije korona virusa marsikdo ni bil pripravljen. Tukaj govorimo tako o krovnih šolskih organizacijah, kot tudi šolah samih, učiteljih, učencih, starših in institucijah, ki s šolami neposredno sodelujejo. [3]

2 DON BOSKOV PREVENTIVNI VZGOJNI SISTEM

Utemeljitelj preventivnega vzgojnega sistema je Janez Bosko, ki se je rodil leta 1815 blizu Torina. Torino je bil v tistih letih pod vplivom industrijske revolucije in v tej situaciji je bilo na cesti veliko mladih, ki so bili revni, izkoriščeni in prepuščeni sami sebi. Janez Bosko je znal prepoznati njihove stiske ter poiskati odgovore nanje. Tako je ustanovil oratorij, ki je kraj zbiranja, igre in primerne zaposlitve. Je prostor, kjer je poskrbljeno za vsestransko rast mladega posameznika, ki ni prepuščen samemu sebi, temveč odrašča v družbi sovrstnikov ter ima ob sebi odrasle ljudi, ki zanj skrbijo in so vredni zaupanja. Svoje pedagoško delovanje je poimenoval preventivni vzgojni sistem. [1, 4]

Don Bosko je zagovarjal stališče, da morajo biti za razvoj pozitivne osebnosti zastopani štirje stebri družbe (to so glavne značilnosti oratorija):

- Dom, ki sprejema. Dom zaznamujejo ljubezen, sprejemanje, domačnost in čustvena toplina. Obenem pa pomeni doslednost, zahtevnost in odgovornost.

- Župnija oz. duhovno okolje, ki vzgaja za vrednote. Človek, če hoče živeti mora vedeti zakaj živi in imeti pred seboj vrednote, za katere želi živeti.
- Šola, ki uvaja v življenje. Fantje, ki jih je don Bosko vzel pod svoje okrilje so bili večinoma nepismeni in neizobraženi. Zasnoval je šolo, ki je bila po meri mladostnikov, predvsem pa je izobraževala za življenje. Namen je bil, da bodo mladi postali koristni člani družbe, v kateri živijo.
- Dvorišče za prijateljske stike in za življenje v veselju. Veselje se izraža v igri, druženju, sproščenosti in ustvarjalnosti. [1, 2]

3 VZGOJA ZA SKUPNOST V DOMU JANEZA BOSKA

V Domu Janeza Boska delujemo po preventivnem vzgojnem sistemu. Eden od naših glavnih ciljev je vzgoja za skupnost. To želimo doseči preko ustvarjanja skupnosti na ravni celotnega dijaškega doma kot na ravni vzgojne skupine. Naš namen je, da bi se mladi v tej skupnosti čutili sprejete, slišane, ljubljene in razumljene. Želimo jim ponuditi varno okolje, kjer preživijo najstniška leta. Mladim nudimo priložnost za osebnostno in duhovno rast ter jim zagotavljamo okolje, kjer se lahko izobražujejo ter razvijajo v odgovorne odrasle posameznike.

Nekaj naših najpomembnejših elementov vzgoje za skupnost:

- vzgojna skupina: je osnovna celica, kjer se dogaja vzgoja za skupnost. V našem dijaškem domu smo sprejeli nekaj usmeritev, da sledimo temu elementu-od prostorov vzgojne skupine, ki združujejo, vsakodnevnih večernih srečanj, kjer ustvarimo sproščeno okolje in ponudimo vsebine za osebnostno in duhovno rast pa vse do zunanjih znakov, ki spodbujajo pripadnost vzgojni skupini, kot so majice, puloverji.
- vloga vzgojitelja: don Boskov vzgojitelj ni zgolj v službi, ampak se trudimo, da bi vsak od vzgojiteljev ponotranjil don Boskovo karizmo in svoje delo razumel kot poslanstvo. Ključna vzgojiteljeva vloga je, da se dijakom približa na ljubezniv način, ki je njim razumljiv. Eno izmed prioritetnih okolij vzgojnega delovanja so odmori, ko vzgojitelj preživi večino časa s svojo vzgojno skupino. Takrat se mladostniki najbolj sprostijo in lahko največ izvemo o njih. Tako se ustvari zaupen odnos med dijakom in vzgojiteljem. Dijaki dobijo občutek, da so nam pomembni in da smo vredni zaupanja. Kot vzgojiteljica v dijaku vedno iščem točko, občutljivo za dobro. Ko se opremo nanjo lahko dijaka motiviramo, vodimo in usmerjamo k njegovim ciljem. [1, 2, 4] Vzgojitelj je odgovoren za dobro vodenje vzgojne skupine, obenem pa je pozoren na vsakega posameznika, ki ga preko različnih načinov tudi osebno spremlja.
- vzgojni vikendi: so zelo pomembni za razvoj in povezanost vzgojne skupine. S tem se krepi povezanost dijakov med seboj, razvija in oblikuje se nova dinamika skupine. Zaradi skupnega neobremenjenega bivanja so dijaki bolj sproščeni in se lahko pokažejo v drugačni luči kot v dijaškem domu. Vzgojni vikend je vedno zasnovan na izbrani temi, ki mladim pomaga pri osebni rasti. Poleg tega dijakom damo izziv, da sami poskrbijo za vsa gospodinjska opravila (priprava jedilnika, nabava hrane, kuhanje, pospravljanje), večkrat pa samoiniciativno poskrbijo tudi za prostočasne dejavnosti. Na ta način lahko dijakom pokažemo vse dobre plati sobivanja v skupnosti in pristnega stika z ljudmi.

4 E-VZGOJNI VIKEND »BOD' NA KAVČU!«

V šolskem letu 2019/2020 sem prevzela novo vzgojno skupino, katero je sestavljalo 16 deklet 1. letnika. Ob pripravah na novo šolsko leto sem načrtovala izvedbo vzgojnega vikenda v mesecu aprilu 2020.. Kot že omenjeno vzgojni vikend prinaša veliko pozitivnih plati tako za vzgojno skupino kot za posameznika. Če je to nova vzgojna skupina kot v mojem primeru, pa je ta vikend še toliko bolj pomemben. Ko se je začelo delo na daljavo sem začela razmišljati kako bi lahko ne glede na situacijo vzgojni vikend uspela realizirati. In porodila se mi je ideja o e-vzgojnem vikendu.

Sama ideja e-vzgojnega vikenda je bila identična tisti, ki bi se izvajal v živo, le da bi tu celotno delo potekalo preko Zoom aplikacije. Idejo sem predstavila dekletom in takoj so bile za izvedbo.

Tako sem se lotila načrtovanja e-vikenda, ki sem ga poimenovala “Bod’ na kavču!”. Z dekleti smo na samem začetku izbrale vikend, ko naj bi svoj čas v večjem delu dneva namenile našemu druženju. O tem e-vzgojnem vikendu sem obvestila tudi njihove starše. Pred samim začetkom e-vikenda so dekleta v svoje poštne nabiralnike prejele obvestilo in navodila za izvedbo vikenda.

4.1 Potek e-vzgojnega vikenda

E-vzgojni vikend smo pričeli v petek ob 20.30 na skupnem Zoom srečanju. Sprva sem pripravila uvod v vikend, predstavila potek, poskrbela za tehnične podrobnosti. Nato je sledil skupinski ogled filma z naslovom »Počutim se lepo« (angl. I feel pretty) preko aplikacije Rave. Po ogledu filma smo skupaj zaključile večer.

Naslednje jutro smo začele dan skupaj na Zoom aplikaciji ob 10.00. V dopoldanskem druženju, ki je trajalo 2 uri sem dekleta razdelila v manjše skupine in jih razdelila v posamezne sobe na Zoom-u. Njihova primarna nalog ia je bila, da se znotraj skupine bolje spoznajo. V pomoč so jim bila navodila, ki so jih dobile v Zoom sobe po posameznih urah. Tako so na začetku prebrale navodila, katerim so kasneje sledile. Da sem dosegla večjo dinamiko dela sem po določenem času združila po dve sobi skupaj in jim posredovala novo navodilo za delo. Na koncu so se zopet vse združile v eni sobi in prejele še zadnje navodilo za delo.

Poanta dela po skupinah je bila v tem, da se dekleta med seboj spoznavajo, gradijo na zaupanju ter s tem krepijo skupnost vzgojne skupine.

Primeri dela po skupinah so naslednji:

- Pogovor. Da bi le ta lažje stekel sem jim napisala nekaj vprašanj, katera so lahko služila lažjemu predstavljanju sebe. Primeri vprašanj: kakšno bi bilo tvoje življenje, če ne bi poznala strahu, v kaj verjameš pri ljubezni, opiši svoje najljubše preživljanje deževnega dne, po čem želiš, da bi se te ljudje spominjali, če bi živela le še 5 let, bi kaj spremenila in če ja, kaj?

- Nekomu polepšati dan z gesto, ki si jo izmislite same. Tako je ena od skupin pripravila mini pevski nastop za eno od sester dijakinje, ki je bila v naši vzgojni skupini. Druga skupina je povabila dotičnega maturanta na Zoom ter mu povedala zakaj jim je všeč.
- Napisati zgodbo, ki vključuje v naprej pripravljene besede. Ko smo bile ponovno vse združene so skupine podelile svoje zgodbe in poskrbele za kar nekaj izvabljenih nasmeškov na obraz.

Po ponovnem srečanju vseh deklet v eni sobi smo si podelile svoje misli in občutke, ki so jih spremljale pri spoznavanju druga druge ter opravljanju nalog. Sledil je odmor za kosilo.

Po odmoru za kosilo smo se ponovno srečale na Zoomu. Popoldanski del je bil namenjen osebnemu delu. Pri pripravi le tega sem izhajala iz filma, ki smo si ga pogledale večer prej. Dekleta so prejela navodila za osebno delo v Wordovem dokumentu. Za osebno delo sem se odločila, ker je v vsaki skupini pomemben vsak posameznik. Pomembno je, da se tega zaveda ter da okrepi samega sebe. Osebno delo je zahtevalo napisati pismo samemu sebi. Iz navodil dekletom izhaja naslednji odstavek: »Vzemi si čas in bod' na kavču. Napiši si pismo. Pri tem bodi…

Bodi sočutna do sebe. Bodi si najboljša prijateljica. Bodi tista, ki se sprejema v vsej svoji polnosti in šibkosti. Bodi si opora, bodi si oseba, ki te brezpogojno sprejema in ljubi. Bodi tista, ki odpušča. Bodi tista, ki razume najglobljo bolečino, ko se obsojaš. Bodi tista, ki je prijazna, ki pomirja.

Nato to pismo shrani na varno. Preberi si ga vsakič, ko boš dvomila vase. Ko se boš obsojala. Ko boš pri sebi iskala napake. Ko boš žalostna. Ko boš razočarana. Ko boš …"

Da je bilo dekletom lažje napisati pismo sebi so dobile tudi nekaj iztočnic o čem lahko pišejo. Iztočnice so izhajale iz ogledanega filma. Za pisanje pisma si je vsaka punca vzela toliko časa kot ga je potrebovala.

Večer smo zaključile na Zoomu z družabnim večerom. Nekaj deklet se je samoiniciativno javilo in pripravilo dve družabni igri: kviz o članicah 9. vzgojne skupine ter Scrabble 9. vzgojne skupine. Preostanek večera smo preživele ob skupnem igranju spletnih iger, kot je npr. Codenmaes in Skribbl.

V nedeljo je sledil zaključek e-vzgojnega vikenda na katerega so bile povabljene celotne družine dijakinj. V sodelovanju z ravnateljem dijaškega doma smo pripravili Zoom sv. mašo, pri kateri so sodelovale dijakinje in njihove družine.

4.2 Odzivi dijakinj in njihovih staršev na e-vzgojni vikend

Po zaključku e-vzgojnega vikenda sem povabila dekleta, da podajo svoje videnje na izvedbo, vsebino samega e-vzgojnega vikenda.

Dijakinja M.: "Petra, hvala, ker si si vzela čas za nas. Hvala, da si pripravila e-vzgojni vikend, ki je bil noro dober. Res sem spoznala kaj novega še o kakšni punci, s katero se sicer ne bi zapletla v pogovor. In tisto osebno delo je bilo težko, ampak tako dobro. Res si bom shranila pismo in ga prebrala vsakič, k obo težko. Sedaj pa že odštevam dneve, da se vidimo v živo."

Dijakinja B.: "Tole je bila pa res dobra ideja, da smo izpeljale vzgojni vikend pa četudi na daljavo. Jaz sem res uživala. Hvala, rada vas imam, punce."

Dijakinja L.: "A imamo lahko še kakšen tak vikend, sej vseeno, če na daljavo, samo da je?"

Dijakinja E.: "Meni je bilo res všeč osebno delo. Sploh tisti nagovor, da naj bom sama sebi najboljša prijateljica. Vem, da sem vedno najbolj stroga do sebe. Morda pa bo sedaj kaj drugače, ker tole pismo sebi bom sigurno shranila. Hvala."

Samoiniciativno pa je prišlo tudi nekaj zahval staršev:

Mami T.: "Res sem hvaležna za trud, da boste kljub vsemu izpeljali vikend. Vem, da bo J. to veliko pomenilo in tudi veliko dalo… od vas pa zahtevalo veliko energije. Zato res še enkrat iskrena hvala in se vidimo v nedeljo na Zoomu."

Mami B.: "Petra, osebno bi se rada zahvalila za edinstveno idejo, za skupno sv. mašo, pri kateri je bilo moč čutiti povezanost. Lepo je bilo in še vedno odmeva. Hvala."

Mami S.: "Še enkrat najlepša hvala za včerajšnje skupno srečanje. Nam je bilo lepo biti del neke take skoraj že družinske skupnosti. Naša N. je bila navdušena nad celotnim vikendom."

5 ZAKLJUČEK

V dneh e-vzgojnega vikenda je bilo čutiti željo dijakinj po povezovanju, sklepanju novih prijateljstev, dela na sebi. Na podlagi osebnega dela, ki sem jim ga pripravila, se je odprlo kar nekaj dijakinj, ki so si kasneje želele individualnega dela z menoj. Zaključimo lahko, da je e-vzgojni vikend doprinesel k boljši povezanosti skupnosti vzgojne skupine, da se je poglobil odnos dijakinja-vzgojiteljica, obenem pa so se tudi starši lahko počutili kot del širše skupnosti, v katero so vključene njihove mladostnice.

Z lahkoto sicer trdimo, da obstaja kar nekaj preprek pri e-vzgojnem vikendu, če le tega primerjam v vzgojnim vikendom, ki je sicer izveden v »živo«, a obenem se je izkazalo, da so vsi glavni nameni lahko doseženi tudi na način predstavljen v tem prispevku.

LITERATURA IN VIRI

[1] Tone Ciglar. 2004. Rad vas imam. Ljubljana, Salve.
[2] Carlo Nanni. 2011. Don Boskov preventivni sistem. Ljubljana, Salve.
[3] Gašper Strniša in drugi. Discord kot platforma za izvedbo pouka na daljavo. Vzgoja in izobraževanje v informacijski družbi – zbornik 24. mednarodne multikonference. Uredila: U. Rajkovič in B. Batagelj, Ljubljana, 8. oktober 2021. Institut »Jožef Štefan«, Ljubljana.
[4] Peter Končan. 2015. Don Boskov preventivni vzgojni sistem: duhovna in vzgojna izkušnja. Vzgoja, let. 17, št. 67. Ljubljana.

Biti z mladimi tudi v času izobraževanja na daljavo

How To Offer Assistance to Youth During Remote Study?

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POVZETEK

V prispevku smo predstavili preventivni vzgojni sistem, sistem po katerem delujemo vzgojitelji v Domu Janeza Boska. Preventivni vzgojni sistem daje veliko vlogo vzgojitelju, kateremu so mladi zaupani v vzgojo. Janez Bosko, utemeljitelj preventivnega sistema je razvil obliko pomoči, ki jo je poimenoval asistenca. Pomembno je, da imajo mladi ob sebi osebo, ki ji lahko zaupajo in se ji odprejo.

V nadaljevanju predstavimo primere dobre prakse, ki smo jih pripravili vzgojitelji v Domu Janeza Boska v času izobraževanja na daljavo. Dijaški domovi smo se prilagodili situaciji ter tudi v skladu z navodili in priporočili pripravili in oblikovali vrsto spletnih vsebin. Glavni namen le teh je bil ostati v stiku z mladostniki, jim biti asistenca v teh nepredvidljivih in novih časih. Dijaki so izkazali velik interes za vsebine, ki so jim bile ponujene. Obenem pa se je z večino ohranil pristen stik.

KLJUČNE BESEDE

Preventivni vzgojni sistem, asistenca, dobra praksa, izobraževanje na daljavo

ABSTRACT

The article showcases a preventive educational system, on which the Janes Bosko boarding school operates. It gives teaches, who's responsibility is to educate the youth, an important and responsible role. Janez Bosko, the founder of the preventive system had developed a means of support, which he called "assistance". It is important for the youth to have access to somebody they can trust and feel comfortable opening to.

In the continuation, I will present cases of good practices that were prepared by teaches of Janez Bosko boarding school during the time of remote study. The boarding schools adjusted to the situation and in accordance with the received instructions and recommendations, prepared variety of online contents. The main reason was to stay in touch with the youth, and to be of assistance to that during the challenging and unpredictable times. The students have expressed interest for the prepared content that was on offer and at the same time remain a genuine connection and relationship.

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KEYWORDS

Preventive educational system, assistance, good case studies, remote study

1 UVOD

V šolskem letu 2019/2020 se je tako rekoč iz danes na jutri zgodilo, da smo pričeli z izobraževanjem na daljavo, zaradi epidemije korona virusa.

Lahko rečemo, da na kaj takšnega nismo bili pripravljeni, ne ustanove, ne posamezni pedagoški delavci. Situacija je od nas terjala hitro prilagoditev ter še hitrejše učenje uporabe novih spletnih orodij.

Vzgojitelji v Domu Janeza Boska smo v skladu s preventivnim vzgojnim sistemom, sistemom po katerem delujemo v dijaškem domu ter z navodili in priporočili ustvarili vrsto spletnih vsebin, preko katerih smo ohranjali stik z dijaki, ki so nam zaupani v vzgojo. Eden izmed namenov teh spletnih vsebin je bil tudi ta da ohranimo skupnost, ki smo jo ustvarjali v »živo«.

2 PREVENTIVNI VZGOJNI SISTEM

Utemeljitelj preventivnega vzgojnega sistema je veliki pedagog Janez Bosko. Živel je v bližini Torina v letih, ko je bilo mesto pod velikim vplivom industrijske revolucije. Tako je bilo na cesti veliko mladih, ki so bili prepuščeni sami sebi, revščini ter izkoriščanju. Janez Bosko je čutil njihovo stisko ter jim želel ponuditi prostor, kjer se bodo čutili ljubljene, vredne zaupanja. Za njih je ustanovil mesto zbiranja, igre in primerne zaposlitve. Ta kraj je poimenoval oratorij. Don Bosko je tako skrbel za mlade na več ravneh: nudil jim je streho nad glavo, hrano in druge nujne pogoje za preživetje, med njimi tudi občutek varnosti. Tako jih je pridobil na svojo stran in jih začel vzgajati v samozavestne, odgovorne posameznike, ki lahko družbi enakopravno dajejo vse svoje potenciale.

Temeljni vodili preventivnega vzgojnega sistema sta ljubezen in zaupanje. Brez ljubezni do mladih ni zaupanje v odnosu mladi-vzgojitelj in brez tega zaupanja po njegovo vzgoja ni mogoča. [2]

Preventivni vzgojni sistem temelji na budni navzočnosti vzgojitelja, ki se z dijaki pogovarja kot ljubeč starš, je vodja pri vsakem dogodku, daje nasvete in ljubeznivo opominja. Pomembna je domačnost z mladimi (zlasti v njihovem prostem času), ki postopoma preide v ljubezen in zaupanje. [3]

Janez Bosko je predpostavljal, da je dober vzgojitelj čuteč, podkovan v pedagoškem znanju, in dober poznavalec razvoja in potreb otrok, z izostrenim smislom za podajanje znanja otrokom. »Ni dovolj, da živi za fante, ampak naj z njimi doživlja njihovo življenje.« [2] Don Bosko je s tem sistemom svoje vzgojitelje spodbujal k temu, da mlade spoznajo in da oni spoznajo njih, medtem ko z njimi preživljajo prosti čas. [3]

3 ASISTENCA ALI BITI Z MLADIMI

Don Bosko je razumel, da mladi potrebujejo ob sebi osebo, ki jih bo lahko vodila, na katero se lahko obrnejo, ko so v težavah, in preko katere projicirajo svoje znanje in izkušnje, predvsem pa da imajo ob sebi osebo, ki ji lahko zaupajo in se ji odprejo. Zato je razvil svojevrstno obliko pomoči, ki jo je poimenoval asistenca.

Asistenca je odraz odgovornosti za otroka in je sorazmerna z zrelostjo in samostojnostjo otrok. [2]

Vodilo vzgojiteljev v salezijanskih ustanovah je biti z mladimi, kar pa je tudi glavno vodilo asistence. Ni namreč dovolj, da vzgojitelj živi za mlade, ampak je pomembno, da z njimi doživlja njihovo življenje, tako da so oni v ospredju njegovega dela.

Biti z mladimi pomeni združitev dveh svetov, saj si vzgojitelj in mlad človek med seboj delita izkušnje, življenje, odnose. Mladi potrebujejo prijatelja, ki jih spremlja, razume, jim svetuje in pomaga. Vzgojitelj torej predstavlja tega prijatelja.

Asistenca pomeni tudi aktiven odnos, v katerem vzgojitelj deluje tako, da se z dijakom ukvarja, ga usmerja, mu pomaga. S tem izraža resnično odgovornost za mlade. Biti zraven ne pomeni samo fizične prisotnosti, ampak označuje živo, čutečo navzočnost, ki je zaznamovana z ljubeznivim odnosom. [2]

Asistenca je torej koncept vzgoje, pri katerem vzgojitelj postane mlademu blizu, z njim vzpostavlja prijateljski odnos, z namenom, da mladega lažje usmerja, mu pomaga, opominja in tako odgovorno pristopa k vzgoji.

Biti vsem vse je istočasno posebnost in prednost preventivnega sistema in tisto, zaradi česar je ta vzgojni sistem tako težak za vzgojitelje. S svojo prisotnostjo lahko vzgojitelj vzpostavi veliko možnosti za vplivanje na mladostnika, ki so bolj učinkovite kot kazni, vendar pa to za vzgojitelja pomeni veliko več časa, ki ga posveti le posamezniku in ne skupini.

4 VZGOJNI ODNOS

Vzgoja ni samo individualno delovanje vzgojitelja, ampak predvsem delo vzgojnega okolja, kjer so odnosi podobni družinskim. Tak vzgojni odnos je prežet z ljubeznivostjo, prijateljstvom, zaupanjem, naklonjenostjo, sprejemanjem, asistenco, ki lahko traja tudi po tem, ko mladostnik ni več v vzgojnem procesu.

Skrb za dobre odnose pomeni prizadevati si za to, da te imajo kot vzgojitelja radi. Konkretno to pomeni, da si jim blizu, da pridobiš njihovo zaupanje, da te kljub drugačni starosti, vlogi ali osebnosti sprejmejo takšnega kot si, prav tako pa seveda tudi ti njih. [1] Dom, v katerem veljajo takšni odnosi, pomeni resničnost, ki jo zaznamujejo ljubezen, zaupanje, domačnost, prisrčnost. Z vnašanjem teh vrednot v vzgojno delovanje zavračamo uradne, hladne odnose, ki temeljijo na avtoriteti. Prav ta namreč mlade odvrača od sočloveka. Zato vzgojitelj ne pridiga ali daje ukaze, ampak jim govori iskreno iz srca v srce. V takšnem okolju lahko sproščeno in iskreno skupaj rešujejo izzive, ki jih prinaša življenje. [4]

4.1 Besedica na uho

Kot posebnost v preventivnem sistemu je potrebno omeniti tudi besedico na uho ali kot jih imenuje, zaupne besede. Don Bosko je to uporabljala kot vzgojno sredstvo za dosego poslušnosti in ubogljivosti, predvsem pa takrat, ko je želel podati nasvet. Bosko ni želel s strahom vplivati na svoje gojence.

Janez Bosko je na takšen način gojencem približal »očetovsko figuro«, ki je hkrati avtoriteta in tudi prijatelj, zaupnik, nekdo, h kateremu se obrneš po nasvet. Kadarkoli je imel občutek, da je nekoga potrebno pohvaliti ali mu podati grajo, ga je poklical na samo in mu grajo prišepnil na uho. Tako pa je tudi pohvalil. In pohvala z besedico na uho je imela veliko večji učinek, kot pa bi ga imela, če bi dejanje pohvalil na glas pred vsemi. [2]

5 DELO Z DIJAKI V ČASU IZOBRAŽEVANJA NA DALJAVO V DOMU JANEZA BOSKA

V začetku meseca marca leta 2020 je bil potrjen prvi primer okužene osebe s COVID-19 v Sloveniji. Ni minilo dolgo kar je bila razglašena epidemija in je bilo sprejetih vrsto ukrepov za zajezitev omenjenega virusa. Eden izmed ukrepov je bil tudi popolno zaprtje šolskega prostora ter pričetek izobraževanja na daljavo za vse učence in dijake.

Študij na daljavo je oblika indiferentnega izobraževanja, pri katerem sta učitelj in učenec ločena, sam proces izobraževanja organizira izobraževalna institucija, ki nudi možnost dvosmernega komuniciranja ter organizira občasna srečanja. Velik pomen pri študiju na daljavo imajo mediji, ki so lahko mehanski ali elektronski. [5]

Na spletni strani NIJZ lahko dostopamo do Priporočil in modelov za izvajanje izobraževanja na daljavo. V priporočilih za dijaški dom je navedeno, da je dijaški dom dolžen izvajati podporo dijakom na daljavo. Vzgojitelj naj bi dijake podpiral na daljavo preko dogovorjenih spletnih orodij, v primeru njihove neodzivnosti pa tudi preko drugih komunikacijskih kanalov. [6]

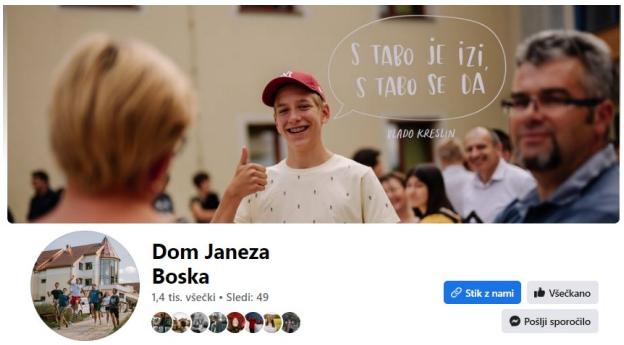
Ugotovimo lahko, da smo bili vzgojitelji v dijaških domovih dolžni ohranjati stik z dijaki tudi v času izobraževanja na daljavo, obenem pa je v Domu Janeza Boska asistenca vzgojitelja na prvem mestu že v osnovi.

5.1 Facebook stran Dom Janeza Boska

Vzgojitelji Doma Janeza Boska smo na samem začetku izobraževanja na daljavo naredili načrt kako bomo ohranili stik z mladostniki, ki so nam zaupani v vzgojo. Tako smo se odločili, da ustvarimo Facebook stran Dom Janeza Boska. Omenjena stran je bila namenjena celotni skupnosti dijaškega doma.

Facebook stran smo uporabljali za spodbujanje aktivnega preživljanja prostega časa dijakov v času izobraževanja na daljavo. Tako smo jim postavljali različne izzive, jih vabili k deljenju različnih fotografij, informacij … Nekaj bolj zanimivih dogodkov, ki so se zvrstili na strani so npr. izvedba klubskega večera, ko je eden od dijakov pripravil glasbeni večer in vrtel glasbo kot DJ, pica izziv – dijake smo povabili, da pripravijo tradicionalne pice ob don Boskovem prazniku in to tudi

posnamejo, izziv s hrenom – kdo lahko poje sveže nariban hren ob praznovanju Velike noči in kasneje nominira nove pogumne jedce, med bolj obiskanimi so bile tudi nedeljske sv. maše, ki so jih vodili salezijanci iz želimeljske kapele in vrsto drugih dogodkov. Spletna stran se je obdržala in ostala aktualne tudi naprej in služi objavljanju fotografij dogodkov, obveščanju o dogodkih.



Slika 1: Facebook stran Dom Janeza Boska

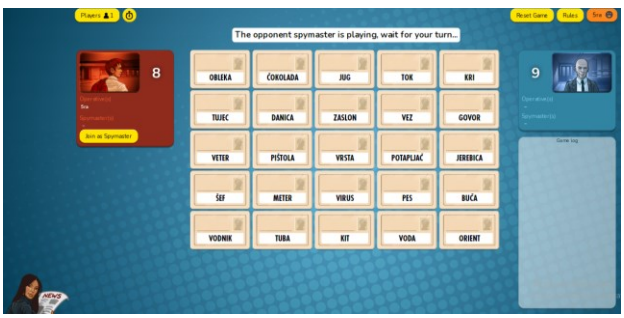
5.2 Vzgojno delo znotraj vzgojne skupine

Vzgojno delo vzgojitelja v vzgojni skupini poteka na skupinskem in individualnem nivoju. Skupinsko delo poteka s celotno vzgojno skupino ali znotraj manjših podskupin, medtem ko je individualni nivo usmerjen k individualnemu delu.

Z namenom skupinskega dela smo se vzgojitelji v Domu Janeza Boska dogovoril s svojo vzgojno skupino za tedenski termin srečevanja preko videokonference. Za ta namen smo uporabljali aplikacijo Zoom.

Redna tedenska srečanja so večinoma potekala po ustaljenem redu.

Sama sem video klic vedno pričela z obvestili za prihajajoči teden, sledil je kratek pregled preteklega tedna, čas za izmenjavo mnenj, informacij, praznovanja … Najbolj efektiven čas z vidika ohranjanja stika z vzgojno skupino in gradnjo vzgojnega odnosa pa je bil tedaj, ko smo pričele z družabnimi igrami preko spleta. To je bil moment, ko sem kot vzgojiteljica izkoristila prosti čas in krepila odnos z dijakinjami. Ta čas je bil pomemben, ker sem potem lažje dostopala do vsake posameznice in jo spremljala na individualnem nivoju. Tako smo npr. v tem času večkrat igrale spletno igro Skribbl, Codenames, občasno so dekleta pripravile različne kvize z uporabo aplikacije Kahoot…



Slika 2: Primer družabne igre Codenames

V začetku adventnega časa sem dijakinjam pripravila spletni adventni koledar. Ta je bil sestavljen iz različnih nalog in izzivov za vsak dan v decembru. Nekatere naloge so bile individualne, druge skupinske, spet tretje namenjene osebam, ki niso bile del naše vzgojne skupine.

Namen adventnega koledarja je bil v spodbudi k individualnemu delu, krepitvi odnosa v vzgojni skupini, med cimrami, spodbuda k dobrim delom za ljudi v naši okolici. Dijakinje so bile navdušene nad spletnih adventnim koledarjem, prav tako nad nalogami. Podale so predlog, da bi ga pripravila še kdaj ne le v adventnem času.

Da je bilo vse skupaj še bolj pristno smo istočasno žrebale osebo, kateri smo po pošti poslale simbolično darilo za praznike.

Slika 3: Primer spletnega adventnega koledarja

Dijakom smo v času izobraževanja na daljavo ponudili ne le zabavne vsebine, a tudi poučne. Tako smo izvedli tudi kar nekaj debatnih večerov. Pobuda za njih je prišla iz strain dijakov. Prav to je tudi razlog, da so bili tako dobro obiskani, ter da smo vedno odprli aktualne teme in imeli kvalitetne pogovore, ki so se zavlekli precej v pozne ure.

Slika 4: Online debatni večer

Vzgojitelji smo pripravili večji del tem za debatne večere. Debatirali smo o evtanaziji, hitri modi, temperamentu, kako vrstni red rojstev v družini vpliva na posameznika, kako krotiti stres … Da so bili debatni večeri dobro sprejeti dokazuje tudi dejstvo, da smo z njimi nadaljevali tudi po tem, ko smo po dolgem času zopet začeli sobivati v dijaškem domu.

Ob Prešernovem kulturnem prazniku smo dijakom pripravili "Prešernovo sobo pobega". Le to sem oblikovala s pomočjo Google Obrazci.
Sama soba pobega je bila zastavljena tako, da so dijaki odgovarjali na v naprej zastavljena vprašanja. V primeru, da so odgovorili pravilno se jim je odprlo novo vprašanje, v nasprotnem primeru se jim je izpisala spodbuda ali namig.
Da je bilo reševanje bolj zanimivo smo dijake razvrstili v nekaj sob na aplikaciji Zoom in so znotraj manjših skupin skupaj reševali online sobo pobega. Ko so sobo zaključili so se vrnili v prvotno sobo Zoom-a.

Slika 5: Primer vprašanja v Prešernovi sobi pobega

Dijakom je bila omenjena soba všeč. Večina skupin se je zelo hitro rešila iz sobe pobega, le eni skupini je eno od vprašanj povzročalo večje preglavice in so zaprosili za pomoč.

V Domu Janeza Boska dijake spremljamo preko različnih metod. Ena izmed njih je tudi osebni načrt, ki ga skupaj z dijakom sestavimo na začetku šolskega leta, ob koncu leta pa ga tudi evalviramo. Pomembno je, da je osebni načrt izraz dijakovih želja in ciljev.
Glede na to, da smo šolsko leto 2019/2020 zaključili na daljavo sem se odločila, da z vsako dijakinjo opravim individualni video razgovor, kjer bova evalvirali osebni načrt. Da je bilo dekletom lažje reflektirati in nato razpravljati o samih dosežkih in možnostih za izboljšave v prihodnjem šolskem letu sem jim predhodno pripravila vprašalnik z usmeritvami za pogovor o osebnostnemm napredku, šolski uspešnosti. Ta vprašalnik sem pripravila s pomočjo spletne stran Padlet, ki omogoča komentiranje večim ljudem.

Dijakinje so izpostavile, da jim je bil takšen način reflektiranja blizu, saj je kasnejši pogovor lažje stekel, ker sva imeli obe pred seboj že zapisano refleksijo. Dobra stran Padlet-a je tudi ta, da lahko kadarkoli vneseš dodatne komentarje.

6 ZAKLJUČEK

Na začetku izobraževanja na daljavo smo vzgojitelji hitro poprijeli za idejo, da z mladimi ostanemo v stiku preko spletnih medijev. Zagon je bil zares velik in iz tega se je razvilo nekaj zelo dobrih idej, ki jih z lahkoto prenesemo v dijaški dom tudi po tem, ko se je izobraževanje na daljavo že zaključilo.

Dijaki so na začetku zelo dobro sprejeli vsebine, ki smo jim jih ponudili. Lahko rečemo, da je bila vsaka vsebina dobro »všečkana«, dijaki do dajali odzive in pobude za spremembe, dopolnitve ponujenih vsebin. Tudi dijaki so bili na začetku samoiniciativni in so nam posredovali svoje ideje. Dejstvo pa je, da je s časom ta začetna navdušenost začela hlapeti. Vzgojitelji smo se tako osredotočili zlasti na individualno delo z dijaki, skupinske vsebine niso bile več tako pogoste.

A namen, da ostanemo v stiku z mladimi, ki so nam zaupani v vzgojo je bil zagotovo izpolnjen. Kako vemo? Tako, da smo z večino dijakov imeli stike vsaj 1x tedensko. Dodaten pokazatelj, da je to uspelo pa je bilo tudi zaključno srečanje vzgojne skupine v centru Ljubljane, kamor so prišle prav vse dijakinje, ki so bile tisto šolsko leto v moji vzgojni skupini.

Vsebine, ki smo jih ustvarjali vzgojitelji v Domu Janeza Boska so se dotaknile tudi staršev. Le ti so samoiniciativno ob koncu šolskega leta pošiljali zahvale za asistenco. Marsikateri starši pa so tudi sami sodelovali pri posameznih vsebinah, ki so bile javno dostopne.

Ob koncu šolskega leta 2020/21 smo vzgojitelji naredili refleksijo vseh dogodkov, vsebin, ki smo jih izvajali tako na ravni dijaškega doma kot na ravni posameznih vzgojnih skupin. Hitro smo lahko videli kje nam je šlo dobro, kje pa ostajajo možnosti za izboljšavo. In dejstvo je, da smo se do prihodnjega šolskega leta lahko že pripravili na ponovno izobraževanja na daljavo. V času izobraževanju na daljavo smo bili vzgojitelji primorani biti kreativni, učeči, saj smo bili zelo na hitro vrženi v novo situacijo, kateri se je bilo potrebno hitro prilagoditi, če smo želeli doseči osnovni namen, biti z mladimi tudi v času izobraževanja na daljavo. Lahko bi rekla, da nas je tu rešila lastna samoiniciativnost, dobro povezan kolektiv, kajti krovne organizacije so pri tem zatajile, saj nam niso ponudile nobenega »supporta«, da bi bilo delo v danih razmerah lažje in še bolj učinkovito tudi za nas pedagoške delavce.

LITERATURA IN VIRI

[1] Carlo Nanni. 2011. Don Boskov preventivni sistem. Ljubljana, Salve.
[2] Tone Ciglar. 2004. Rad vas imam. Ljubljana, Salve.
[3] Braido. 2011. Pedagoška izkušnja Janeza Boska. Ljubljana, Salve.
[4] Tone Ciglar. 2009. Vzgajamo z don Boskovim srcem. Ljubljana, Salve.
[5] Manja Svajger. 2021. Vzgoja in izobraževanje v času epidemije covid-19 v Sloveniji – Sistematični pregled raziskav. Maribor.
[6] Šolsko leto 2021/22 v Republiki Sloveniji v razmerah, povezanih s covidom-19. Modeli in priporočila. Dostopno na naslovu:
[7] https://www.nijz.si/sites/www.nijz.si/files/uploaded/modeli_in_priporocila_2021_22.pdf (9. 8. 2022)

Uporaba spletne ankete pri izbirnem predmetu filmska

Use of the Online Survey in the Elective Subject of Film Education

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POVZETEK

V prispevku predstavljam eno od možnosti uporabe informacijsko-komunikacijske tehnologije pri pouku izbirnega predmeta filmska vzgoja. Otrok lahko predmet izbere zadnja tri leta osnovne šole. Izvaja se eno uro na teden, torej 35 ur v šolskem letu. Predmet je obiskovalo 15 učencev osmih razredov. Učenci so se za evalvacijo dela odločili za spletno anketo 1KA in jo tudi uspešno izvedli. Pri tem so medpredmetno sodelovali (z izbirnim predmetom multimedija). Izvajali so sodelovalno učenje, ki krepi občutek za odgovorno timsko delo in medsebojno komunikacijo. Delali so v skupinah, vodja pa je rezultate povzel. Pri učencih se je povečala motivacija za delo, obenem pa so se z uporabo digitalnega orodja kreativno lotili sodelovalnega in problemskega učenja in ob tem razvijali svoje digitalne kompetence, ki veljajo za skupino ključnih kompetenc 21. stoletja.

Filmska umetnost je ena najmlajših umetnosti. Združuje besedno, likovno, glasbeno, plesno in gledališko umetnost. Film se je razvijal in se razvija še danes tako na umetnostnem področju kot tudi na tehnološkem. Zato je smiselno, da tudi učenci povezujejo različne ravni in področja, ko teorijo in prakso filma spoznavajo.

Pri izvedbi spletne ankete so si pomagali s pametnimi telefoni, spletom in že prej omenjeno spletno aplikacijo. Delo se jim je zdelo zabavno in poučno, rezultati pa so bili vidni še isto šolsko uro.

Učenci in učenke so ugotovili, da je možnosti za različne spletne ankete še kar nekaj in da bi jih lahko večkrat uporabljali za predstavitev tudi drugih tem.

KLJUČNE BESEDE

Izbirni predmet filmska vzgoja, spletne ankete 1KA, medpredmetna povezava, sodelovalno učenje

ABSTRACT

In this article, we present one way of using information-communication technology for teaching the elective subject Film Education. Students may select this subject in the last three years of primary school. For the final evaluation, the students decided on an online survey using the 1KA application. This included interdisciplinary work with subject matter from the elective subject Multimedia. Students worked in groups in order to improve their skills at teamwork and communication. Group leaders reported the groups' results.

Film is one of the youngest art forms. It includes the characteristics of writing, visual arts, music, dancing and theatre. Its history has always been a combination of artistic and technological developments. Therefore, it is appropriate for students to combine different views and approaches whilst studying the theory and practice of film.

To implement the online survey, students used smartphones and the Worldwide Web along with the aforementioned 1KA application. They had fun while doing this and got results during the same school session.

The students concluded that there are many more possibilities for using online surveys and that they could use them for presenting evaluations of other subjects, too.

KEYWORDS

Elective subject Film Education, 1KA online surveys, interdisciplinary schoolwork, cooperative learning

1 OPERATIVNI CILJI IN VSEBINE

Izbirni predmet Filmska vzgoja obstaja šele od leta 2018 in ga uvrščamo med družboslovne izbirne predmete. Učenec zadnje triade osnovne šole ga lahko izbere v sedmem, osmem ali devetem razredu. Otrok lahko predmet izbere vsako leto eno za drugim ali samo poljubno leto [1]. Zasnovan je modularno in predvideva tri module po 35 ur: Kaj je film, Filmski žanri in Umetnost in družba. Moduli so lahko samostojni, lahko pa se tudi dopolnjujejo in nadgrajujejo. Filmsko vzgojo poučujem dve leti in jo bom tudi naslednje šolsko leto. V skupini, ki sem jo poučevala, je bilo 15 otrok osmošolcev. Pouk je potekal eno šolsko uro na teden. Ob koncu šolskega leta so učenci s spletno anketo ugotavljali, kdo je njihov najljubši igralec/igralka, tuji in domači film ter filmski žanr.

2 OPREDELITEV PREDMETA

Film je eno najbolj razširjenih področij umetnosti med mladimi. V ospredju filmske vzgoje je obravnavanje filma kot umetnosti, množičnega medija in tehničnega proizvoda. Predmet izpostavlja doživetje filma, spoznavanje osnov filmske umetnosti in filmsko

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ustvarjalnost. Film omogoča razmislek o življenjskih temah, posameznikovih in družbenih vrednotah ter spodbuja mlade, da si ustvarijo svoj pogled na svet. Filmska vzgoja zato vpliva na učenčev družbeni, etični in čustveni razvoj, pripomore k raziskovanju univerzalnih tem ter spodbuja k razlikovanju in sprejemanju različnih pogledov na svet ter na družbene in kulturne korenine našega naroda.

Film predstavlja v današnjem času, ki je vse bolj podvržen avdiovizualnemu dojemanju sveta, eno najbolj pomembnih in hkrati priročnih sredstev za soočanje mladih s temeljnimi dejavniki sodobne družbe in kulture. Predmet filmska vzgoja zajema širok spekter elementov, ki opredeljujejo film – obravnava ga kot umetniško delo, kot sestavino avdiovizualne kulture, kot sredstvo obveščanja in kot element novih tehnologij. Namenjen je spoznavanju osnov filmske umetnosti, filmskemu doživetju in filmski ustvarjalnosti. Poudarek predmeta je na vzgoji gledalca, ki film doživlja in ga razume kritično ter ustvarjalno.

Film pomembno vpliva na doživljanje in razumevanje sveta v vsej mnogoplastnosti, ki se stopnjuje z vedno večjo vlogo filmskih in avdiovizualnih vsebin v sodobnem življenju, množičnih medijih in novih socialnih omrežjih.

3 SPLOŠNI CILJI PREDMETA

Navedla bom glavne cilje, ki jih učenci pri predmetu osvojijo. Učenci in učenke spoznavajo, kaj sta film in avdiovizualna dejavnost, razumejo film kot ustvarjalni proces, umetniško predstavljanje (filmska projekcija), vzpostavljajo neposredni stik s filmom, filmskimi ustvarjalci in izvajalci na področju kulture in filma, krepijo doživetje filma in oblikujejo ter artikulirajo svoja merila za vrednotenje filma, spoznavajo filmske žanre in najpomembnejša razvojna obdobja v filmski zgodovini. Razvijajo tudi veščine interpretacije filma in se učijo vizualno izražati svoja spoznanja.

3.1 Operativni učni cilji

Razdeljeni so na tri širša poglavja, in sicer Kaj je film, Filmski žanri in Film in družba.

Za oglede filmov, razpravo, doživetje in interpretacijo je predvidenih 15 ur.

V poglavju Filmski žanri raziskujemo temeljne vrste (igrani, dokumentarni, animirani in eksperimentalni) in osnovne oblike (kratkometražni, srednjemetražni, dolgometražni) filma, proces nastajanja filma, filmske poklice, učenci se seznanijo z osnovni izrazni elementi filma (igra, scenografija, kostumografija, maska, osvetljava, glasba). Spoznajo tudi zgodovinski razvoj filma, filmsko ustvarjalnost, predstavnike filmske umetnosti (slovenske in tuje).

Pri poglavju Film in družba smo se pogovarjali o načinih sprejemanja filma: doživljanju, razumevanju, njegovem interpretiranju in vrednotenju. Učenci so razmišljali o filmu tudi tako, da so napisali oceno filma in jo predstavili sošolcem.

4 STANDARDI ZNANJA

S standardi znanja je opredeljena stopnja doseganja učnih ciljev. Določajo obseg in zahtevnost znanja.

Ključni standardi znanja so, da učenec/učenka zna razložiti, kaj sta film in avdiovizualna dejavnost, pozna različne filmske vrste in jih predstavi na primeru, prepozna različne filmske žanre in njihove temeljne značilnosti ter jih razloži na primeru. Otrok ve, kateri so osnovni filmski izrazni elementi in razume njihovo vlogo; pozna in razloži osnovne filmske ustvarjalne postopke in razvije pozitiven odnos do filmske kulture kot pomembnega dejavnika splošne razgledanosti.

5 OGLEDI FILMOV

Osrednja dejavnost vsakega modula je ogled filma z razpravo. Priporoča se ogled petih celovečernih filmov z razpravo v vsakem modulu. Za vsak ogled filma smo namenili tri šolske ure, razprava je sledila takoj po ogledu filma.

6 MEDPREDMETNE POVEZAVE

Pomen filmske vzgoje pride še posebej do izraza v različnih oblikah medpredmetnega povezovanja.

Filmsko vzgojo lahko povezujemo z različnimi predmeti. Pri slovenščini kot primerjava z literarnimi deli in dramskimi uprizoritvami. Pri zgodovini in naravoslovju je film kot učni pripomoček; učenci se učijo skozi film s posebnim poudarkom na dokumentarnih filmih. Pri pouku glasbene umetnosti lahko spoznavajo vloge filmske glasbe, glasbenega filma.

Pri pouku računalništva (multimedija) so možnosti različne: poznavanje računalniških programov, predvsem montažnih; pri filmskem ustvarjanju pa si lahko pomagajo tudi z viri s svetovnega spleta. V našem primeru so si učenci pomagali pri izdelavi spletne ankete. Sistem za spletno anketiranje je hiter, učinkovit, zanesljiv in praktičen sistem za evalviranje dela na šoli.

7 IZDELAVA SPLETNE ANKETE IN REZULTATI

Proti koncu šolskega leta smo se z učenci dogovorili za pripravo ankete o filmski žanrih, igralcih in filmih, ki so jih najbolj prepričali in so jim najbolj všeč. Razdelili so se v različno velike skupine. Ker so bili nekateri vpisani tudi na izbirni predmet Multimedija, so poznali spletne anket 1KA, En klik anketa [2].

Študenti, učenci, raziskovalci, učitelji in drugi z Arnes AAI računom lahko na ločeni namestitvi 1KA.Arnes.si uporabljajo 1KA brezplačno in brez omejitev pod običajnimi pogoji.

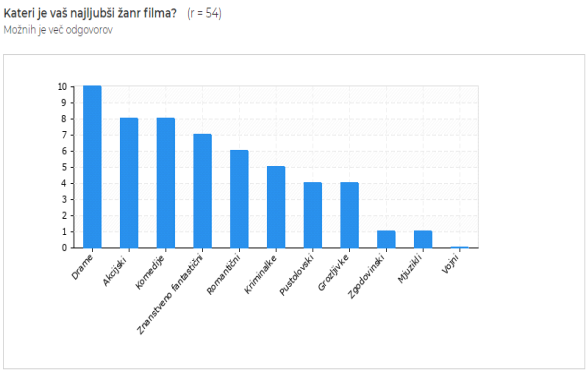
Aplikacija 1KA je lahko nameščena na poljubnem strežniku. Matična namestitev je na domeni1KA arnes.si na strežniku Centra za družboslovno informatiko, Fakultete za družbene vede, Univerze v Ljubljani.

Kot je zapisano v splošnih pogojih uporabe 1KA, lahko uporabnik e-maila vabila k sodelovanju pošilja le naslovnikom, ki so na veljaven način pristali na to.

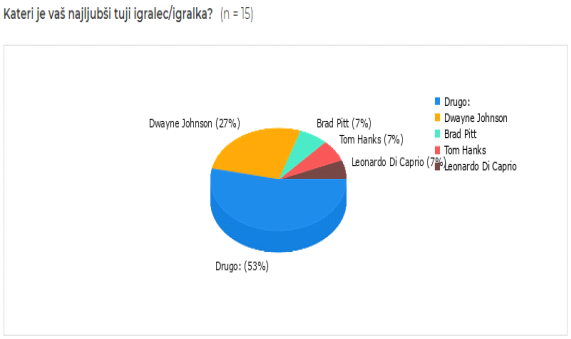
Vmesnik 1KA za odgovarjanje na anketo je prilagojen tudi mobilnim napravam (slika 1). Ko je učenec s klikom na URL naslov odprl anketo, se je vsebina avtomatsko prilagodila njegovi napravi. Za uporabnike androidnih telefonov pa je na voljo tudi mobilna aplikacija 1KA, ki omogoča izdelavo enostavnih anket in pregled odgovorov anket, izdelanih preko spletne aplikacije. Aplikacijo so si učenci naložili prek aplikacije Google Store.

Slika 1: Učenci so reševali anketo

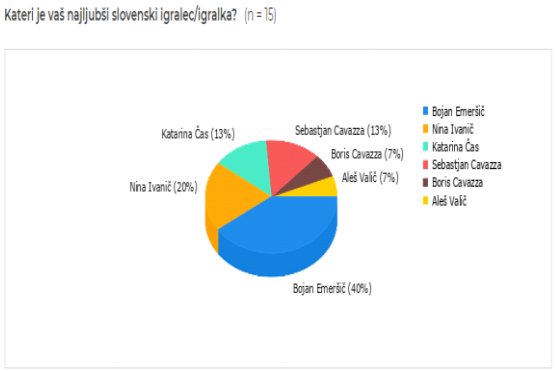
Učenci in učenke izbirnega predmeta so na tak način ustvarili tri ankete. Za predstavitev v tem članku sem izbrala eno. Najprej je vodja skupine vsem poslal URL naslov, ki je bil časovno omejen. Učenci so si na mobilne telefone naložili aplikacijo in prek telefona reševali anketo. Rezultati so se zbirali pri enem učencu v obliki tortnega prikaza ali stolpca (Slike 2−6).



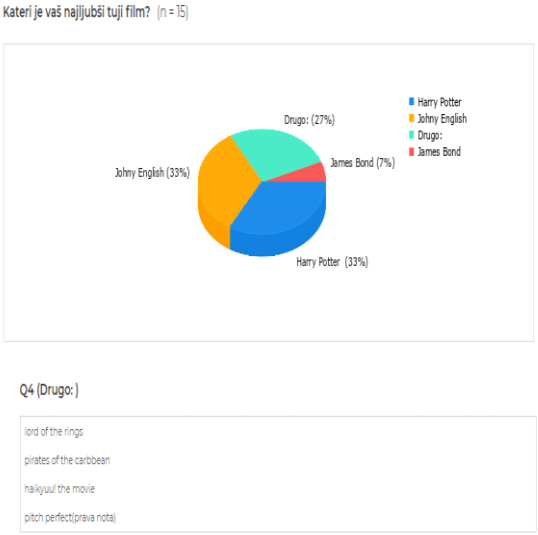
Slika 2: Prikaz odgovorov na vprašanje o priljubljenem filmskem žanru



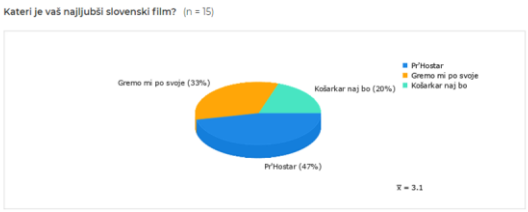
Slika 3: Prikaz odgovorov na vprašanje o najljubšem tujem igralcu



Slika 4: Prikaz odgovorov na vprašanje o najljubšem slovenskem igralcu ali igralki



Slika 5: Prikaz odgovorov na vprašanje o najljubšem tujem filmu



Slika 6: Prikaz odgovorov na vprašanje o najljubšem slovenskem filmu

Analiza odgovorov je pokazala, da učenci, ki so bili vpisani na izbirni predmet filmska vzgoja, najrajši spremljajo filmske drame, manj pa druge filmske žanre, kot so akcijski filmi in komedije. Na zadnjem mestu so vojni filmi. Pri tem vprašanju je bilo možnih več odgovorov, pri drugih pa ne. Večina učencev bi izbrala katerega drugega tujega igralca ali igralko in ne tistega, ki je bil v anketi na voljo. Bojan Emeršič je po mnenju otrok njihov najljubši slovenski igralec (40 odstotkov), sledijo mu Nina Ivanič, Katarina Čas, Sebastian Cavazza, na repu sta Boris

Cavazza in Aleš Valič. Najljubši tuji film je Harry Potter, domači pa Pr' Hostar, ki mu sledita Gremo mi po svoje in Košarkar naj bo. Pri najljubšem tujem filmu gre najbrž za vpliv knjige v več delih, ki jo učenci radi berejo, Pr' Hostar pa je slovenska komedija, ki je dosegla veliko gledanost.

8 ZAKLJUČEK

Učenci izbirnega predmeta filmska vzgoja so predvideno snov iz učnega načrta za ta predmet nadgradili še z izdelavo ankete 1KA. To je spletna anketa, ki je učencem prosto dostopna. Med sabo so se povezali prek mobilne aplikacije 1KA in anketo rešili. Pri tem so medpredmetno sodelovali, saj so nadgradili znanje izbirnega predmeta multimedija. Medpredmetno povezovanje je celosten didaktični pristop – pomeni horizontalno in vertikalno povezovanje znanj, vsebin in učnih spretnosti. V skladu s humanističnimi pogledi spodbuja samostojno in aktivno pridobivanje učnih izkušenj. Poteka v celoviti dejavnosti učenca, vključujoč njegove spoznavne, čustvene in telesne funkcije. Medpredmetne povezave določajo skupni nameni [3].

Ker so delali po skupinah, so izvajali tudi sodelovalno učenje. Skupaj so se dogovarjali glede vsebin vprašanj. Vsak učenec torej opravi svojo nalogo ter nato pomaga drugim članom skupine, da jo tudi oni uspešno opravijo. Pri tem je ključnega pomena ustrezno sodelovanje med učenci. Pomembno je, da vsak učenec doseže najboljši učinek pri učenju ter hkrati pomaga drugim članom pri tem, da razumejo učno snov in da uspešno sodelujejo [4].

Izkazalo se je, da je uporaba informacijsko-komunikacijske tehnologije popestrila pouk, hkrati so učenci na hiter način prišli do zanimivih rezultatov. Pri tem so uporabljali mobilne telefone in računalnik, spletne aplikacije in lastno znanje. Zdelo se jim je zabavno, poučno in koristno, saj so razvijali svoje digitalne kompetence − tako informacijsko pismenost kot zmožnost sodelovanja in komuniciranja v spletnem okolju. Učenci so imeli večjo motivacijo za nadaljnje delo. Spletne aplikacije in kvizi so se v pedagoškem procesu izkazali tudi pri osvajanju novih tem in utrjevanju snovi.

V prihodnjem šolskem letu bi bila spletna anketa lahko uporabljena že v uvodnih urah omenjenega izbirnega predmeta in bi z vprašanji preverjala predznanje učencev, njihova pričakovanja in interese. Na ta način bi bili učenci aktivneje vključeni v načrtovanje konkretnih vsebin, ki bodo obravnavane pri filmski vzgoji.

LITERATURA IN VIRI

[1] Učni načrt izbirnega predmeta Filmska vzgoja. https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/izbirni/3-letni-lahko-krajsi/Filmska_vzgoja_izbirni.pdf (1. 8. 2022)

[2] 1KA (Verzija 17.05.02) [programska oprema]. (2017). Ljubljana: Fakulteta za družbene vede. Dostopno prek https://www.1ka.si.

[3] SICHERL-KAFOL, Barbara, 2008, Medpredmetno povezovanje v osnovni šoli. Didakta [na spletu]. 2008. Vol. 18/19, p. 7–9. (1. 8. 2022) Pridobljeno na: http://www.didakta.si/doc/revija_didakta_2008_november.pdf.

[4] Polak, Alenka, 2020, Sodelovalno učenje, Predstavitev za starše, Pedagoška fakulteta UL. 2020.

Učenje svetlobe na daljavo

Online Teaching About Light

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POVZETEK

Pandemija je šokirala ves svet in spremenila marsikateri segment našega življenja, tudi izobraževanje ni izvzeto. Klasične metode oz. bolje rečeno sistemi poučevanja so se morali čez dan prilagoditi in spremeniti na način, da so bila človeška življenja zaščitena in da je bil hkrati izpad znanja čim manjši. V prispevku so predstavljeni pozitivni in negativni učinki poučevanja na daljavo ter navedenih je nekaj konkretnih primerov učenja svetlobe na daljavo v okviru predmeta fizika. Na slikah so prikazani eksperimenti in povezave različne IKT opreme (računalnik, kamera, iPad, spletna kamera, magnetna tabla), brez katere bi bilo raziskovanje svetlobe pri učenju fizike zelo okrnjeno, dolgočasno.

KLJUČNE BESEDE

IKT oprema, simulacija, eksperiment, poučevanje svetlobe

ABSTRACT

The COVID-19 pandemic shocked the whole world and changed many segments of our lives, here also education is no exception. Classical methods or better said, teaching systems had to adapt and changed over the night in a such a way that human lives were protected and that at the same time the loss of knowledge was as small as possible. The paper represents the positive and negative effects of distance learning and gives some concrete examples of online learning of title of light within Physics. The given pictures illustrate experiments and useful connections of various ICT equipment (such as computer, camera, iPad, web camera, magnetic board), without which the learning Physics would have been very limited and boring.

KEYWORDS

ICT equipment, simulation, experiment, teaching light

1 UVOD

Spletno izobraževanje je oblika izobraževanja, ki se izvaja prek interneta. Učenci pri tem uporabljajo svoje domače računalnike ali pametne naprave in prek njih obiskujejo spletna predavanja ter urejajo vse potrebne zadolžitve. Med pandemijo Covid-19 sta se digitalno poučevanje in učenje pokazala kot nujen vir izobraževanja za učence in šole po vsem svetu. Digitalna preobrazba družbe je seveda terjala svoj dolg tudi pri tovrstnem poučevanju fizike.

Učenje fizike naj bi bilo življenjsko. Prepletanje teorije same s seboj vodi v večinoma dolgočasne ure, ki razen teoretičnega znanja ne prebudijo zanimanja za praktičen (eksperimentalni) del fizike, ki pogosto na enostaven način poveže razred z življenjskimi primeri. Pomembno je, da učenci prepoznajo fiziko tudi popoldne, ko se je ne učijo za oceno, ampak raziskujejo sto in eno dejavnost, ki je vsaj deloma povezana z naravoslovjem. Učitelji, ki kvalitetno predavajo fiziko na vseh stopnjah izobraževanja, uporabljajo poleg IKT tehnologije tudi eksperimentalni pouk. V zadnjih mesecih oz. bolje rečeno, zdaj že letih, se je poučevanje deloma spremenilo, ker so se morali predavatelji prilagoditi na poučevanje na daljavo ali na kombinirano poučevanje (v živo in na daljavo) [1]. V prispevku bo v nadaljevanju predstavljenih nekaj različnih preprostih poskusov, animacij in načinov, kako poučevanje svetlobe, med delom na daljavo, približati mladim fizikom [2].

2 JEDRO

Poučevanje in tudi učenje sta kompleksna in povezana procesa. Veliko dejavnikov se mora zvrstiti, da je prenos in zapomnitev informacije na relaciji učitelj-učenec, uspešna. Učenje na daljavo žal ni nova tema za vse udeležence, tako učence in učitelje kot tudi starše. Številni starši so se v zadnjih letih pogosto srečali v vlogi učitelja, kar ni nujno slabo, saj mnogi zdaj bolj cenijo učiteljski poklic, ki z leti izgublja ugled v družbi in je pogosto zapostavljen. Po internih pogovorih in anketah si velika večina udeležencev; tj. otrok in staršev, želi, da bi izobraževanje v prihodnje potekalo po »starih« ustaljenih smernicah; brez uporabe zaščitnih mask, samotestiranj, karanten ...

Na začetku prispevka se bomo tako dotaknili nekaterih pomembnih prednosti in slabosti v splošnem, ki jih prinese učenje na daljavo; v drugem delu pa bomo na praktičnem primeru obravnave Svetlobe, primerjali klasični in digitalni pouk fizike, ki se zahteva v osmem razredu osnovne šole.

Začnimo s prednostmi spletnega izobraževanja. Fleksibilnost je zagotovo tako staršem kot učencem pomenila nekakšno komoditeto. Učenci so na naši šoli do 8. ure zjutraj dobili vsa navodila, kaj učitelji pričakujejo, da bodo v tem dnevu storili, in kdaj jih čakajo obvezne videokonference. Na podlagi teh podatkov so si lažje organizirali dan in si individualno prilagodili šolske in zunajšolske obveznosti. Predvsem vozači so

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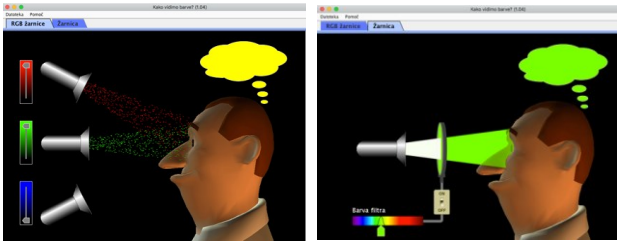
privarčevali predvsem pri času, ki so ga prej porabili, da so od doma prišli v šolo in nazaj. Starši so tako privarčevali nekaj evrov pri prevozu. Glavna prednost je, da so bili doma »varni«, saj se niso družili s sošolci in 500 ali več- učenci na šoli. S tem se je delež potencialnih okužb zagotovo zmanjšal.

Kmalu pa se je na strani učencev (in tudi nekaterih učiteljev) pokazala prva šibkost v precej raznoliki IKT opremi in kompetenci uporabe le-te. Več deležnikov se je možno trudilo, da so zagotovili vsaj osnovno opremo, tako internetno povezljivost kot strojno opremo, ki je bila nujno potrebna za aktivno spremljanje in udeležbo v učno-vzgojnem procesu. Druga slabost je ta, da je do epidemije mnogo staršev mladostnike podila stran od ekranov, potem pa se je zgodba čez noč obrnila in so bili primorani veliko ur na dan preživeti na ta način. Neprijetne posledice bo družba občutila še dolgo. Interakcija s sočlovekom je bila zelo motena. Šola, ki ima kot taka, več nalog, ne le, da mlade nauči novih znanj, ampak jih hkrati tudi vzgaja. Interakcija na ravni učenec-učenec in učitelj-učenec je pri tej obliki šolanja zelo motena. Devetošolci so najprej postali apatični in jih je bilo najtežje motivirati za sodelovalno učenje. Izklop kamer je bil z njihove strani pogost odziv. Tako je bila »človeška« interakcija še dodatno otežena. Mlajši učenci (konkretno šestošolci) so pokazali veliko več interesa in volje do videokonferenc in »online« druženja. Nadzor poteka učne ure in spremljanje napredka učencev je prav tako zelo otežen. Oddana domača naloga v spletno učilnico še ne pomeni, da je avtor avtentičen. Starši so pogosto naredili levji delež obveznosti, da bi otroku pomagali, niso se pa zavedali, da s tem ne koristijo svojemu otroku. Vredno je omeniti še samodisciplino in motnje. Peščica otrok je bila sposobna, da so sami sestavili svoj urnik dela in se ga disciplinirano držali, oddajali potrebno in brez večjih zapletov zaključili ocene. Motenj doma je bilo precej. V družini je lahko več otrok, prostorov za videoklice pa premalo, tudi starši so morali delati od doma ali pa so preprosto gledali nogomet, tudi hišni ljubljenčki so nas znali nasmejati.

Učitelji so s strani ministrstva dobili številne napotke, kako ocenjevati »druge oblike dela« in ne uporabljati klasičnega ustnega in pisnega ocenjevanja znanja. Na ta račun so povprečne ocene letele v nebo. Povprečje za vpis v nekatere gimnazije ali pogoji za pridobitev Zoisove štipendije so še vedno neživljenjski, lahko rečemo tudi smešni.

Mnogim učiteljem fizike, ki so kljub izrednim razmeram na šolah vztrajali pri eksperimentalnem in IKT pouku, se je priprava na ure pošteno podaljšala. V učilnici za fiziko so naloženi številni programi, ki omogočajo izvedbo in analizo poskusov. Na vseh ostalih računalnikih te opreme seveda ni. Ker se je bilo treba vsako uro seliti v drugo učilnico, teh pa ni bilo malo, je bil delovni dan daljši, da si je moral učitelj pripravil vse potrebno za, že vpeljano in v prejšnjih letih preverjeno, učno uro. Da ne omenjamo kopice pripomočkov, ki jih je bilo treba iz ure v uro prenašati, dobesedno, po celi šoli. Glede na to, da neugodne razmere trajajo že več let, je potrebno kar nekaj notranje motivacije, da zgornjega opisa dela učitelj ne zamenja za kredo in tablo.

Sledi opis poučevanja svetlobe po klasičnem sistemu in primerjava z delom na daljavo. V uvodu pri obravnavi teme Svetloba se omeni primerjava mešanja barv pri fiziki in likovnem pouku. Učenci imajo več izkušenj z delom s čopičem in z barvami; simulacija »color vision« [3] na sliki 1 in 2 pa pokaže, da npr. pri mešenju rdeče, zelene in modre svetlobe dobimo belo barvo. Simulacija je prosto dostopna na spletni strani, zato jo lahko uporabimo tako pri rednem pouku kot pri delu na daljavo. Ne škodi, če učitelj povezavo doda v spletno učilnico, tako da lahko radovedni učenci dodatne funkcije »stestirajo« doma.



Slike 1 in 2: Simulacija »Color vision« [3] ali v prevodu »Kako vidimo barve«

Pri spektru elektromagnetnega valovanja se pri svetlobi omenita infrardeča in ultravijolična svetloba. Obe sta za naše oči nevidni. IR svetlobo je najbolj priročno opazovati z dotično kamero; UV svetlobo pa lahko demonstriramo z »nevidnim pisalom« in UV svetilko (slika 3). Poskus brez težav demonstriramo prek spletne kamere.

Slika 3: Nevidno UV pisalo

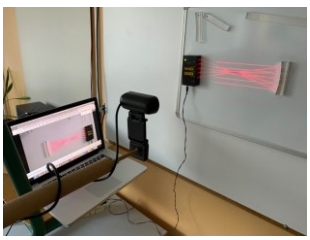
V učnem načrtu je nekaj ur namenjenih obravnavi leč in zrcal. Najboljši pristop učenja je kombinacija eksperimentiranja (slike 4, 5 in 6), razlage s pomočjo magnetne table in optične zbirke ter uporaba namenske aplikacije na iPadu. Seveda pa je utrjevanje s pomočjo delovnega zvezka in učbenika nujno, če želimo trajno znanje. Slika 4 prikazuje konkavno ali vbočeno zrcalo za ličenje ali britje, ki ga mladina pozna, saj je pogost pripomoček v kopalnicah. Sami povedo, da je slika povečana, prav obrnjena; ne moremo pa je ujeti na zaslon, zato je navidezna. Že med konferenco lahko za nekaj sekund zapustijo računalnike in sami eksperimentalno ugotavljajo, kdo od njih je videl najbolj povečano sliko svojega obraza, razmislijo, od česa je to odvisno, kdaj vidijo ostro sliko ipd.

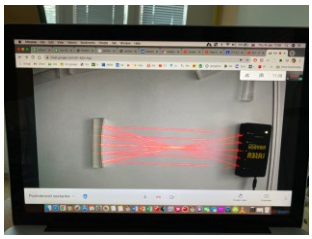
Sliki 4: Konkavno zrcalo za ličenje

Če obrnemo ukrivljenost zrcala, dobimo konveksno ali izbočeno zrcalo. Pri njem se zorni kot poveča, na ta račun pa se slika zmanjša. Ne mestu je vprašanje, kje v življenju učenci srečajo takšno zrcalo, kje bi lahko bilo uporabno ali še drugače, kje dnevno rešuje številna življenja. Na sliki 6 je prikazan Van de Graaffov generator, ki ga lahko učitelj nosi po razredu. Učenci pri tem opazujejo, če se kdaj vidijo enako velike kot v ravnem zrcalu, če lahko sliko ujamejo na zaslon, se kdaj vidijo megleno ali vidijo narobe obrnjeno sliko. Pri delu na daljavo si lahko učitelji pomagamo s kamero ali pa učence spomnimo na zrcalo ob cesti (slika 5). Je pa »v živo« izkustveno učenje, v tem primeru, bistveno bolj produktivno.

Sliki 5 in 6: Konveksno zrcalo ob cesti in Van de Graaffov generator

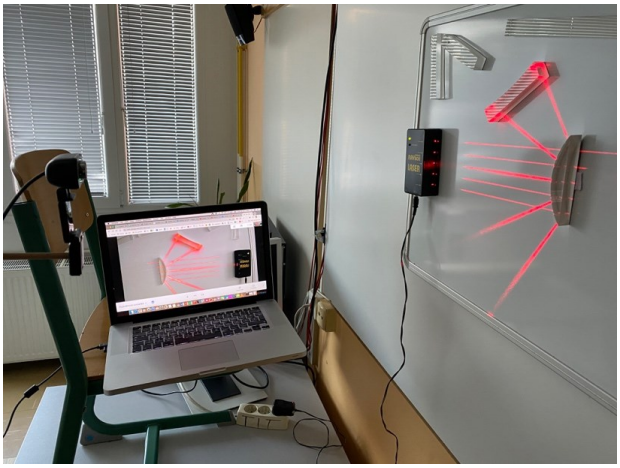
Osnovno poznavanje preprostih pojmov, kot so npr. goriščna razdalja, teme, gorišče in navidezno gorišče so nujno potrebni. S pomočjo vzporednega snopa laserskih žarkov na magnetni tabli je razlaga preprosta. Pri šolanju na daljavo pa je v tem primeru nazornost poskusa še večja. Trditev prikazujeta sliki 7 in 8.





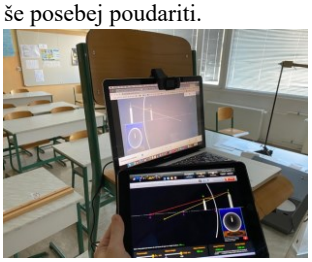
Sliki 7 in 8: Konkavno zrcalo na magnetni tabli v razredu in v videokonferenci

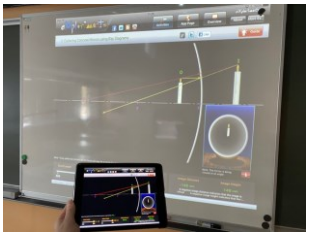
Osebni stik prek videokonference je zelo zaželen, kar v tem primeru pomeni, da učitelj med uro večkrat preklaplja med vsaj dvema kamerama (pogled na magnetno tablo; slika 9) in med kamero na računalniku, zato je pomembno, da je računalnik in posledično tudi mikrofon blizu mesta razlage.



Slika 9: Konveksno zrcalo na magnetni tabli v razredu in med videokonferenco na prenosnem računalniku

Dobrodošli so namenski programi (sliki 10 in 11) pri določeni temi, ki zelo nazorno in v kratkem času prikažejo bistvo ter nazorno povežejo eksperiment, razlago in vsakdanje življenje. To je pika na i, ki zaključi razlago snovi pri Svetlobi. Po potrebi lahko učitelj na tablo doriše (slika 11), kar meni, da je potrebno še posebej poudariti.





Sliki 10 in 11: Aplikacija »Ray Optics«; povezava iPada, računalnika, projektorja in spletne kamere

3 ZAKLJUČEK

Poučevanje na daljavo se je zgodilo »čez noč« in takrat so bili vsi učitelji primorani se znajti po svojih najboljših močeh. Mlajši generaciji je bilo verjetno malo lažje, saj so bolj vešči dela z računalnikom in IKT opremo, saj so se predhodno več usposabljali na tem področju [4]. Se je pa zgodba precej podaljšala in zdaj imajo vsi precej izkušenj s takšnim delom. Kot smo že omenili v tem prispevku, so plusi in minusi pri obeh načinih učenja. Smiselno je, da za vsako posamezno temo razmislimo, katere pristope »na daljavo« je smotrno uvesti kot nekakšen podaljšek oz. dodatek v klasični pouk. Npr. bolj pogosta uporaba spletne učilnice, oddaja pomembnih domačih nalog v spletno učilnico, konferenca za učitelje na daljavo idr. Sodobna tehnologija nam mora biti v pomoč. Osebno sem velik zagovornik le-te, moramo pa kritično presoditi, kolikšen del ur

namenimo takšnemu sistemu dela, da ure niso prenasičene in da se bistvo ne izgubi. Priporočljivo je vsakih nekaj ur »presekati« ustaljeni način dela in za eno šolsko uro spet uporabiti samo »kredo in tablo«.

LITERATURA IN VIRI

[1] J. Singh, K. Steele, L. Singh: Combining the Best of Online and Face-to-Face Learning: Hybrid and Blended Learning Approach for COVID-19 (splet). 2021. Dostopno na naslovu https://journals.sagepub.com/doi/full/10.1177/00472395211047865

[2] K. Ndihokubwayoa, J. Uwamahoroa, I. Ndayambajeb: Effectiveness of PhET Simulations and YouTube Videos to Improve the Learning of Optics in Rwandan Secondary Schools (splet). 2021. Dostopno na naslovu

[3] https://journals.co.za/doi/epdf/10.1080/18117295.2020.1818042

[4] Phet interactive simulations (University of Colorado Boulder), Color vision (splet). 2022. Dostopno na naslovu

[5] https://phet.colorado.edu/en/simulations/color-vision (10.8.2022)

[6] H. Beyazoglu: Psihologija pandemije; Posamezniki in družba v času koronske krize (splet). 2020. Dostopno na naslovu

[7] https://dlib.si/stream/URN:NBN:SI:DOC-V1B59SOJ/33d1c335-e08e-4ac9-b1ed-e6b54c5e0d44/PDF

Učna akademija – skupnost učiteljev, ki temelji na kolegialnem sodelovanju in skupnem učenju

Learning Academy – A Community of Teachers Based on Collegial Cooperation and Joint Learning

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POVZETEK

Epidemija covida-19 je močno zarezala v življenje ljudi. Vpliv ni bil le fizične in psihološke narave, soočiti se je bilo potrebno tudi s (pre)hitrimi prilagoditvami na nov način dela. Učitelji so v pogojih zaprtja šol, večina prvič v karieri, morali izvajati izobraževanje na daljavo. Prehod na nove oblike dela je porajal različne odzive – pozitivne in negativne. Nekateri so se pokazali takoj, drugi z zamikom. Odvisno od starosti, zmožnosti dojemanja in spoprijemanja s situacijo, preteklih izkušenj, pa tudi podpore. Članek opisuje novonastalo podporno okolje za učitelje v Šolskem centru Kranj. Učna akademija je skupnost učiteljev, ki je na način on-line delavnic, kjer so posamezniki primere dobre prakse kolegialno delili med sodelavce, povezala kolektiv in s skupnim učenjem ter deljenjem izkušenj rešila marsikatero učiteljevo dilemo in strah.

KLJUČNE BESEDE

Pripadnost, skupnost, pomoč, delavnice, podpora, MC Teams, izkušnje

ABSTRACT

The covid-19 epidemic has greatly affected people's lives. The impact is not only of a physical and psychological nature, it was also necessary to deal with (too) quick adaptations to a new way of working. In the conditions of the closed school, the teachers, most of them for the first time in their careers, had to carry out distance education. The transition to new forms of work generated various reactions - positive and negative. Some manifested themselves immediately, others with a delay - depending on age, ability to perceive and cope with the situation, past experiences, as well as support. The article describes the newly created support environment for teachers in the School Center Kranj. The learning academy is a community of teachers who, through online workshops where individuals shared examples of good practice collegially among their colleagues, connected the collective and solved many dilemmas and fears through joint learning and sharing experiences.

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KEYWORDS

Affiliation, community, help, workshops, support, MC Teams, experience

1 UVOD

Spremembe so stalnica. Vse bolj pa se navajamo na to, da se dogajajo hitreje in so kompleksnejše. Poleg spreminjanja ciljev izobraževanja, generacij učencev in pojmovanja znanja se spreminjajo tudi oblike dela. Posledično se spreminja vloga učitelja. Epidemija Covida-19 je še bolj zamajala že tako hitro spreminjajoče se temelje našega šolstva in povzročila kaotično stanje. Države so v času pandemije sprejemale raznovrstne ukrepe. Le-ti so se odvijali tudi v našem šolskem sistemu in jih je spodbujal tudi Zavod RS za šolstvo v sodelovanju z Ministrstvom za izobraževanje, znanost in šport. Med ključnimi dejavnostmi, ki jih navajajo avtorji v Analizi izobraževanja na daljavo v času prvega vala epidemije covida-19 v Sloveniji [1], poleg spodbujanja k spremljanju ter nadzoru učencev, formativnemu spremljanju in podpori ranljivim skupinam, navajajo tudi pomembnost dviga kapacitet nacionalnih platform za izobraževanje na daljavo, spodbujanja učiteljev k izobraževanju za poučevanje na daljavo ter medsebojnemu sodelovanju in tudi vzpostavitev sodobnih odprtih informacijskih virov.

Delo na daljavo je enakovredno delu v razredu, raba sodobne informacijsko komunikacijske tehnologije (v nadaljevanju IKT) pa je osnovni pogoj za njegovo uspešno izvedbo. Poleg izbrane tehnologije so za kvalitetno izvedbo pouka na medmrežju ključne tudi digitalne kompetence učitelja. Le-te so med učitelji različne, zato sta tehnična in sistemska podpora nujni.

2 PODPORNO OKOLJE

V času prvega vala epidemije je po rezultatih analize [2], medsebojna pomoč učiteljev, v okviru izmenjave idej, gradiv in primerov dobrih praks, intenzivno potekala v spletnih učilnicah Zavoda RS za šolstvo, veliko se je razpravljalo in objavljalo v forumih. Poleg tega so bila organizirana različna izobraževanja, ki so se nadaljevala tudi v času po epidemiji, delovale so študijske skupine. Navkljub množični podpori so se učitelji še vedno znašli v situacijah, ko so pri uporabi različnih spletnih učnih okolij (spletna učilnica Moodle, Google Classroom …) ter

uporabi videokonferenčnega okolja za namene poučevanja na daljavo, za preverjanja in ocenjevanja znanja na daljavo, sestavljanja nalog in dejavnosti za samostojno učenje, izdelave posnetkov idr. potrebovali tehnično podporo. Na ŠC Kranj smo z namenom tovrstne podpore, s pomočjo programske opreme Microsoft Teams, učiteljem ponudili vključitev v skupnost, ki jih medsebojno povezuje in jih s primeri dobrih praks opolnomoči za delo. Izhajali smo iz dejstva, da je medsebojna pomoč najučinkovitejša pomoč. Pomeni, »da se učimo drug od drugega in drug z drugim, z notranjimi močmi (sodelovalna organizacijska kultura šole, kolegialno učenje …) in z zunanjo podporo (medšolska sodelovanja na različnih ravneh, usposabljanja …)«, kot v prispevku o sodelovanju piše Katja Pavlič Škerjanc [3]. Dandanes je na voljo sicer obilo spletnih pomočnikov, vendar je prav, da konkretne rešitve vsako šolsko okolje poišče in vzpostavi zase.

2.1 Programska oprema Microsoft Teams

Z namenom dviga e-kompetentnosti se je celoten kolektiv ŠC Kranj, vključno s tehničnim osebjem, leta 2018 vključil v 60-urni izobraževalni program Razvoj digitalne pismenosti prek uporabe storitev v oblaku. Poudarek programa je bil na programski opremi Microsoft Tems v storitvi Office 365 [4], ki je naročniška storitev v oblaku, v kateri so poleg Teamsov, združena najboljša orodja za izvedbo dela na medmrežju (Excel, Word, Power Point, OneNote idr.). Storitev je v začetnem vodniku aplikacije [5] definirana kot delovni prostor, ki omogoča klepete in nudi različna orodja za ustvarjanje različnih vsebin in je tako digitalno središče za komunikacijo med učitelji in učenci, učitelji v kolektivu, med nadrejenimi in podrejenimi. Izkazalo se je, da je bila odločitev vodstva za tovrstno usposabljanje, kljub nekaterim pomislekom in kritikam, pravilna, saj se je pomanjkanje znanja uporabe IKT realno pokazalo šele s prisilnim prehodom na delo na daljavo. ŠC Kranj je kot programsko orodje za izvedbo pouka od doma tako izbral Microsoft Teams, vendar kljub temu, da so učitelji znanje za uporabo Temsov že pridobili na usposabljanju, je bilo s prenekaterimi učitelji tečaj potrebno ponoviti ali obnoviti.

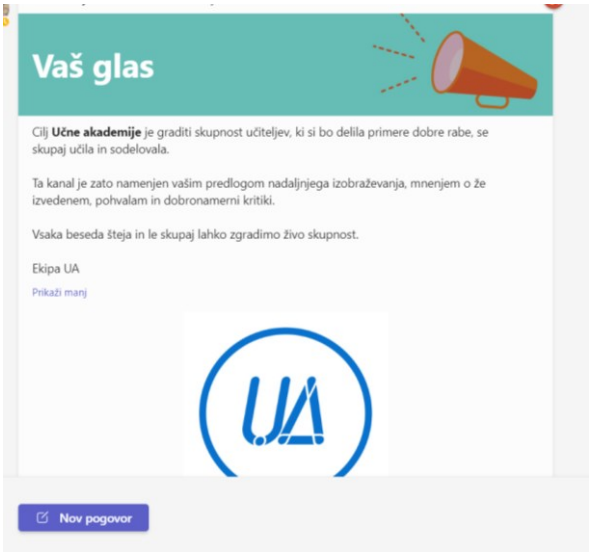
2.2.1 Delovanje programske opreme Teams. Office 365 so storitve in orodja, ki omogočajo komunikacijo med vsemi udeleženci v izobraževanju. Vsaka ustanova ima administratorja, ki uporabnikom dodeli uporabniški račun in geslo. Dostop pa omogoča brezplačno uporabo.

Medmrežna komunikacija v programskem orodju Microsoft Teams se začne s postavitvijo ekipe. Lahko smo njen lastnik, lahko pa se že ustvarjeni ekipi zgolj pridružimo in postanemo njen član. Lastnik ekipe določa, kdo bo njen član in lahko vključi le željene posameznike. Obenem članom določi stopnjo upravljanja ekipe (solastnik ekipe ali član) in pravice sodelovanja in moderiranja v ekipi (objava in deljenje dokumentov, uporaba memov, nalepk …). Vsaka ekipa si ustvari svoje kanale. Prvi kanal se imenuje »Splošno«, in se oblikuje ob stvaritvi ekipe. Je namenjen osnovnim informacijam in ga lastnik po potrebi lahko zaklene. Vsak naknadno dodan kanal poimenujemo poljubno glede na tematiko, znotraj kanala pa se odvijajo klepeti, videokonference, delijo se dokumenti, le-te pa lahko preko že omenjenih on-line aplikacij tudi skupno urejamo.

2.2 Učna akademija

Učna akademija je v aplikaciji Microsoft Teams nastala kot odgovor na tehnična, pa tudi vsebinska vprašanja, ki so se učiteljem porajala v času izvedbe dela na daljavo. Članstvo v njej je prostovoljno. Šolski center Kranj deluje v okviru petih organizacijskih enot, trenutno je v Učno akademijo vključenih 109 članov, tri osebe imajo status lastnika ekipe, kar je skoraj 2/3 zaposlenih.

Kot že omenjeno v uvodu, se dileme razrešujejo v obliki spletnih seminarjev (webinarjev), ki jih Arnes poimenuje tudi predavanja na spletu. Izvajalec in udeleženci se seminarja udeležijo hkrati, med seboj pa komunicirajo ali preko video in zvočne povezave ali pa s pisnimi komentarji [6]. Uvodna stran Učne akademije je predstavljena na sliki 1.

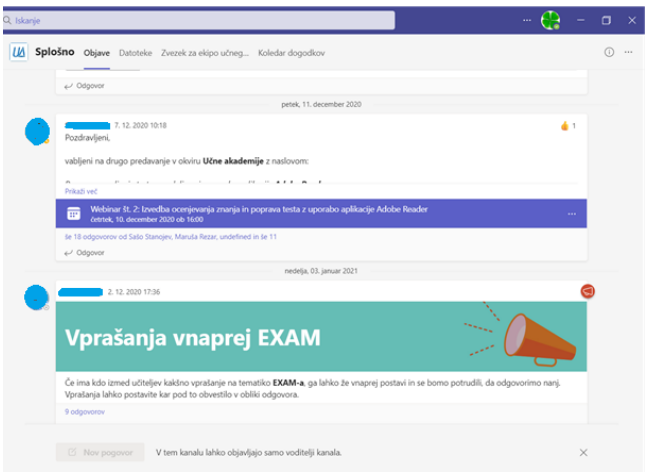


Slika 1 : Učna akademija ŠC Kranj (vir: lasten)

Znotraj ekipe Učna akademija so se oblikovali štirje kanali:

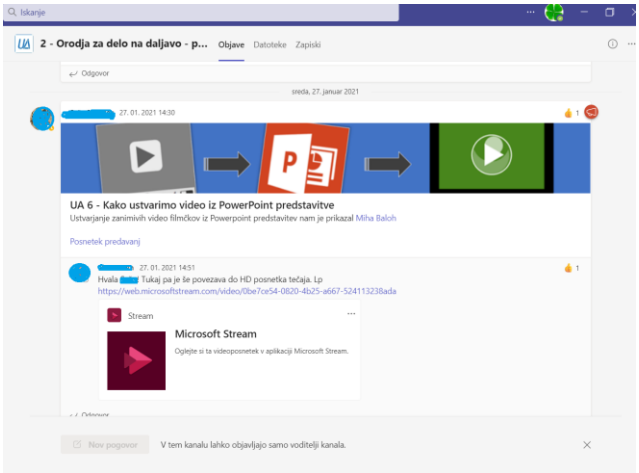
- Splošno
- Orodja za ocenjevanje
- Orodja za delo na daljavo
- Predlogi, mnenja, komentarji

V kanalu splošno se objavljajo vabila za spletne seminarje (webinarje) na različne teme, njihove kratke vsebine ter koledar dogodkov. Slika 2 predstavlja eno od takšnih objav. Termini posameznih usposabljanj se večinoma določajo s pomočjo aplikacije forms, kjer člani glasujejo za najprimernejšega. Izbran je termin z največ glasovi, na ta način pa dosežemo čim večjo udeležbo. Prav tako se v tem kanalu vnaprej zbirajo vprašanja za predavanja v napovedniku. Tisti, ki seminar pripravlja, se tako lahko bolje pripravi in se že v predstavitvi podrobneje dotakne dotičnih težav in predstavi možne rešitve.



Slika 2 : Učna akademija - kanal Splošno (vir: lasten)

Videokonferenčni seminarji (webinarji) potekajo v kanalih orodja za ocenjevanje in orodja za delo na daljavo, razvrščeno glede na tematiko. Seminarji potekajo v živo, posnetki ter prosojnice ali razna gradiva pa se shranjujejo v posameznem kanalu pod zavihkom datoteke. Uporabniki imajo tako vedno možnost, da si seminar ogledajo ponovno ali pa si ogledajo le določene odseke, ki jih zanimajo. Obenem znotraj kanala, v komentarjih, poteka tudi razprava na predstavitev. Na vprašanja, pripombe ali dileme lahko odgovarjajo vsi uporabniki in delijo svoje znanje in izkušnje. Primer seminarja v kanalu s komentarji predstavlja slika 3.



Slika 3: Učna akademija – Primer objave v kanalu Orodja za delo na daljavo

V kanalu predlogi, mnenja, komentarji se objavljajo pobude in ideje za nove seminarje ter raznorazne povezave na druge poučne in zanimive vsebine.

2.2.1 Izvajalci spletnih seminarjev. Izvajalce spletnih seminarjev v Učni akademiji izbiramo znotraj kolektiva ŠC Kranj. S tem, ko učitelji delijo svoje znanje med sodelavci in delujejo v timskem duhu, doživljajo profesionalno in osebnostno rast. Učna akademija je primer oblike povezovanja in sodelovanja učiteljev, kjer se vzpostavlja okolje medsebojnega zaupanja. S tem, ko si pomagamo, se povezujemo. Verjamemo in zaupamo v znanje drug drugega, pa tudi priznati si upamo, da ne vemo vedno vsega, četudi se od nas, učiteljev, marsikdaj pričakuje, da smo vsevedni.

2.2.2 Izzivi za prihodnost. Prvenstveno je Učna akademija nastala kot podporno okolje učiteljem v času soočanja s težavami ob delu na daljavo. Tematika videokonferenčnih seminarjev je bila v celoti vezana na to problematiko. Vsekakor bi bilo, glede na pozitiven odziv udeleženih, smiselno njeno idejo razširiti tudi na druge teme, ki niso usmerjene samo v pridobivanje veščin za delo, ampak tudi v kvalitetno preživljanje prostega časa ter fizično in psihično vzdržljivost. Razmisliti bi bilo potrebno tudi o morebitnem skrbniku ekipe, ki bi skrbel za kontinuirana usposabljanja, da ideja ne bi zamrla. S tem pa bi se verjetno Učna akademija morala širiti tudi na izvajalce izven našega Centra – kolege iz drugih šol ter nepedagoške strokovnjake iz Slovenije in tujine.

3 ZAKLJUČEK

Spremenjen način poučevanja, ki ga je zahtevala epidemija covida-19, je marsikaterega učitelja postavila v težak položaj. Brez izjeme smo morali vsi, ne glede na stopnjo digitalne kompetentnosti, izvedbo svojega dela prenesti na medmrežje. Zmeda, ki jo je v šolskem prostoru povzročila pandemija, nas je naučila, da je edina prava in trajna rešitev ta, da se naučimo to zmedo sprejeti in z njo živeti. Pri tem je najpomembneje, da se medsebojno povežemo in si medsebojno pomagamo. Interni učni centri, kot je Učna akademija, so primeri dobre prakse, ki lahko pomembno pripomorejo h kvaliteti dela kot tudi k profesionalnemu razvoju pedagoških delavcev. Pomembno je, da so vsebine raznolike in niso usmerjene le na eno področje. Učitelj namreč potrebuje širše podporno okolje, ki mu bo oporo nudilo pri pridobivanju IKT ter pedagoških kompetenc ter mu koristilo pri osebnih izzivih.

VIRI IN LITERATURA

[1] Rupnik Vec. T., Silvar. B., idr. (2020) Analiza izobraževanja na daljavo v času prvega vala epidemije covida-19 v Sloveniji (online). (Najdeno 1. 8. 2022). Najdeno na spletnem naslovu https://www.zrss.si/pdf/izobrazevanje_na_daljavo_covid19.pdf

[2] Rupnik Vec. T., Silvar. B., idr. (2020) Analiza izobraževanja na daljavo v času prvega vala epidemije covida-19 v Sloveniji (online). (Najdeno 1. 8. 2022). Najdeno na spletnem naslovu https://www.zrss.si/pdf/izobrazevanje_na_daljavo_covid19.pdf

[3] Pavlič Škerjanc K., Sodelovati, ne sodelovati: to ni tu vprašanje. (oneline). Najdeno 5. 8. 2022 na spletnem naslovu http://publikacija.k56.si/strokovnjaki/4.%20Katja%20Pavlic%20Skerjanc.%20Sodelovati,%20ne%20sodelovati;%20to%20ni%20tu%20vprasanje.pdf

[4] Začetni vodnik aplikacije Microsoft Teams za vodstvene delavce v šoli. Microsoft. (online). (Najdeno 1. 8. 2018). Najdeno na spletnem naslovu https://support.office.com/sl-si/article/za%C4%8Detni-vodnik-aplikacije-microsoft-teams-za-vodstvene-delavce-v-%C5%A1oli-f054451e-5c94-4023-9ac0-797981d10971

[5] Kaj je Office 365? (online). (Najdeno 2. 8. 2018). Najdeno na spletnem naslovu https://products.office.com/sl-si/home

[6] Kaj je spletni seminar? (online) (Najdeno 8. 8. 2022) Najdeno na spletnem naslovu https://www.arnes.si/kaj-je-spletni-seminar-webinar-in-kaj-je-most/

Problem zasebnosti in varnost uporabnikov na družbenih omrežjih

The Problem of the Privacy and Security of Users on Social Networks

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POVZETEK

V prispevku raziskujemo problematiko dojemanja zasebnosti in varnosti slovenskih uporabnikov družbenih omrežij. Kljub več raziskavam na tem področju zaznavamo v slovenskem prostoru manko raziskav, ki bi preučevale mlade uporabnike družbenih omrežij v Sloveniji. Glavni namen raziskave je bil tako preučiti vpliv spola oz. izobrazbe uporabnika na dojemanje zasebnosti in varnosti. V ta namen smo zasnovali anketni vprašalnik in ga poslali predstavnikom fakultet in srednjih šol v podravski regiji. Prav tako samo ga posredovali študentom in dijakom teh izobraževalnih ustanov. Rezultati so pokazali, da ženske bolje dojemajo zasebnost na družbenih omrežjih kot moški. Rezultati so prav tako razkrili, da to, na katerem področju se uporabniki izobražujejo, statistično značilno vpliva na dojemanje varnosti. Po drugi strani pa iz pridobljenih rezultatov ne moremo trditi, da bi spol vplival na dojemanje varnosti ali da bi področje izobraževanja vplivalo na dojemanje zasebnosti na družbenih omrežjih. Rezultati lahko v prihodnje služijo kot podlaga za nadaljnje raziskovanje področja dojemanja zasebnosti in varnosti slovenskih študentov in dijakov oziroma uporabnikov družbenih omrežij.

KLJUČNE BESEDE

Družbena omrežja, zasebnost, varnost, tveganje, uporabniški podatki

ABSTRACT

In this paper, we explore the issue of Slovenian social network users' perceptions of privacy and security. Despite several studies in this area, we perceive a lack of research on young social network users in Slovenia. The main aim of the research was to examine the impact of gender and education on users' perceptions of privacy and security. For this purpose, we designed a questionnaire and sent it to representatives of Faculties and Secondary Schools in the Podravje region. It was also distributed to students of these educational institutions. The results showed that women have a better perception of privacy on social networks than men. The results also revealed that the area in which users are educated has a statistically significant impact on perceptions of security. On the other hand, the results do not suggest that gender influences the perception of security, or that the field of education influences the perception of privacy on social networks. The results may serve as a basis for future research in the area of the privacy and security perceptions of Slovenian students and social network users.

KEYWORDS

Social networks, privacy, security, risk, user data

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1 UVOD

Na družbenih omrežjih obstaja mnogo groženj zasebnosti in varnosti, ki so ji uporabniki le-teh nenehno izpostavljeni. Družbena omrežja so izraz za spletno programsko opremo in storitve, ki uporabnikom omogočajo, da se družijo na spletu in izmenjujejo mnenja, razpravljajo, komunicirajo in sodelujejo v kakršnikoli obliki družbene interakcije; ta lahko zajema različne vrste medijev. Lahko vključuje ustvarjanje novih vsebin ali priporočanje in izmenjavo že obstoječih [1]. V svoji raziskovalni študiji predstavljamo izsledke raziskave, v kateri smo preučevali dojemanje pojmov zasebnosti in varnosti slovenskih uporabnikov družbenih omrežij.

V slovenskem prostoru zaznavamo manko na področju raziskav na temo zasebnosti in varnosti na družbenih omrežjih med (mlajšimi) prebivalci Slovenije. Tako smo se s pomočjo obstoječe študije, ki je bila izvedena v Iraku [2], odločili raziskati to področje.

V svoji raziskavi smo preučevali dojemanje zasebnosti in varnosti uporabnikov na družbenih omrežjih, raziskava pa je bila izvedena med slovenskimi mladimi. Druge študije, ki smo jih zaznali na podobno temo, se od naše razlikujejo po dejstvih, da

so bile izvedene v drugih državah, na drugih starostnih skupinah ali na drugačnih družbenih omrežjih.

V prispevku smo najprej predstavili postopek razvijanja ideje za raziskavo ter opis strategije iskanja za konceptualni pregled raziskave. Temu sledi opredelitev temeljnih konceptov: družbena omrežja, zasebnost na družbenih omrežjih in varnost na družbenih omrežjih, podali smo pa tudi relacije med temi koncepti. Nadalje je predstavljen pregled sorodnih del.

Sledi opis metodologije, kjer so predstavljene spremenljivke in raziskovalna vprašanja. Sledi vzorčenje, kjer je opisano, kako smo prišli do udeležencev v raziskavi. Sam postopek raziskave je opisan v nadaljevanju. Sledi še opis uporabljenih merskih instrumentov in predstavitev statistične analize podatkov. Nato so predstavljeni in interpretirani rezultati raziskovanja, tem pa sledita še diskusija in zaključek, kjer smo povzeli naše ugotovitve.

2 TEORETIČNI OKVIR IN OZADJE

2.1 Spletna družbena omrežja

Spletna družbena omrežja Kaplan in Haenlein [3] definirata kot skupino internetnih aplikacij, ki temeljijo na ideoloških in tehnoloških temeljih spleta 2.0 in omogočajo ustvarjanje in izmenjavo uporabniško generiranih vsebin. Ryan [1] označi družbena omrežja kot izraz za spletno programsko opremo in storitve, ki uporabnikom omogočajo, da se družijo na spletu in izmenjajo mnenja, razpravljajo, komunicirajo in sodelujejo v kakršni koli obliki družbene interakcije. Ta interakcija lahko zajema besedilo, zvok, slike, video in druge medije, posamično ali v kateri koli kombinaciji. Lahko vključuje ustvarjanje novih vsebin ali pa priporočanje in izmenjavo že obstoječih. Lahko se uporabljajo za pregledovanje in ocenjevanje izdelkov, storitev in blagovnih znamk, za razprave o vročih temah, ukvarjanje s hobiji, interesi in strastmi. Omogočajo tudi izmenjavo izkušenj in strokovnega znanja. Cao [4] zapiše, da je pojem družbena omrežja prvič uporabljen v devetdesetih letih 20. stoletja, z razvojem računalnikov in tehnologije za splet. Popularna so postala leta 2008 in so za več milijonov oseb oziroma uporabnikov spremenila način komuniciranja [4]. Mnogo družbenih omrežij razvija razmerja na več ravneh (npr. več platform) [5]. Howard in Parks [6] sta podala bolj kompleksno opredelitev družbenih omrežij, in sicer, da so sestavljena iz treh delov: 1. Informacijska infrastruktura in orodja za proizvodnjo in distribucijo vsebin. 2. Vsebina v digitalni obliki osebnih sporočil, novic, idej in kulturnih izdelkov. 3. Osebe, organizacije in industrije, ki ustvarjajo in zajemajo digitalne vsebine. Zaradi enostavnosti uporabe, hitrosti in dosega so družbeni mediji hitro spremili javni diskurz v družbi ter postavljajo trende in agende v temah, ki segajo od okolja in politike do tehnologije in zabavne industrije.

2.2 Zasebnost

Zasebnost je temelj človeškega dostojanstva in drugih vrednot, kot sta svoboda združevanja in svoboda govora, piše Kovačič [7]. Navaja, da so vse človekove pravice neke vrste vidiki pravice do zasebnosti, kot trdijo nekateri drugi avtorji. Pravica do zasebnosti je temeljna, vendar ne absolutna, v sodobni družbi pa je postala ena najpomembnejših človekovih pravic. Zasebnost ima več dimenzij, med katerimi je tudi informacijska zasebnost (zasebnost na spletu). Kovačič [7] navaja, da je problem računalniške tehnologije in interneta predvsem v tem, da tehnologija že sama po sebi omogoča možnost zlorabe zasebnosti. Obravnava tudi različne načine ogrožanja zasebnosti na spletu. Tudi Lapenta in Jørgensen [8] omenjata več dimenzij zasebnosti, pri čemer izpostavljata, da pravica do zasebnosti velja tako za „offline" kot tudi „online" področje, torej ima zasebnost na spletu enako pomembno vlogo kot izven spleta. V skladu s preobrazbo javne sfere pravice do zasebnosti, se koncept spletne zasebnosti uporablja za predstavitev posebnih izzivov in posledic na spletu. Posamezniki imajo pravico do zasebnosti ne samo v zasebni domeni, ampak tudi v javnem prostoru – sem lahko štejemo tudi družbena omrežja. Z družbenimi omrežji se pojavijo nove skrbi v povezavi z zasebnostjo, o čemer pišejo Ahn, Shehab in Squicciarini [9]. Na splošno je vprašanje zasebnosti na družbenih omrežjih povezano z določljivostjo in povezljivostjo informacij, ki so na voljo v tem družbenem okolju, njihovih možnih prejemnikov in načinov uporabe. Zasebnost na družbenih omrežjih je tesno povezana z varnostjo [10].

2.3 Varnost

S porastom uporabe družbenih omrežij je prišlo do pogostih težav pri ohranjanju varnosti posameznikov. Ključni dejavnik pri spletni ali kibernetski varnosti je posamezni uporabnik [11]. Posameznikove izkušnje in dojemanje varnosti na spletnih mestih v družbenih medijih so večplastne in vključujejo ne le digitalno zasebnost, varnost in nadlegovanje, temveč tudi varnost in dobro počutje izven spleta [12]. Z uporabo izraza varnost na družbenih omrežjih vključujemo tako kršitev varnosti, kot tudi drugih možnih zaznav groženj, na primer tistih, ki se nanašajo na fizično varnost. To je lahko še posebej pomembno za uporabnike družabnih medijev, glede na odnos med družabnimi mediji in spletnim nadlegovanjem [13]. Več študij in nedavnih poročil novic je poudarilo povečano tveganje osebnih podatkov, ki jih obdelujejo spletna družbena omrežja ter pomanjkanje ozaveščenosti uporabnikov [14].

Uporabljeni koncepti se med seboj ne izključujejo. Na družbenih omrežjih si želimo predvsem komunikacije – izmenjavo mnenj, razprave in sodelovanja [1]. Kljub komunikaciji, pa sta zelo pomembni zasebnost in varnost na družbenih omrežjih, ki se močno prepletata med seboj. Kot smo že prej omenili, je poleg varnosti, ki si je želimo tudi izven spleta [12], predvsem zasebnost tista, ki jo ne le da želimo, temveč jo lahko tudi zahtevamo – na spletu ali drugod [8].

3 PREGLED SORODNIH DEL

Pregledali smo sorodna dela, raziskave, izvedene na področju družbenih omrežij, zasebnosti, ozaveščanja o varnosti na družbenih omrežjih ter jih v nadaljevanju podrobneje predstavili. Izpostavili smo tudi pomanjkljivosti raziskav, ki smo jih opazili.

Zeebaree, Ameen in Sadeeq [2] so želeli opozoriti na težave z varnostjo, ki se pojavljajo z množično uporabo družbenih omrežij in podali predloge, kako izboljšati s tem povezano kulturo uporabe (znanje, veščine in vedenje pri uporabi družbenih omrežij). Pri tem so se osredotočili na uporabo pametnih telefonov, saj so ugotovili, da so ti v povezavi z družbenimi omrežji najbolj uporabljana elektronska naprava.

Izvedli so študijo s pomočjo kvantitativne metode (vprašalnika), kjer so ugotavljali, kako družbena omrežja uporabljajo ljudje iz pokrajine Kurdistan (Irak) in ali se zavedajo groženj in tveganj, ki so jim izpostavljeni z njihovo uporabo. V študiji je sodelovalo 350 ljudi s tamkajšnje javne univerze - uporabnikov družbenih omrežij. Avtorji so ugotovili, da obstaja grožnja varnosti na družbenih omrežij, kar je nakazalo potrebo po programih usposabljanja in ozaveščanja uporabnikov za varno uporabo oz. povečanju t. i. kiberkulture. Podali so smernice za uporabo družbenih omrežij, s poudarkom na zmanjševanju groženj in tveganj pri deljenju osebnih podatkov s strani uporabnikov. Menimo, da je slaba stran te študije, da so avtorji uporabili premajhen vzorec ljudi glede na velik razpon starosti (15-63 let), zaradi česar rezultati morda niso najbolj zanesljivi. Temu bi se mi izognili tako, da bi določili manjši razpon starosti ali povečali vzorec, pri čemer je slednje težje izvedljivo.

Zhang in Gupta [15] sta raziskovala ali se z rastjo popularnosti družbenih omrežij zvišuje tudi varnost posameznika med uporabo le-teh. V raziskavi sta se posvetila predvsem meritvam varnosti in zaupanja družbenih omrežij. V začetku sta naredila pregled spletnih napadov na družbenih omrežjih ter z njimi povezane obveščevalne aplikacije. Družbena omrežja sta analizirala na podlagi preučevanja posameznih uporabnikov in skupin. Predstavila sta tudi motivacije za tovrstne napade. Ugotovila sta, da kršitev varnosti na družbenih omrežjih neposredno vpliva na gospodarsko rast organizacije, saj pride do nezaupanja z uporabnikove strani. V delu sta predstavila tudi možne načine izboljšanja varnosti na družbenih omrežjih. Krepitev zaupanja med uporabnikom in družbenim omrežjem zagotavlja višji nivo varnosti. To lahko omrežja dosežejo tako, da so o uporabi osebnih in finančnih podatkov popolnoma transparentna. Uporabniki lahko namreč nastavijo, s kom bodo delili informacije, a vseeno bo družbeno omrežje te podatke zmeraj imelo. Prišla sta do ugotovitve, da bi uporabniki morali biti dobro ozaveščeni o načinih zavarovanja svoje spletne identitete, čemur pa ni zmeraj tako. Zaupanje uporabnika družbenemu omrežju lahko zelo pripomore k boljši varnosti in večji uspešnosti organizacije. Menimo, da bi v raziskavi morda lahko dodali še anketo, kjer bi uporabnike vprašali o njihovem dojemanju varnosti in zaupanju na družbenih omrežjih. Tako bi lahko dodali dodatno perspektivo k tematiki.

Rathore, Sharma in drugi [16] so se v svoji raziskavi osredotočili predvsem na preučevanje varnostnih vprašanj in izzivov pri družbenih omrežjih, predstavijo pa tudi zelo podrobno grožnje glede varnosti in zasebnosti pri le-teh. Predstavijo tudi podrobno analizo več možnih rešitev za doseg zaščite na družabnih omrežij. Sledijo še smeri za prihodnost in predlogi za varnostne odzive. V zaključku poudarijo, da so družbena omrežja postala zaželen medij za komunikacijo za več milijard uporabnikov interneta, vendar pa lahko te storitve uporabnike izpostavijo resnim tveganjem, kar se tiče njihove spletne varnosti. V delu se avtorji sklicujejo na mnogo drugih del. Ta sorodna študija se ukvarja z varnostjo oziroma zasebnostjo na družbenih omrežjih in podrobno predstavi nevarnosti, do katerih lahko pride na le-teh. (Tem bi lahko bili potencialno žrtve tudi Slovenci.) Avtorji predstavijo tudi možnosti zaščite na družbenih omrežjih. Slabost članka je dejstvo, da je bil izdan leta 2017. V tem času je možno, da je prišlo do novih nevarnosti in groženj, kot tudi do novih rešitev. Prednost študije pa je razsežnost le-te, oziroma njena poglobitev v zgoraj navedene točke članka.

Nemec Zlatolas [17] v svoji doktorski disertaciji (2015) preučuje zasebnost uporabnikov na družbenem omrežju Facebook. Na podlagi rezultatov anketnega vprašalnika, je določila faktorje dojemanja zasebnosti, ki so: samorazkrivanje informacij, vrednost zasebnosti, skrb za zasebnost, zavedanje o zasebnosti, družbena norma zasebnosti, politika zasebnosti in nadzor zasebnosti. Cilj raziskave je bil povezanost vseh naštetih faktorjev. Zaključki dela so obrazložitev spremenljivk. Spremenljivka zavedanja o zasebnosti, ki meri samo obveščenost ljudi o zasebnosti, kršenju le te in postopkih na družbenih omrežjih. Piše tudi o družbeni normi, ki je vpliv drugih ljudi oziroma prijateljev na uporabnika in pa o politiki zasebnosti oz. kako se odraža zaščita njihove zasebnosti in s tem zaupanje informacij. Spremenljivka nadzora zasebnosti meri, koliko nadzora imajo uporabniki nad tem ter kdo vse lahko dostopa do informacij uporabnika. Poleg tega so pomembne tudi vrednosti zasebnosti, skrb za zasebnosti in razkrivanje osebnih informacij. Avtorica navaja, da je cilj dela bil upoštevati vse spremenljivke, ki vplivajo na zasebnosti in razkrivanje informacij na družbenem omrežju Facebook. Kot slabost študije bi šteli to, da je bila raziskava izvedena zgolj na enem družbenem omrežju, Facebooku. Smiselno bi bilo dodati še kakšno drugo družbeno omrežje, na primer Instagram, ki je z leti postal (zlasti med mladimi) še posebej priljubljen. Druga slabost je leto izida, ki je 2015, saj so se medtem družbena omrežja razvijala naprej, pojavila pa so se že tudi nova. Prednost dela je velik vzorec anketirancev, zaradi česar so rezultati študije reprezentativnejši.

4 METODOLOGIJA

4.1 Raziskovalna vprašanja

Določili smo štiri raziskovalna vprašanja, ki so se dotikala naše problematike. Zanimala nas je povezava med spolom uporabnika in dojemanjem zasebnosti (RV1) ter varnosti (RV2), prav tako pa tudi povezava med izobrazbo ter dojemanjem zasebnosti (RV3) ter varnosti (RV4). Vsa raziskovalna vprašanja so bila inferenčnega tipa.

RV1: Ali spol uporabnika vpliva na dojemanje zasebnosti na družbenih omrežjih?

RV2: Ali spol uporabnika vpliva na dojemanje varnosti na družbenih omrežjih?

RV3: Ali področje izobrazbe uporabnika vpliva na dojemanje zasebnosti na družbenih omrežjih?

RV4: Ali področje izobrazbe uporabnika vpliva na dojemanje varnosti na družbenih omrežjih?

4.2 Vzorčenje in udeleženci raziskave

V naši raziskavi smo se osredotočili na dojemanje zasebnosti in varnosti slovenskih uporabnikov družbenih omrežij. V ta namen smo določili našo ciljno skupino, ki so bili mladi [18], in iz nje dobili vzorec. Vključili smo dijake in študente podravskih srednjih šol, višjih šol in fakultet. Odločili smo se za merski instrument v obliki spletnega anketnega vprašalnika.

Pri raziskavi smo se poslužili se sistema večstopenjskega vzorčenja in določili pet mariborskih srednjih šol ter pet fakultet mariborske univerze, ki smo jim poslali dopis in k reševanju povabili njihove dijake oz. študente. S tem smo želeli dosegati različne izobraževalne skupine in smeri. Vprašalnik smo

posredovali predstavnikom organizacij – srednjih šol in fakultet, prav tako pa tudi predstavnikom dijakov in študentov. Izbrane srednje šole so bile: Srednja elektro-računalniška šola Maribor, Srednja šola za oblikovanje Maribor, Biotehniška šola Maribor, III. gimnazija Maribor in Škofijska gimnazija AMS Maribor. Fakultete, na katere smo poslali dopis, so bile: Fakulteta za elektrotehniko, računalništvo in informatiko, Ekonomsko-poslovna fakulteta, Fakulteta za kmetijstvo in biosistemske vede, Pedagoška fakulteta in Fakulteta za naravoslovje in matematiko.

4.3 Postopek raziskave

Po definiranju teoretičnega okvirja, pregledu sorodnih del in določitvi spremenljivk ter raziskovalnih vprašanj, smo izvedli spletni anketni vprašalnik o dojemanju zasebnosti in varnosti na družbenih omrežjih. Po zasnovi anketnega vprašalnika smo tega preoblikovali in naložili na spletno stran 1ka Arnes, preko katere smo anketo nato tudi izvedli. Vprašalnik smo posredovali petim srednjim šolam in petim visokošolskim in visokošolskim fakultetam in jih povabili k reševanju.

Zbiranje podatkov je potekalo od 21. 12. 2021 do 10. 1. 2022. Vprašalnik smo 10. 1. 2022 zaključili in nadaljevali z analizo podatkov s pomočjo programa IBM SPSS Statistics. Podatke smo uredili, neustrezne izločili in s pomočjo uporabe ustreznih statističnih testov pridobili rezultate.

4.4 Merski instrument

Vprašalnik je bil zasnovan iz demografskih vprašanj in vsebinskega sklopa, navezujočega na dojemanje varnosti in zasebnosti na družbenih omrežjih. Na začetku smo izmed demografskih vprašanj zastavili le vprašanje o spolu in starosti. Po vsebinskem sklopu vprašanj so na zadnji strani sledila še nekatera demografska vprašanja: trenutni status, področje izobraževanja ter smer in regija izobraževanja.

V vsebinskem sklopu smo vprašanja razdelili glede na to, če so se navezovala na dojemanje zasebnosti ali dojemanje varnosti na družbenih omrežjih. Najprej je sledilo splošno vprašanje, če sploh uporabljajo družbena omrežja. Vsi, ki so odgovorili z ne, so vprašalnik zaključili, ostali so nadaljevali s sklopom vprašanj o uporabi družbenih omrežij in dojemanju zasebnosti ter varnosti. Pri sklopu vprašanj o družbenih omrežjih smo uporabili različne tipe odgovorov, medtem ko smo pri sklopu vprašanj o dojemanju zasebnosti na družbenih omrežjih in dojemanju varnosti na družbenih omrežjih, uporabili petstopenjsko Likertovo lestvico odgovorov, kjer so anketiranci odgovarjali koliko se strinjajo z določenimi vprašanji oziroma trditvami.

Najprej smo določili spremenljivke oziroma variable. Merljive spremenljivke so: spol (V1), starost (V2), status (V3) in področje izobraževanja (V4). Vrednosti spremenljivke spol: moški, ženski. Vrednosti spremenljivke starost: do 15, 16-20, 21-25, 26-30, 31+. Vrednosti spremenljivke status: dijak, študent, zaposlen, brezposeln, drugo. Vrednosti spremenljivke področje izobraževanja [19]: naravoslovne vede, tehniške in tehnološke vede, medicinske in zdravstvene vede, kmetijske vede, družbene vede, humanistične vede, splošno izobraževanje, ne vem.

Določeni latentni spremenljivki oziroma variabli sta: dojemanje zasebnosti na družbenih omrežjih (V5) [17] in dojemanje varnosti na družbenih omrežjih (V6); prikazani sta v Tabeli 1.

Tabela 1: Seznam latentnih spremenljivk

Ime spremenljivke	Indikatorji
Dojemanje zasebnosti na družbenih omrežjih	Pomembnost zasebnosti[1] Deljenje podatkov[2] Nadzor nad podatki[3]
Dojemanje varnosti na družbenih omrežjih	Občutek varnosti[4] Zavedanje nevarnosti[5] Poznavanje nevarnosti[6]

5 REZULTATI

V nadaljevanju so prikazani rezultati analize podatkov izvedene raziskave na temo dojemanja zasebnosti in dojemanja varnosti na družbenih omrežjih.

Pri prvem raziskovalnem vprašanju (RV1) smo najprej naredili test zanesljivosti za indikatorje latentne spremenljivke "Dojemanje zasebnosti". Uporabili smo test Cronbach Alpha. Ker se ni izkazalo, da bi vsi indikatorji zanesljivo prispevali k merjenju latentne spremenljivke, smo v analizi odstranili dva indikatorja ("Nadzor nad podatki na družbenih omrežjih" in "Nadzor nad podatki, ki se posredujejo družbenim omrežjem") in tako dobili novo spremenljivko "Dojemanje zasebnosti".

Izvedli smo test normalnosti porazdelitve podatkov za RV1 (Kolmogorov-Smirnov test), kjer smo ugotovili, da podatki niso normalno porazdeljeni ($p < 0,05$). Glede na nastopajoči spremenljivki in nenormalno porazdelitev podatkov, smo izbrali Mann-Whitneyjev U test.

Rezultati testa so pokazali, da ženske boljše dojemajo zasebnost na družbenih omrežjih v primerjavi z moškimi ($U = 295$; $Z = -3,37$; $p < 0,001$). Povprečni rang za ženske je znašal ($x = 46,32$) za moške pa ($y = 25,53$).

Pri drugem raziskovalnem vprašanju (RV2) smo najprej naredili test zanesljivosti za indikatorje latentne spremenljivke Dojemanje varnosti. Uporabili smo test Cronbach Alpha.

Ker se ni izkazalo, da bi vsi indikatorji zanesljivo prispevali k merjenju latentne spremenljivke, smo v analizi odstranili dva indikatorja ("Varnost na družbenih omrežjih", "Potencialna tarča nevarnosti") in tako dobili novo spremenljivko "Dojemanje varnosti".

Izvedli smo test normalnosti porazdelitve podatkov za RV2 (Kolmogorov-Smirnov test), kjer smo ugotovili, da podatki niso normalno porazdeljeni ($p < 0,05$). Glede na nastopajoči spremenljivki in nenormalno porazdelitev podatkov, smo izbrali Mann-Whitneyjev U test.

[1] *Pomembnost zasebnosti:* Menim, da je zasebnost na družbenih omrežjih pomembna.
[2] *Deljenje podatkov:* Moti me, ko moram na družbenih omrežjih deliti osebne podatke.
[3] *Nadzor nad podatki:* Menim, da lahko nadziram, katere osebne podatke prikazujem na družbenih omrežjih; Menim, da imam nadzor nad podatki, ki jih posredujem družbenim omrežjem; Skrbi me, da družbena omrežja zbirajo preveč mojih osebnih informacij; Trudim se obdržati zasebnost na družbenih omrežjih.
[4] *Občutek varnosti:* Na družbenih omrežjih se počutim varno.
[5] *Zavedanje nevarnosti:* Menim, da na družbenih omrežjih obstajajo nevarnosti; Skrbi me, da sem lahko potencialna tarča nevarnosti na družbenih omrežjih.
[6] *Poznavanje nevarnosti:* Na družbenih omrežjih poznam potencialne nevarnosti (npr. phishing, kraja identitete, itd.).

Rezultati testa so pokazali, da ne moremo trditi, da spol vpliva na dojemanje varnosti na družbenih omrežjih, ker je $p > 0,05$ (sig. = 0,846).

Pri tretjem raziskovalnem vprašanju (RV3) smo najprej združili vrednosti neodvisne spremenljivke "Področje izobrazbe" v nove konstrukte. Tako smo dobili naslednje vrednosti: "Splošno izobraževanje" (konstrukt 1), "Naravoslovne in kmetijske vede" (konstrukt 2) ter "Družbene, tehniške in tehnološke vede" (konstrukt 3). V analizo nismo vključili vrednosti "Humanistične vede", "Medicinske in zdravstvene vede" ter vrednosti "Ne vem", saj noben izmed udeležencev v raziskavi ni izbral teh vrednosti. Pri analizi smo vključili tudi prej določeno spremenljivko "Dojemanje zasebnosti".

Izvedli smo test normalne porazdelitve podatkov za RV3 (Kolmogorov-Smirnov test), kjer smo ugotovili, da podatki niso normalno porazdeljeni ($p < 0,05$). Na podlagi nenormalne porazdelitve smo izbrali Kruskal-Wallisov H test.

Pri naši študiji se je izkazalo, da ne moremo trditi, da področje izobraževanja vpliva na dojemanje zasebnosti na družbenih omrežjih, ker je $p > 0,05$ (sig. = 0,094).

Pred statistično analizo pri četrtem raziskovalnem vprašanju smo najprej izvedli test normalnosti porazdelitve podatkov (Kolmogorov-Smirnov test), kjer smo ugotovili, da podatki niso normalno porazdeljeni ($p < 0,05$). Glede na nastopajoči spremenljivki in nenormalnost porazdelitev podatkov smo izbrali Kruskal-Wallisov H test. Pri analizi smo uporabili spremenljivki "Področje izobrazbe" in "Dojemanje varnosti", ki smo jih določili pri analizi prejšnjih raziskovalnih vprašanj.

Rezultati testa so pokazali, da področje izobraževanja vpliva na dojemanje varnosti na družbenih omrežjih, $H(2) = 9,08$, $p < 0,05$. Povprečni rang za konstrukt 1 znaša 37,8; za konstrukt 2 znaša 34,53 in za konstrukt 3 znaša 53,93.

6 DISKUSIJA

Vse obstoječe študije, ki smo jih vključili, smo z našo študijo poskusili nadgraditi. Nobena izmed njih ni zastavljena na enak način, vendar se s tem vsaka posebej lahko dopolnjuje z našo.

V prvi študiji [2] so avtorji ugotovili, da obstaja grožnja varnosti na družbenih omrežjih ter so podali smernice kako zmanjšati grožnje. Tudi v naši študiji smo se osredotočali na dojemanje varnosti, pri čemer so rezultati testa pokazali, da ne moremo trditi, da spol vpliva na dojemanje varnosti na družbenih omrežjih (RV2). Pri tem moramo poudariti, da sta obe študiji imeli majhen vzorec udeležencev. Tako rezultati obeh študij morda niso zanesljivi.

Pri drugi študiji [15] so avtorji ugotovili, da tem boljše je zaupanje uporabnikov družbenih omrežij in bolj kot so ozaveščeni o varnosti, tem bolj so varni. Že obstoječi študiji smo v pregledu sorodnih del predlagali, da bi avtorji lahko dodali anketni vprašalnik o dojemanju varnosti uporabnikov na družbenih omrežjih. V naši študiji smo to storili mi; v naši raziskavi smo torej želeli izvedeti, kakšen vpliv imata spol in področje izobrazbe na dojemanje varnosti na družbenih omrežjih. Rezultati so pokazali, da področje izobrazbe (za razliko od spola, RV2) vpliva na dojemanje varnosti na družbenih omrežjih (RV4).

V tretji študiji [16] so se avtorji prav tako ukvarjali z varnostjo in zasebnostjo na družbenih omrežij. Pri tem so se osredotočali predvsem na nevarnosti na družbenih omrežjih. V naši študiji se nismo pretirano osredotočali na nevarnosti na družbenih omrežjih, temveč smo jih dodali le kot konstrukt pri dojemanju varnosti na družbenih omrežjih.

V četrti študiji [17] je avtorica imela večji vzorec udeležencev, kot smo ga imeli v naši študiji. Osredotočila se je na zasebnost uporabnikov družbenega omrežja Facebook. Študija se osredotoča na več dejavnikov zasebnosti na Facebooku in ne toliko na dojemanje zasebnosti na družbenih omrežjih. V naši študiji smo tako dodali še dojemanje varnosti na družbenih omrežjih.

7 ZAKLJUČEK

Z raziskavo smo želeli raziskati dojemanje zasebnosti in varnosti slovenskih uporabnikov družbenih omrežij. Pri tem nas je predvsem zanimalo ali dejavniki, kot sta spol in področje izobrazbe, vplivajo na posameznikovo dojemanje zasebnosti in varnosti na družbenih omrežjih.

Ugotovili smo, da je v naši raziskavi spol statistično značilno vplival na dojemanje zasebnosti na družbenih omrežjih. V naši raziskavi se je izkazalo, da anketiranci ženskega spola bolje dojemajo zasebnost na družbenih omrežjih. Pri tem je potrebno izpostaviti, da bi se rezultati morda spremenili v primeru enakega števila anketirancev obeh spolov. Naš vzorec je namreč zajemal 63 žensk in le 19 moških. Za razliko od dojemanja zasebnosti, pa smo pri dojemanju varnosti na družbenih omrežjih ugotovili, da v naši raziskavi spol nanj ni statistično značilno vplival.

Pri analiziranju vpliva področja izobrazbe na dojemanje zasebnosti in varnosti smo prišli do obratnih rezultatov. Ugotovili smo namreč, da v naši raziskavi področje izobrazbe statistično pomembno ne vpliva na dojemanje zasebnosti, hkrati pa se je pokazal vpliv področja izobrazbe na dojemanje varnosti na družbenih omrežjih.

Glavna omejitev naše raziskave je, da je bil odziv na anketni vprašalnik razmeroma majhen (n=82) in tako vzorec ni reprezentativen. Med anketiranci je prav tako prišlo do neuravnoteženosti števila študentov in dijakov iz različnih študijskih smeri ter neravnovesja v številu moških in ženskih respondentov. Rezultati bi se morda spremenili v primeru večjih in bolj enakomernih števil vrst anketirancev. Kot drugo omejitev bi izpostavili še majhno geografsko področje v naši raziskavi. V primeru razširitve geografskega območja iz le ene regije na več bi morda dobili drugačne rezultate. Menimo, da bi v prihodnje našo raziskavo lahko nadgradili z večjim vzorcem ter glede na število različnih področij izobrazbe in spola čim bolj enakomernim. Predlagamo tudi razširitev geografskega območja. Za večjo natančnost in lažje analiziranje vpliva bi lahko dodali ali spremenili tudi konstrukte pri Dojemanju varnosti.

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LITERATURA IN VIRI

[1] Ryan, D. (2014). *Understanding digital marketing.* London: Kogan Page. Pridobljeno s: http://www.ascdegreecollege.ac.in/wp-content/uploads/2020/12/Understanding-Digital-Marketing.pdf (18. 10. 2021)

[2] Zeebaree, S., Ameen, S., & Sadeeq, M. (2020). Social Media Networks Security Threats, Risks and Recommendation: A Case Study in the Kurdistan

Region. *International Journal of Innovation, Creativity and Change, 13,* 349-365. Pridobljeno s: https://www.researchgate.net/publication/348930053 (7. 10. 2021)

[3] Kaplan, A. M., Haenlein, M. (2010). Users of the World, Unite! The Challenges and Opportunities of Social Media. *Business Horizons.*

[4] Cao, B. L. (2011). Social media: definition, history of development, features and future – the ambiguous cognition of social media. *Journal of Human Radio & Television University, 47*(3), 65-69.

[5] Jalili, M., Orouskhani, Y., Asgari, M., Alipourfard, N., Perc, M., (2017). Link prediction in multiplex online social networks. *The Royal Society Publishing.* Pridobljeno s: https://royalsocietypublishing.org/doi/10.1098/rsos.160863 (18. 10. 2021)

[6] Howard, P. N., & Parks, M. R. (2012). Social media and political change: Capacity, constraint, and consequence. *Journal of Communication, 62,* 359–362

[7] Kovačič, M. (2003). *Zasebnost na internetu*. Ljubljana: Mirovni inštitut.

[8] Lapenta, G. H., & Jørgensen, R. F. (2015). Youth, privacy and online media: Framing the right to privacy in public policy-making. *First Monday.* Pridobljeno s: https://journals.uic.edu/ojs/index.php/fm/article/view/5568 (19. 10. 2021)

[9] Ahn, G. J., Shehab, M., & Squicciarini, A. (2011). Security and privacy in social networks. *IEEE Internet Computing*, *15*(3), 10-12. Pridobljeno s: https://ieeexplore.ieee.org/abstract/document/5755600 (18. 10. 2021)

[10] *Conference on Web and Social Media* (Vol. 13, pp. 405-416). Pridobljeno s: https://ojs.aaai.org/index.php/ICWSM/article/view/3356/3224 (18. 10. 2021)

[11] Anderson, C. L., & Agarwal, R. (2010). Practicing safe computing: A multimethod empirical examination of home computer user security behavioral intentions. *MIS quarterly,* 613-643. Pridobljeno s: https://sci-hub.se/https://www.jstor.org/stable/25750694 (18. 10. 2021)

[12] Redmiles, E. M., Bodford, J., & Blackwell, L. (2019, July). "I just want to feel safe": A Diary Study of Safety Perceptions on Social Media. In *Proceedings of the International AAAI Conference on Web and Social Media* (Vol. 13, pp. 405-416).

[13] Duggan, M. (2017). *Online harassment 2017.* Pridobljeno s: https://www.cybersmile.org/wp-content/uploads/PI_2017.07.11_Online-Harassment_FINAL.pdf (18. 10. 2021)

[14] Joshi, P., & Kuo, C. C. J. (2011, July). Security and privacy in online social networks: A survey. In *2011 IEEE international conference on multimedia and Expo* (pp. 1-6). IEEE. Pridobljeno s: https://ieeexplore.ieee.org/abstract/document/5755600 (18. 10. 2021)

[15] Zhang, Z., & Gupta, B. B. (2018). Social media security and trustworthiness: overview and new direction. *Future Generation Computer Systems, 86,* 914-925. Pridobljeno s: https://www.sciencedirect.com/science/article/abs/pii/S0167739X16303879 (7. 10. 2021)

[16] Rathore, S., Sharma, P. K., Loia, V., Jeong, Y. S., & Park, J. H. (2017). Social network security: Issues, challenges, threats, and solutions. *Information sciences, 421,* 43-69. Pridobljeno s: https://www.sciencedirect.com/science/article/abs/pii/S0020025517309106 (7. 10. 2021)

[17] Nemec Zlatolas, L. (2015). *Model vpliva zasebnosti na razkrivanje informacij uporabnikov družbenega omrežja Facebook* (Doktorska disertacija, Univerza v Mariboru). Pridobljeno s: https://dk.um.si/Dokument.php?id=82890 (7. 10. 2021)

[18] Svetin, I. (2019). *Mladi v Sloveniji: več kot polovica jih je vključenih v formalno izobraževanje.* Pridobljeno s: https://www.stat.mladisi/StatWeb/news/Index/8070 (22. 11. 2021)

[19] FOS. (2007). *Klasifikacija področij znanosti in tehnologije.* Pridobljeno s http://www.arrs.si/sl/gradivo/sifranti/inc/FOS-2007.pdf (29. 11. 2021)

Analiza rezultatov tretjega poskusnega tekmovanja v programiranju z delčki Pišek

Analysis of the Results of the Third Pišek Block-Based Programming Competition

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POVZETEK

V prispevku analiziramo značilnosti nalog, ki vplivajo na učenčevo uspešnost pri reševanju nalog v okolju Pišek. Za ta namen z uporabo metod strojnega učenja modeliramo dosežke učencev iz tretjega poskusnega šolskega tekmovanja Pišek, ki je potekalo leta 2021 in je bilo organizirano pod okriljem društva ACM Slovenija. Opisujemo in ocenjeno težavnost in diskriminativnost tekmovalnih nalog v osnovnošolskih tekmovalnih kategorijah ter navajamo oblike nalog in otežitve programskega okolja, ki so imele največji vpliv na dosežke tekmovalcev znotraj posamezne tekmovalne kategorije. Z indeksom težavnosti in indeksom diskriminativnosti ocenjujemo, katere naloge so tekmovalcem v največji izziv za reševanje oz. katere naloge najbolje ločijo med dosežki tekmovalcev. V nadaljevanju znotraj vsake tekmovalne kategorije kategoriziramo naloge glede na predstavitvene oblike nalog (naloge na mreži, želvja grafika, vhodno-izhodne naloge) in otežitve programskega okolja (omejeno število delčkov, razširjen nabor delčkov, testi). Za vsako tekmovalno kategorijo z napovednimi modeli - zgrajenimi z uporabo naključnih gozdov - ocenjujemo, katere spremenljivke (značilnosti) imajo največji vpliv na dosežke tekmovalcev.

KLJUČNE BESEDE

Tekmovanje, Pišek, programiranje, delčki, koncepti, oblike, otežitve, naloge

ABSTRACT

In this paper, we analyse the task characteristics that influence students' performance in solving tasks in the Pišek environment. To this end, we use machine learning methods to model the performance of students in the third Pišek School Trial Competition, which took place in 2021 and was organised under the auspices of ACM Slovenia. We describe and evaluate the difficulty and discriminability of the competition tasks in the primary school competition categories, and list the task formats and software environment complexity that had the greatest impact on the performance of the participants in each competition category. We characterise the tasks using a difficulty index and a discriminability index. These two measures are used to assess which tasks were the biggest challenge for participants and which tasks best discriminated between participants' performance, respectively. Within each competition category, we categorize the tasks according to the tasks forms (tasks on the grid, turtle graphics, input-output tasks) and the programming environment complexity (limited number of blocks, extended set of blocks, tests). For each competition category, we use predictive models built using random forests to evaluate which variables (features) have the greatest impact on participants' performance.

KEYWORDS

Competition, Pišek, programming, blocks, concepts, forms, complexity, tasks

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1 UVOD

V digitalni družbi ima programiranje pomembno vlogo, saj je ustvarjanje programske opreme ključni element vseh digitalnih naprav. Vendar programiranje ni le pisanje kode, je mnogo več kot to. Z učenjem programiranja se naučimo reševati probleme, kreativno, logično in abstraktno razmišljati. Znanje programiranja nam omogoča boljše razumevanje tehnologije, njenih prednosti in omejitev. Zaradi vseh pozitivnih lastnosti učenja programiranja je pomembno, da programiranje postane del obveznega osnovnošolskega kurikula.

Z uveljavljanjem položaja računalništva v osnovnošolskih kurikulumih so se v zadnjih dveh desetletjih ukvarjale številne evropske države [1]. V slovenskih osnovnih šolah se računalniške vsebine poučujejo v okviru neobveznega izbirnega predmeta računalništvo v drugem triletju osnovne šole in obveznega izbirnega predmeta računalništvo v tretjem triletju osnovne šole, kar pomeni, da se zaradi izbirnosti mnogi učenci v času osnovnošolskega izobraževanja z računalništvom ne srečajo. Učna načrta za oba osnovnošolska računalniška predmeta vsebujeta vsebine s področja programiranja, pri čemer je pri obveznem izbirnem predmetu računalništvo programiranje del izbirnih vsebin. S programiranjem se lahko učenci srečajo pri še dveh izbirnih naravoslovnih predmetih, in sicer pri robotiki v

tehniki in pri elektroniki z robotiko. Izključenost oz. slaba zastopanost računalništva v osnovnošolskem in srednješolskem izobraževanju pri učencih vodi do nepoznavanja temeljnih računalniških vsebin. To omejitev lahko delno presežemo z izvedbo računalniških tekmovanj in s tem pripomoremo k boljšemu razumevanju delovanja digitalnega sveta ter verjetno k odločitvi nekaterih dijakov za študij računalništva [2]. Jukić in Matić trdita, da tekmovanja ustvarijo okoliščine, ki omogočijo računalništvu in drugim predmetnim področjem, da postanejo bolj zanimiva za učenje [3]. Tekmovanja iz računalništva omogočajo uporabo novega znanja in predstavljajo dober način za medpredmetno povezovanje tehnologije, naravoslovja, matematike in izobraževanja [4].

2 TEKMOVANJE PIŠEK

Društvo ACM Slovenija poleg univerzitetnega programerskega maratona (v nadaljevanju tekmovanje UPM), tekmovanja iz računalništva in informatike (v nadaljevanju tekmovanje RTK) in tekmovanja iz računalniškega mišljenja Bober (v nandaljevanju tekmovanje Bober) organizira osnovnošolsko in srednješolsko tekmovanje iz programiranja z delčki Pišek (v nadaljevanju tekmovanje Pišek) [5]. Namen tekmovanja Pišek je spodbuditi zanimanje učencev za programiranje in ustvariti okolje, kjer učenci tekmujejo med seboj iz osnov programiranja in razvijajo svoj talent za programiranje. Tekmovanje Pišek predstavlja most med tekmovanjema Bober, ki privabi veliko tekmovalcev, in tekmovanjem RTK, ki privabi le malo tekmovalcev [6]. Tekmovanje Pišek je bilo leta 2022 prvič uradno izvedeno. Pred tem je od leta 2020 do leta 2021 potekalo na poskusni ravni. Izvedena so bila tri poskusna tekmovanja. Zadnje od poskusnih tekmovanj je beležilo prek 1000 udeležencev. Vsa tekmovanja so potekala v programskem jeziku Blockly na francoskem strežniku, podobnem sistemu Algoreja, ki omogoča izvedbo tekmovanja z avtomatskim preverjanjem pravilnosti rešitev [6]. Tekmovalne naloge oblikuje Programski svet tekmovanja.

2.1 Tretje poskusno tekmovanje Pišek

Tretje poskusno tekmovanje je potekalo od 1. 2. 2021 do 12. 2. 2021 in je beležilo prek 1000 udeležencev. Tekmovanje je trajalo 35 min in je bilo izvedeno v sledečih tekmovalnih kategorijah:

- 4.–6. razred osnovne šole - začetniki
- 4.–6. razred osnovne šole - napredni
- 7.–9. razred osnovne šole - začetniki
- 7.–9. razred osnovne šole - napredni
- srednja šola - začetniki
- srednja šola - napredni [7].

2.2 Naloge na tretjem poskusnem tekmovanju Pišek

Naloge na tekmovanju Pišek se razlikujejo v programskih konceptih v rešitvah nalog, predstavitvenih oblikah nalog in otežitvah programskega okolja. To so skupine dejavnikov, ki jih bomo v nadaljevanju podrobneje predstavili. Posamezne dejavnike[1] bolj natančno opisujemo s ciljem, da bi dobili globlji vpogled vanje in v njihov vpliv na kognitivno zahtevnost nalog, za katero domnevamo, da se pokaže pri tekmovalnem rezultatu tekmovalcev.

2.2.1 Programski koncepti. Z modifikacijo nabora programskih konceptov, ki ga je predlagal programski svet tekmovanja Pišek in naborom programskih konceptov iz Kongove, S. C. [8] in Brennan, K. in Resnick, M. [9] študije smo opisali značilnosti tekmovanja Pišek in za potrebe naše raziskave oblikovali sledeč nabor programskih konceptov.

- Zaporedje ukazov
- Zanka:
  - Končna zanka
  - Zanka s pogojem
  - Kompleksnejša zanka
  - Vgnezdene zanke
- Pogojni stavek
- Podatki:
  - Branje in izpis podatkov o spremenljivka
- Nizi
- Operator:
  - Logični in primerjalni operatorji
- Senzorji
- Funkcija

2.2.2 Predstavitvene oblike nalog. Z modifikacijo nabora predstavitvenih oblik nalog, ki jih je predlagal programski svet tekmovanja Pišek smo opisali značilnosti tekmovanja Pišek in za potrebe naše raziskave oblikovali sledeč nabor predstavitvenih oblik nalog.

Želvja grafika: tekmovalci z uporabo želvje grafike ustvarijo program, ki izriše zahtevano grafično podobo. Takšne naloge pogosto vključujejo večkratne ponovitve določenega zaporedja ukazov (Slika 1).

Slika 1: Želvja grafika

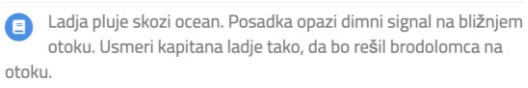
Vhodno-izhodna naloga: tekmovalci sestavijo program, ki prebere vhodne podatke in ob upoštevanju njihovih značilnosti izpiše ustrezno vrednost na izhodu (Slika).

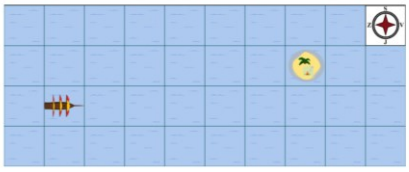
Slika 2: Vhodno-izhodna naloga

[1] Dejavniki, opisne karakteristike nalog. Pozneje pri modeliranju s strojnim učenjem nastopajo kot spremenljivke.

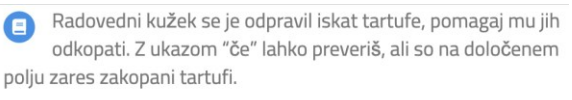
Naloga na mreži: tekmovalci sestavijo program, ki premika lik po mreži in z njim opravlja zahtevana opravila. Lik se premika bodisi relativno glede na pozicijo (naprej, nazaj, levo, desno, okoli), bodisi absolutno (sever, jug, zahod, vzhod).

- **Mreža brez aktivnosti**: tekmovalci sestavijo program, ki premika lik od začetnega do ciljnega polja (Slika).
- **Mreža z aktivnostmi:** tekmovalci sestavijo program, ki premika lik od začetnega do ciljnega polja in medtem na označenih poljih izvede zahtevano aktivnost npr. pobere predmet, se obrne za 90° itd. (Slika).
- **Mreža s prostorsko razpršenimi aktivnostmi:** tekmovalci sestavijo program, ki premika lik od začetnega do ciljnega polja na način, da obišče vsa polja na mreži in med potjo na označenih poljih izvede zahtevano aktivnost npr. pobere predmet, se obrne za 90° itd. (slika 5).
- **Mreža s prepovedanimi polji:** tekmovalci sestavijo program, ki premika lik od začetnega do ciljnega polja, a le po poljih, na katerih ni ovire. Oviro lahko predstavlja reka, ograja, cesta itd. (Slika).
- **Mreža z vzorcem:** tekmovalci na mreži prepoznajo vzorec in sestavijo program, ki premika lik od začetnega do končnega polja, skladno z razpoznanim vzorcem (Slika).





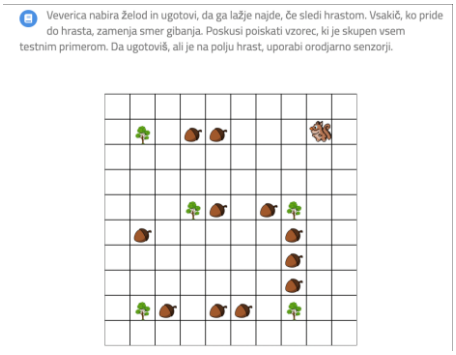
Slika 3: Mreža brez aktivnosti



Slika 4: Mreža z aktivnosti

Slika 5: Mreža s prostorsko razpršenimi aktivnostmi

Slika 6: Mreža s prepovedanimi polji

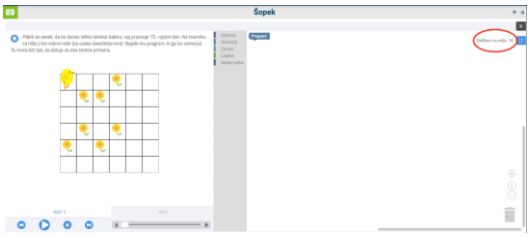


Slika 7: Mreža z vzorcem

2.2.3 Otežitve programskega okolja. Z modifikacijo nabora otežitev programskega okolja, ki sta ga opredelila M. Lokar in M. Mujkić [10] smo opisali značilnosti tekmovanja Pišek in za potrebe naše raziskave, oblikovali sledeč nabor otežitev programskega okolja.

Brez otežitev: naloga ne vsebuje omejenega števila delčkov, testov ali razširjenega nabora delčkov.

Omejeno število delčkov: omejitev določa največje možno število porabljenih delčkov za rešitev problema. Omejitev števila delčkov tekmovalce spodbudi k ustvarjanju krajše in kognitivno zahtevnejše rešitve (Slika).



Slika 8: Omejeno število delčkov

Prisotnost testov: omejitev preverja splošnost rešitve in zagotavlja, da program celostno reši problem. Naloga s testi je uspešno rešena takrat, ko program prestane vse teste (Slika).

Slika 9: Prisotnost testov

Razširjen nabor delčkov: vsaka od nalog vsebuje zbirko delčkov, ki jo je možno uporabiti med reševanjem naloge. Naloge z razširjenim naborom delčkov poleg nujno potrebnih delčkov vsebujejo tudi odvečne delčke, kar lahko zmede tekmovalca in vpliva na uspešnost njegovega reševanja naloge (Slika).

Slika 10: Razširjen nabor delčkov

3 ANALIZA

3.1 Vzorec

V raziskavi smo analizirali tekmovalne naloge, ki so bile uporabljene na šolski ravni tretjega poskusnega tekmovanja Pišek v šolskem letu 2020/21. Preučili smo dosežke tekmovalcev, ki so tekmovali v tekmovalnih kategorijah za osnovno šolo:

- 4.–6. razred osnovne šole - začetniki
- 4.–6. razred osnovne šole - napredni
- 7.–9. razred osnovne šole - začetniki
- 7.–9. razred osnovne šole - napredni

Vzorec je sestavlja vsega 1494 osnovnošolskih tekmovalcev, ki so tekmovali na tretjem poskusnem tekmovanju iz programiranja z delčki Pišek.

3.2 Obdelava podatkov

3.2.1 Indeks težavnosti nalog. Težavnost nalog smo določili z izračunom indeksa težavnosti. Indeks težavnosti nalog je definiran kot povprečen delež doseženih točk tekmovalcev pri posamezni nalogi. Indeks težavnosti zavzema vrednost med 0 in 1. Zahtevnejša ko je naloga, nižji je indeks težavnosti [11]. Naloga je zahtevna, če ima indeks manjši ali enak 0,33 in lahka, če ima indeks večji ali enak 0,70.

3.2.2 Indeks diskriminativnosti nalog. Diskriminativnost nalog smo določili z izračunom indeksa diskriminativnosti. Indeks diskriminativnosti je definiran kot razlika med indeksom težavnosti naloge zgornje tretjine vzorca in indeksom težavnosti naloge spodnje tretjine vzorca, pri čemer je vzorec razdeljen na tretjine glede na končni dosežek tekmovalcev. Indeks diskriminativnosti pove, v kolikšni meri naloga ločuje med dosežki tekmovalcev zgornje in spodnje tretjine. Indeks diskriminativnosti zavzame vrednost med -1 in 1 in je pozitiven, če so tekmovalci zgornje tretjine uspešneje rešili nalogo kot tekmovalci spodnje tretjine ter negativen, če so tekmovalci spodnje tretjine uspešneje rešili nalogo kot tekmovalci zgornje tretjine. Vrednost indeksa okoli nič ponazarja, da so tekmovalci obeh tretjin približno enako dobro rešili nalogo.

3.2.3 Napovedni modeli. Moč vpliva predstavnostnih oblik nalog in otežitve programskega okolja na dosežke tekmovalcev smo izmerili z metodo strojnega učenja, naključni gozdovi. Z naključnimi gozdovi smo ustvarili več modelov in iz njih razbrali, kateri dejavniki so imeli največji vpliv na dosežek tekmovalca na tekmovanju. V napovednih modelih smo za ciljno spremenljivko uporablili dosežek učenca na tekmovanju, izražen v obliki deleža doseženih točk na tekmovanju. Za neodvisne napovedne spremenljivke smo uporabili dosežek učenca pri nalogah, ki se ujemajo v predstavitvenih oblikah nalog in otežitvah programskega okolja. Napovedne modele smo oblikovani za vse tekmovalne kategorije. Preverili smo uspešnost vsakega napovednega modela in z interpretacijo napovednih modelov odkrili, kateri dejavniki so na tretjem poskusnem tekmovanju Pišek najbolj pomembni oz. imajo največji vpliv na dosežek tekmovalca na tekmovanju Pišek.

4 REZULTATI

4.1 Analiza težavnost in diskriminativnost nalog

4.1.1 Način analize podatkov. Vse spodaj opisane rezultate smo dobili z izračunom indeksa težavnosti in diskriminativnosti nalog v izbrani tekmovalni kategoriji.

4.1.2 Ugotovitve. V vseh tekmovalnih kategorijah je najlažja prva naloga in najtežja zadnja naloga, kar je razvidno iz indeksov težavnosti nalog (Tabela).

V tekmovalni kategoriji od 4. do 6. razreda (začetniki), je najtežja naloga Skriti tartufi (5. naloga), ki je hkrati tudi najbolj diskriminativna (Tabela in Tabela 2). V ostalih tekmovalnih kategorijah je najtežja naloga najmanj diskriminativna. Od tod lahko sklepamo, da so bile v preostalih tekmovalnih kategorijah

5. naloge zelo težke za reševanje, saj jih je rešilo majhno število tekmovalcev (Tabela 2).

Tabela 1: Indeks težavnosti tekmovalnih nalog

Naloga	Od 4. do 6. razreda (začetniki)	Od 4. do 6. razreda (napredni)	Od 7. do 9. razreda (začetniki)	Od 7. do 9. razreda (napredni)
1. naloga	0,969	0,747	0,870	0,533
2. naloga	0,945	0,399	0,829	0,476
3. naloga	0,856	0,399	0,602	0,286
4. naloga	0,869	0,283	0,554	0,381
5. naloga	0,733	0,134	0,078	0,076

Tabela 2: Indeks diskriminativnosti tekmovalnih nalog

Naloga	Od 4. do 6. razreda (začetniki)	Od 4. do 6. razreda (napredni)	Od 7. do 9. razreda (začetniki)	Od 7. do 9. razreda (napredni)
1. naloga	0,095	0,724	0,344	0,943
2. naloga	0,170	0,908	0,467	0,971
3. naloga	0,396	0,931	0,911	0,800
4. naloga	0,435	0,770	0,956	0,771
5. naloga	0,802	0,391	0,233	0,229

Indeksa težavnosti naloge Ubbi dubbi (5. naloga) iz tekmovalne kategorije od 7. do 9. razreda (začetniki) in naloge Ježek pospravlja (5. naloga) iz tekmovalne kategorije od 7. do 9. razreda (napredni) sta zelo nizka, kar nakazuje na preveliko zahtevnost obeh nalog (Tabela).

Najbolje so bile zasnovane naloge v kategoriji od 4. do 6. razreda (napredni). Glede na indeks težavnosti je tekmovalna kategorija imela eno lahko nalogo, dve srednje zahtevni nalogi in eno težko nalogo (Tabela). Vse ostale kategorije so imele preveč lahkih nalog.

4.2 Analiza programskih konceptov v rešitvah nalog

4.2.1 Način analize podatkov. Spodaj navedene rezultate smo dobili z izračunom indeksa težavnosti nalog Nezani element in Skriti tartufi iz tekmovalne kategorije od 4. do 6. razreda (začetniki) in povezovanjem dobljenih podatkov s prisotnostjo in razporeditvijo programskih konceptov v rešitvah obeh nalog.

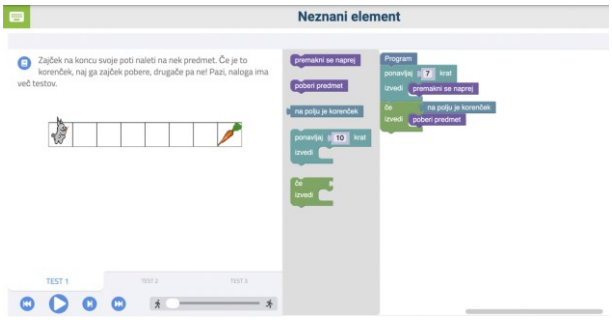
4.2.2 Ugotovitve. V tekmovalni kategoriji od 4. do 6. razreda (napredni) sta prisotni tekmovalni nalogi Neznani element in Skriti tartufi. Naloga Skriti tartufi ima nižji indeks težavnosti kot naloga Neznani element, kar pomeni, da je bila slednja naloga tekmovalcem lažja za reševanje (Tabela).

Nalogi v rešitvah vsebujeta enake programske koncepte: zaporedje ukazov, pogojni stavek in končno zanko, pri čemer so programski koncepti v rešitvi naloge Neznani elementi (Slika 11) drugače razporejeni kot v rešitvi naloge Skriti tartufi (Slika 12).

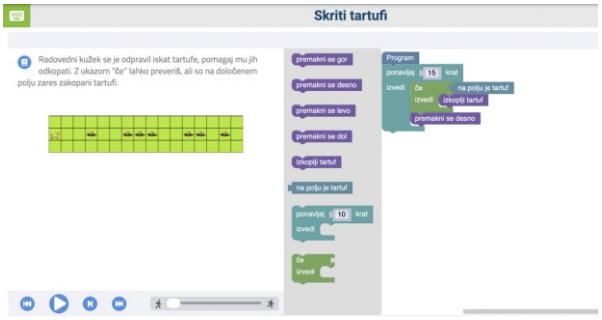
Na podlagi različnih indeksov težavnosti nalog in različne razporeditve enakih programskih konceptov v obeh nalogah, lahko sklepamo, da imajo programski vzorci vpliv na uspešnost reševanja nalog, pri čemer so programski vzorci formalizirane rešitve oz. sklopi med seboj povezanih programskih konceptov, ki jih lahko programer večkrat uporabi za reševanje problemov [12]. Menimo, da je zmožnost prepoznavanja in uporabe programskih vzorcev povezana z izkušnjami posameznika z reševanjem tipičnih problemov, ki izzovejo uporabo ustreznega vzorca [13]. Analiza uporabe programskih vzorcev v rešitvah nalog in njihov vpliv na težavnost naloge je predmet nadaljnjih raziskav.

Tabela 3: Indeks težavnosti nalog Neznani element in Skriti tartufi

Naloga	Indeks težavnosti
Neznani element (3. naloga)	0,856
Skriti tartufi (5. naloga)	0,733



Slika 11: Naloga Neznani element



Slika 12: Naloga skriti tartufi

4.3 Analiza predstavitvenih oblik nalog

4.3.1 Način analize podatkov. Spodaj navedene rezultate smo dobili z interpretacijo napovednih modelov, zgrajenih z naključnimi gozdovi. Za ciljno spremenljivko smo uporabili dosežek učenca na tekmovanju in za neodvisne napovedne spremenljivke dosežek učenca pri nalogah, ki se ujemajo v predstavitvenih oblikah nalog.

4.3.2 Ugotovitve. Na tekmovanju Pišek ima v tekmovalni kategoriji od 4. do 6. razreda (začetniki) dejavnik mreža z aktivnostmi večjo napovedno moč in posledično večji vpliv na dosežek učenca kot dejavnik mreža brez aktivnosti (Tabela).

V tekmovalni kategoriji od 4. do 6. razreda (napredni) analiza dosežkov ni pokazala pomembnih rezultatov. Napovedni model je obema dejavnikoma (mreža z vzorcem in mreža s prepovedanimi polji) pripisal skoraj enako napovedno moč, iz česar smo sklepali, da sta v preučevani tekmovalni kategoriji imeli obe obliki nalog podoben vpliv na dosežek učencev (Tabela).

V kategoriji od 7. do 9. razreda (začetniki) je bil vpliv oblik nalog na dosežek učencev izrazitejši. Napovedni model je dejavnika želvja grafika in mreža z vzorcem označil kot najpomembnejši. Sledili sta jima mreža z aktivnostmi in vhod-izhod (Tabela).

V tekmovalni kategoriji od 7. do 9. razreda (napredni) je model največjo napovedno moč dodelil dejavniku mreža s prostorsko razpršenimi aktivnosti, sledili sta ji želvja grafika in vhod-izhod (Tabela).

Tabela 4: Razporeditev dejavnikov iz skupine predstavitvene oblike nalog od najbolj pomembnega do najmanj pomembnega

Od 4. do 6. razreda (začetniki)	Od 4. do 6. razreda (napredni)	Od 7. do 9. razreda (začetni)	Od 7. do 9. razreda (napredni)
Mreža z aktivnostmi	Mreža s prepovedanimi polji	Želvja grafika	Mreža s prostorsko razpršenimi aktivnostmi
Mreža brez aktivnosti	Mreža z vzorcem	Mreža z vzorcem	Vhod-izhod
		Mreža z aktivnostmi	Želvja grafika
		Vhod-izhod	

4.4 Analiza otežitev programskega okolja

4.4.1 Način analize podatkov. Spodaj navedene rezultate smo dobili z interpretacijo napovednih modelov, zgrajenih z naključnimi gozdovi. Za ciljno spremenljivko smo uporabili dosežek učenca na tekmovanju in za neodvisne napovedne spremenljivke dosežek učenca pri nalogah, ki se ujemajo v otežitvah programskega okolja.

4.4.2 Ugotovitve. Na tekmovanju Pišek imata v tekmovalni kategoriji od 4. do 6. razreda (začetniki) dejavnika omejitev števila delčkov in brez otežitev največji vpliv na dosežke tekmovalcev (Tabela).

V tekmovalni kategoriji od 4. do 6. razreda (napredni) imata največji vpliv dejavnika prisotnost testov in omejeno število delčkov. V preučevani kategoriji je imel najmanjši vpliv na dosežke učencev dejavnik razširjen nabor delčkov (Tabela).

V kategoriji od 7. do 9. razreda (začetniki) sta imela največji vpliv na dosežke tekmovalcev dejavnika omejeno število delčkov in brez otežitev, sledil jima je dejavnik prisotnost testov (Tabela).

V kategoriji od 7. do 9. razreda (napredni) so imeli na dosežke učencev največji vpliv dejavniki omejeno število delčkov in prisotnost testov. Manjši vpliv je imel dejavnik razširjen nabor delčkov (Tabela).

4.5 Analiza predstavitvenih oblik nalog in otežitev programskega okolja

4.5.1 Način analize podatkov. Spodaj navedene rezultate smo dobili z interpretacijo napovednih modelov, zgrajenih z naključnimi gozdovi. Za ciljno spremenljivko smo uporabili dosežek učenca na tekmovanju in za neodvisne napovedne spremenljivke dosežek učenca pri nalogah, ki se ujemajo v predstavitvenih oblikah nalog in otežitveh programskega okolja.

4.5.2 Ugotovitve. V nobeni od tekmovalnih kategorij nismo opazili, da bi dejavniki iz ene skupine (npr. predstavitvene oblike nalog) izstopali pred dejavniki iz druge skupine (npr. otežitve programskega okolja). Od tod smo predpostavili, da imajo oblike nalog in otežitve programskega okolja približno enak vpliv na dosežke učencev na tretjem poskusnem tekmovanju Pišek (Tabela).

Tabela 5: Razporeditev dejavnikov iz skupine otežitve programskega okolja od najbolj pomembnega do najmanj pomembnega

Od 4. do 6. razreda (začetniki)	Od 4. do 6. razreda (napredni)	Od 7. do 9. razreda (začetni)	Od 7. do 9. razreda (napredni)
Omejitev števila delčkov	Prisotnost testov	Omejitev števila delčkov	Omejitev števila delčkov
Brez otežitev	Omejitev števila delčkov	Brez otežitev	Prisotnost testov
Prisotnost testov	Razširjen nabor delčkov	Prisotnost testov	Razširjen nabor delčkov

Tabela 6: Razporeditev dejavnikov iz skupin predstavitvene oblike nalog in otežitve programskega okolja od najbolj pomembnega do najmanj pomembnega

Od 4. do 6. razreda (začetniki)	Od 4. do 6. razreda (napredni)	Od 7. do 9. razreda (začetniki)	Od 7. do 9. razreda (napredni)
Mreža z aktivnostmi	Prisotnost testov	Omejitev števila delčkov	Omejitev števila delčkov
Omejitev števila delčkov	Omejitev števila delčkov	Mreža z aktivnostmi	Prisotnost testov
Mreža brez aktivnosti	Mreža z vzorcem	Želvja grafika	Razširjen nabor delčkov
Prisotnost testov	Mreža s prepovedanimi polji	Mreža z vzorcem	Mreža s prostorsko razpršenimi aktivnostmi
	Razširjen nabor delčkov	Vhod-izhod	Želvja grafika
		Prisotnost testov	Vhod-izhod

5 ZAKLJUČEK

V magistrskem delu smo raziskovali, katere naloge, prisotne na tretjem poskusnem tekmovanju Pišek, so tekmovalci najbolje reševali. Zanimal nas je vpliv programskih konceptov, predstavitvenih oblik nalog in otežitev programskega okolja na dosežke učencev na tekmovanju.

Ugotovili smo, katere naloge so bile znotraj tekmovalnih kategorij najtežje in najbolj diskriminativne ter katere predstavnostne oblike nalog in otežitve programskega okolja so imele največji vpliv na dosežke tekmovalcev. Z analizo primerov smo spoznali, da imata lahko dve nalogi z enakimi programskimi koncepti, ki so znotraj prve naloge drugače razporejeni kot znotraj druge naloge, različna indeksa težavnosti. Na podlagi

tega smo sklepali, da imajo programski vzorci vpliv na uspešnost reševanja nalog.

Modeli, ki smo jih zgradili s statistično analizo in strojnim učenjem, so nam zadovoljivo pojasnili vpliv izbranih dejavnikov na dosežek tekmovalca na tretjem poskusnem tekmovanju Pišek znotraj tekmovalnih kategorij. Vendar kljub temu, da smo izgradili točne napovedne modele z naključnimi gozdovi, dobljenih rezultatov ne moremo posplošiti. Analiza je temeljila na premajhnem vzorcu tekmovalnih nalog znotraj tekmovalnih kategorij, kar se je odražalo v slabi zastopanosti nekaterih dejavnikov. Analiza novih, številčnejših podatkov, bi nam omogočila bolj zanesljivo modeliranje podatkov, boljši vpogled v vpliv posameznih dejavnikov na dosežek tekmovalca in opazovanje odnosov med dejavniki.

6 RAZPRAVA

Z raziskavo smo dobili boljši vpogled v vpliv programskih konceptov, predstavitvenih oblik nalog in otežitev programskega okolja na dosežke učencev. V nadaljevanju bi bilo smiselno analizirati vpliv še drugih dejavnikov kot so:

- značilnosti tekmovalcev (starost, predznanje, zanimanje za računalništvo),
- značilnosti nalog (število besed v nalogi, kompleksnost jezika, kompleksnost grafičnih elementov) ipd.

Z analizo raznolikih dejavnikov bi dobili še boljši vpogled v tekmovalne naloge.

Smiselno bi bilo izvesti tudi kvalitativno raziskavo, v kateri bi uporabili metodo glasnega razmišljanja pri tekmovalcih, ki so različno uspešno reševali srednje težke naloge. Z njo bi opazovali način razmišljanja tekmovalcev in odkrili morebitne napačne miselne predstave, ki se pojavijo med reševanjem nalog.

Predvidevamo, da smo z do sedaj pridobljenimi rezultati članom Programskega sveta tekmovanja Pišek omogočili oboljši vpogled v tekmovalne naloge in posledično lažjo sestavo nadaljnjih tekmovanj Pišek. V bodoče upamo, da bodo rezultati analize v pomoč sestavljavcem učnih načrtov pri izbiri kognitivno ustrezno zahtevnih vsebin za obvezni predmet računalništva. Obenem si želimo, da bodo učitelji na podlagi pojasnjenih rezultatov pridobili koristne informacije, ki jim bodo omogočile kakovostnejše oblikovanje učnih ur.

ZAHVALA

Hvala članom programskega sveta Pišek za omogočen dostop do rezultatov tretjega poskusnega tekmovanja v programiranju z delčki Pišek.

LITERATURA IN VIRI

[1] Caspersen, M. E., Gal-Ezer, J., McGettrick, A. in Nardelli, E. (2018). Informatics for All: The strategy. ACM. https://www.ft-informatik.de/pdf/Informatics4All-Strategy- Paper.pdf

[2] Verhoeff, T. (1997). *The Role of Competitions in Education*. Faculty of Mathematics and Computing Science: Eindhoven, Nizozemska.

[3] Jukič, L., Matić, I. (2011). The role of competitions in computer science curriculum. *Croatian Journal of Education, 13*(3), 201 – 231.

[4] Dagiene, V. (2006). Competition in Information Technology – learning in an attractive way. *Informatics in Education, 5 (1),* 37 – 46. https://www.researchgate.net/publication/220396214_Information_Technology_Contests_Introduction_to_Computer_Science_in_an_Attractive_Way

[5] ACM Tekmovanja. (b. d.). https://tekmovanja.acm.si/

[6] Lokar, M. (2020). Pišek – Programming with Blocks Competition A new Slovenian Programming Competition. Kori, K., Laanpere, M. (ur.) *Proceedings of the International Conference on Informatics in School: Situation, Evaluation and Perspectives: ISSEP 2020* (zv. 2755, str. 1 – 12). CEUR-WS. http://ceur-ws.org/Vol- 2755/

[7] ACM Tekmovanja – Pišek. (b. d.). https://tekmovanja.acm.si/?q=pisek

[8] Kong, S. C. (2019). Components and methods of evaluating computational thinking for fostering creative problem-solvers in senior primary school education. V S. C. Kong (ur.) in H. Abelson (ur.), *Computational Thinking Education* (str. 119 – 141). Singapur: Springer. https://link.springer.com/chapter/10.1007/978-981-13-6528-7_8

[9] Brennan, K. in Resnick, M. (2012). New frameworks for studying and assessing the development of computational thinking. *AERA*. http://web.media.mit.edu/~kbrennan/files/Brennan_Resnick_AERA2012_CT.pdf

[10] Lokar, M. in Mujkić, M. (2021). Računalniško tekmovanje Pišek – oblika vzpodbujanja učenja programiranja za vse. *Uporabna informatika 29* (1) 3 – 15. https://uporabna-informatika.si/index.php/ui/issue/view/2021-01/2021-01

[11] Cankar, G., Hauptman, A., Urank, M. in Zupanc, D. (2010). Priročnik za uporabo »*Orodja za analizo izkazanega znanja ob zaključku srednje šole*«. Državni izpitni center.

[12] Amanullah, K. in Bell, T. (2019). Analysis of Progression of Scratch Users based ontheir Use of Elementary Patterns. *14th International Conference on Computer Science & Education: ICCSE 2019,* (str. 573–578). https://ieeexplore.ieee.org/document/8845495

[13] Zapušek, M. (2022). Domenska ontologija programskih vzorcev pri uvodnem programiranju [doktorska disertacija]. Univerza v Ljubljani, Pedagoška fakulteta.

[14] David Kosiur. 2001. *Understanding Policy-Based Networking* (2nd. ed.). Wiley, New York, NY

Učencem prijazno poučevanje na daljavo

Student-Friendly Distance Learning

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POVZETEK

Med poučevanjem na daljavo je bil učitelj primoran iskati nove metode in oblike dela, s katerimi bi popestril pouk ter podal kakovostno znanje učencem. Pri tem je moral najti ustrezno izobraževalno tehnologijo, ki je bila učencem v pomoč pri doseganju vsebin in ciljev v vzgojno-izobraževalnem procesu. To od učitelja zahteva nenehen razvoj in raziskovanje tega področja. Preko različnih vsebin smo izvajali učenje ter samostojno delo s pomočjo PowerPointa, Geniallya, Padleta, Vibra, Xooltima, Zooma ter Worda. Uporaba zgoraj omenjenih računalniških in spletnih aplikacij je bila učencem v pomoč pri razumevanju snovi ter pridobivanju novih znanj. Hkrati pa jim je omogočala večkratno razlago nove snovi in utrjevanje le-te. Uporabljene aplikacije so učencem omogočale, da so bili v času izobraževanja na daljavo aktivni, da so pridobili in utrdili nova znanja ter da niso izgubili stika s sovrstniki ter šolo. Nastala je cela paleta izdelkov, razlag, primerov dobrih praks, ki jih učitelji lahko brez večjih težav uporabimo pri klasičnem pouku kot pri pouku na daljavo.

KLJUČNE BESEDE

Poučevanje na daljavo, IKT tehnologija, digitalna pismenost

ABSTRACT

During distance teaching, the teacher was forced to look for new methods and forms of work, which would enrich the lessons and transfer quality knowledge to the students. In doing so, he had to find the appropriate educational technology that could help students to grasp the contents and achieve the goals in the educational process. Therefore, the teacher is required to constantly develop and research in the field of distance learning. Through various contents, we carried out group and individual learning with the help of PowerPoint, Genially, Padlet, Viber, Xooltime, Zoom and Word. The use of the above-mentioned computer and online applications helped the students to understand the material and acquire new knowledge. At the same time, it enabled them to listen or watch the explanation for the new learning topic more times and consolidate it. The above-mentioned applications enabled the students to be active during the distance education, to acquire and consolidate new knowledge, and to keep in touch with their peers and school. A whole range of products, explanations, and examples of good practice have been created and they can be used by teachers without difficulty in both traditional and remote classes.

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KEYWORDS

Distance teaching, Information and Communication Technology, digital literacy

1 UVOD

Zadnji dve leti sta prinesli veliko sprememb, še posebno v šolstvu, kjer se je prevetril celotni sistem izobraževanja, ki je potekalo bodisi v šoli, doma ali hibridno. Od učitelja se je vseskozi pričakovalo, da je inovativen, prilagodljiv, predvsem pa, da venomer išče rešitve, kako izpeljati pouk na daljavo, da bo učencem predal čim več znanja. Čeprav danes živimo v digitalni dobi, kjer se na vsakem koraku srečujemo z različnimi oblikami tehnologije, je digitalno pismenih le okoli 50 % Slovencev, povprečje v EU je 53 % [9]. Po podatkih Statističnega urada Slovenije ima dostop do interneta kar 93 % gospodinjstev v Sloveniji, kar je za nekaj odstotkov več v primerjavi z letom pred epidemijo.

Zadnji dve leti je opazen napredek v digitalni pismenosti med učenci. Le-ti so v zadnjih dveh letih pridobili velik spekter tehnološkega znanja na področju digitalne pismenosti.

Večja digitalna pismenost med učenci pa je učitelju omogočila pestrejši, inovativnejši in zanimivejši izbor spletnih programov tako pri pouku na daljavo kot v šoli.

2 METODE DELA

Delo je potekalo v domačem okolju. Zaradi varstva osebnih podatkov bomo v prispevku uporabljali samo moško obliko učenca.

Če smo se prvo leto šolanja na daljavo učitelji najbolj ukvarjali s problemom, kako vešči so učenci z računalnikom ter kakšno je njihovo poznavanje osnovnih računalniških programov, je delo v drugem letu šolanja na daljavo temeljilo na tem, da učencem ponudimo čim bolj kakovosten pouk, s katerim bi učenci pridobili kvalitetno znanje. Pri tem so si lahko učitelji sami izbirali spletno aplikacijo za avdio in video komunikacijo, prav tako so si sami urejali spletne učilnice. Na naši šoli smo se posluževali ZOOM-a ter spletne učilnice XOOLTIME, v okviru easistenta. Kljub temu, da imajo v razredu skoraj vsi petošolci pametne telefone ter da vsakodnevno dostopajo do spleta, bodisi

zaradi komunikacije s sošolci ali pa zaradi igranja igric, so imeli na začetku kar nekaj težav z vpisovanjem v spletno učilnico in pregledovanjem gradiv, zato smo prvi dostop opravili skupaj v šoli. V okviru aktiva petošolcev smo vsaka dva dni naložili domačo nalogo v spletno učilnico, kar se nam je kasneje, v času pouka na daljavo, tudi obrestovalo.

Znotraj aktiva petošolcev smo strmeli k enotnemu sistemu dela, imeli smo enak urnik, enak čas videokonferenc, enako zadolžitev učencev ter enotno podajanje znanja ter ocenjevanja. Poleg rednega pouka smo učencem ponudile tudi dodatni in dopolnilni pouk, poročanje knjig za bralno značko ter svetovalne ure, ki so bile namenjene učencem, ki snovi niso najbolje razumeli ter so rabili dodatno pomoč. Skušali smo pouk na daljavo organizirati tako, da je postal rutina, saj smo s tem močno zmanjšali vlogo staršev, učenci pa so postali samostojnejši in bolj vešči ravnanja z različnimi aplikacijami.

Pri podajanju znanja smo se posluževali različnih spletnih aplikacij, kot so Zoom, Xooltime, Padlet, PowerPoint, X- mind, Genially in Youtube.

Sledilo je samostojno delo s pomočjo IKT v domačem okolju.

Primer slike 1 prikazuje tedensko zadolžitev učencev na daljavo.

ure	PONEDELJEK	TOREK	SREDA	ČETRTEK	PETEK
1. 8.00	SLJ – H. C. Andersen: Mala morska deklica (BERILO)	SLJ –Poustvarjanje – nadaljevanje zgodbe (oddati učiteljici)	MAT – PISNO ODŠTEVANJE DO 10 000 DZ str. SDZ 2/10-14	MAT – PISNO SEŠTEVANJE TER ODŠTEVANJE Znam za več str. 26, 27	SLJ –Ustno preverjanje znanj (odgovore zapiše v zvezek)
2. 9.00	SLJ – H. C. Andersen: Mala morska deklica (odgovori na vprašanja - priponka)	NIT – Voda	SLJ – Značilnosti pravljic – zapis v zvezek v obliki miselnega vzorca	GUM – Na obisku pri teti Pehti – ritmične vaje	ŠPO – Daljši sprehod
3. 10.00	RU- bonton na videokonferencah	NIT – Stanje vode se spreminja	DRU – Alpske pokrajine, rastlinstvo in živalstvo DZ str. 46, 47	TJA -ZOOM	MAT - PONAVLJAMO UL
4.	DRU - Alpske pokrajine, površje, podnebje in vodovje DZ str. 45, 46	MAT – PISNO SEŠTEVANJE DO 10 000 DZ str. SDZ 2/5-9;	DRU – Rastlinski višinski pasovi DZ str. 46	NIT – Voda je topilo – poskusi z vodo (oddati učiteljici)	LUM – Slikanje kavo (oddati učiteljici)
5.	TJA	ŠPO – Telovadimo po stanovanju	TJA	ŠPO – Športna abeceda	LUM – Slikanje kavo
6.	GOS – Družinski proračun Zapis v zvezek, načrt nakupa oddati učiteljici	DOPOLNILNI POUK		BZ	

ZOOM ure so obarvane z rumeno.

Vsak dan morajo obvezno rešiti račune (osnovne računske operacije), ki jih čakajo v razdelku DODATNI POUK. Svoje rešitve naj pošljejo pod komentar, pogovor z učiteljem, na moj mail…

Ta teden morajo oddati nadaljevanje zgodbe (SLJ, torek), poskusi z vodo (NIT, četrtek), izdelek za GOS in izdelek za likovno (petek).

Slika 1. Urnik dela

Kot je razvidno iz slike zgoraj smo s poukom pričeli vsak dan ob 8.00. Učenci so imeli na dan dve videokonferenci, kjer je učitelj podajal snov preko ZOOM aplikacije. Razlaga snovi je potekala s pomočjo drsnic, posnetkov ali frontalno s pomočjo bele table. Pri tem so učenci delali individualno, v parih ali skupinah s pomočjo Breakout Rooms. Poleg videokonferenc so bile pod tabelo z rumeno bravo označene tudi zadolžitve učencev.

Kadar je podajanje in razlaga snovi potekala brez videokonferenc, smo se posluževali predvsem razlage snovi s pomočjo Genially, PowerPointa ter objavljanjem posnetkov na Youtube kanalu.

Primer slike 2 prikazuje razlago snovi s pomočjo programa Genially.

Za uvodno motivacijo pri pouku smo uporabljali tudi program Padlet.

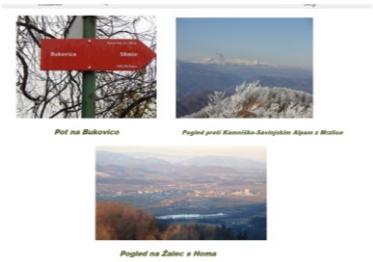
Primer slike 3 prikazuje učenčeve asociacije na besedo Eskim, pri obravnavi eskimske ljudske pravljice To ti je sreča.

Poleg rednega pouka smo imeli še tri izzive, jezikovni izziv (npr. najdi čim več asociacij na besedo šola), matematični izziv (utrjevanje računskih operacij) ter gibalni izziv (npr. kdo naredi čim več trebušnjakov v 1 min). Vsi ti izzivi so bili namenjeni sami popestritvi pouka ter zabavi.

Pri pouku na daljavo smo strmeli, da se učenci čim več gibajo, zato smo ob petkih učence zadolžile, da opravijo daljši sprehod ali se odpravijo na bližnji hrib.

Slika 2. Genially

Slika 3. Uporaba programa Padlet



Slika 4. Športna zadolžitev

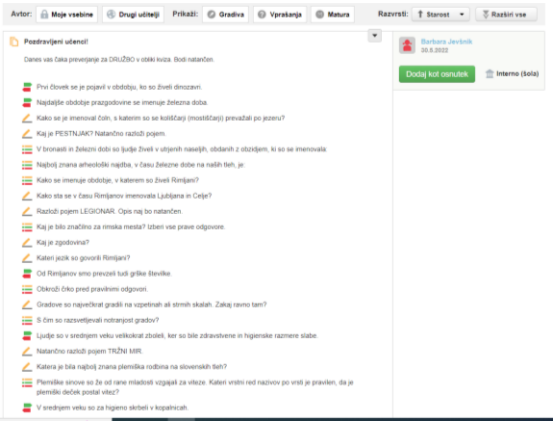
3 REZULTATI

Pomembno se nam zdi, da so bili v času šolanja na daljavo aktivni vsi učenci, tudi učenci tujci. Na naši šoli imamo že kar četrtino učencev tujcev v posameznem oddelku. Učenci so podajali svoje šolske zadolžitve na različne načine, s pomočjo različnih spletnih programov.

Največkrat so uporabili Word, PowerPoint ali pa so izdelek bodisi slikali ali posneli ter ga poslali v spletno učilnico. Kadar je delo doma potekalo praktično (npr. naravoslovni poskusi), so rezultate predstavi na videokonferenci.

Učenci tujci so se pri tem največkrat posluževali aplikacije Viber, naložene na telefon, saj največkrat niso imeli ne računalnika ali tablice. V nekaterih primerih so do spleta dostopali s pomočjo mobilnih podatkov.

Podano snov smo preverjali s pomočjo spletnih kvizov v spletni učilnici Xooltime predvsem pri slovenščini, družbi in naravoslovju in tehniki.



Slika 5. Primer spletnega kviza

Ti kvizi so nam služili, da smo ob vsakem zaključku poglavja ugotovili napredek učenca. Kvizi so bili pri učencih dobro sprejeti, saj od njih niso zahtevali veliko pisanja.

Učenci so imeli najraje praktično delo. Pri tem so bili aktivni vsi učenci, tudi učenci tujci. Pri tem v ospredju niso bile njihove težave z jezikom, zato so bili zelo motivirani za delo in so se zelo izkazali pri sami izdelavi končnega izdelka in pri tem pokazali veliko mero ustvarjalnosti.

Slika 6. Praktični izdelki

Vsem učencem smo s pomočjo odprtih možnosti ponudili različne načine predstavitve, kjer so lahko izkazali svoje znanje, pridobili nove spretnosti in izkušnje. Tako, so vsi učenci, ne glede na učne ali govorne težave izdelali svoj končni izdelek.

Vso gradivo, ki smo ga v teh dveh letih izdelali, nam je v letošnjem šolskem letu pri hibridnem načinu poučevanja zelo koristilo ter nam v veliki meri olajšalo delo. Učenci se zaradi bolezni velikokrat niso mogli priključiti k rednemu pouku. Tako zadolžitve kot samo razlago so imeli naloženo v spletni učilnici, kjer so jo opravili kasneje. Še vedno se poslužujemo preverjanju znanja s pomočjo spletnih kvizov, saj se nam zdi pomembno, da so učenci v razredu digitalno spretni.

4 DISKUSIJA

Vsi zgoraj omenjeni programi, aplikacije, omogočajo, da učenci razvijajo digitalno pismenosti, ki jim omogoča lažje doseganje želenih ciljev.

Tako kot učitelji so tudi učenci v sam pouk na daljavo vložili veliko truda ter iznajdljivosti. Nekateri že na začetku samostojno, drugi ob pomoči odraslih.

Pri tem je nastala res cela paleta izdelkov, razlag, primerov dobrih praks, ki jih brez večjih težav uporabimo pri pouku. Pomembno je, da učitelj sam skrbi za razvijanje digitalnih kompetenc. Učitelj mora sam raziskovati in iskati različne aplikacije, ki so enostavne za uporabo, mora jih zelo dobro poznati, da jih lahko prenese v sam pouk in pri tem izkoristi visoko motivacijo učencev za delo. S tem poskrbi tako za pestrost pouka kot tudi lastno promocijo svojega načina podajanja znanja. Pri tem je zelo pomembno, da dobro presodi, kateri programi so primerni za mlajše učence ter jim v veliki meri olajšajo delo. Učitelj se mora nenehno izobraževati, raziskovati ter iskati nove aplikacije, s katerimi bi lahko izboljšal svoje podajanje znanja.

5 ZAKLJUČKI

Še vedno velja, da je znanje velika vrednota in moč. Učenci bodo lahko uporabljene aplikacije in programe uporabljali in nadgrajevali tudi v prihodnje, bodisi pri pouku kot v vsakdanjem življenju.

Prav v času šolanja na daljavo, karanten, smo zelo dobro občutili, kako je digitalna pismenost pomembna tako za učitelja kot za učence. Spoznali smo, da klasičen pouk ni več dovolj, da je potrebno digitalno znanje, ki so ga učenci v teh letih pridobili nadgrajevati in razvijati, saj jim bo omogočil lažje premagovanje ovir.

REFERENCE

[1] Zupanc Grom, R, Slivar, B., Holcar Brunauer, A. in Rojc, J. (2022). Smernice za izvajanje izobraževanja na daljavo za vzgojno-izobraževalne zavode na področju osnovnega in srednjega šolstva. Ljubljana: ZRSŠ.

[2] www.zrss.si/pdf/smernice_izobrazevanje_na_daljavo.pdf

[3] Javrh, P., Možina, E., Bider, K., Kragelj, K., Volčjak, D., Sepaher, G., Gjerek, L., Matavž, H., Rejec, P., Babič Ivaniš, N. in Brecelj, V. (2018). Digitalna pismenost. Na poti do življenjske uspešnosti. Ljubljana: Andragoški center Slovenije.

[4] https://pismenost.acs.si/wp-content/uploads/2018/09/Digitalna-pismenost-e-verzija.pdf.

[5] Jurišič, M. (1999). Samopodoba šolskega otroka. Ljubljana: Pedagoška fakulteta.

[6] Marentič Požarnik, B. , Magajna, L. , Peklaj, C. (1995). Izziv raznolikosti: stili spoznavanja, učenja, mišljenja. Psihologija učenja in pouka. Nova Gorica: Educa.

[7] Sonck, N., Livingstone, S., Kuiper, E., in de Haan, J. (2011). Digitalna pismenost in veščine varne rabe interneta . DOI=https://safe.si/sites/default/files/digitalskillsreport-eukidsonlineprevod_0.pdf.

[8] Statistični urad Republike Slovenije [SURS]. 2018. Osnovnošolsko izobraževanje. DOI=Uporaba IKT v gospodinjstvih (stat.si)

[9] Železnik, R. (2018). Uvajanje digitalnih tehnologij in spoznavanje računalniške pismenosti pri osnovnošolskih otrocih v Sloveniji. Magistrsko delo. Ljubljana: Pedagoška fakulteta.

[10] Novi ukrepi za spodbujanje ključnih kompetenc in digitalnih spretnosti ter evropske razsežnosti izobraževanja. (2018) EU. IP/18/102. DOI=https://ec.europa.eu/commission/presscorner/detail/sl/IP_18_102

[11] Žontar, R. (2022). Following the path of digitalization in Slovenia and Europe: Are you digitally literate? Where does Slovenia rank in EU? DOI=Following the path of digitalization in Slovenia and Europe: Are you digitally literate? Where does Slovenia rank in the EU? (inak.si)

Kako narediti virtualno učno pot?

How To Make a Virtual Educational Nature Trail?

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POVZETEK

Živimo v času digitalizacije, ko tudi vzgojno-izobraževalno delo postaja vse bolj digitalizirano. K temu pa nas je nedaleč nazaj dodatno spodbudilo tudi šolanje na daljavo. Da bi bil pouk čim bolj zanimiv, učitelji in učenci posegamo tudi po različnih digitalnih orodjih in programih. Na osnovni šoli Antona Martina Slomška Vrhnika smo se lotili projekta izdelave učne poti, s katero smo ob dvajsetletnici naše šole želeli širši javnosti predstavili naravne in kulturne značilnosti naše domače občine, občine Vrhnika. Pri projektu so sodelovali učenci od šestega do devetega razreda in njihovi mentorji. V prispevku bomo predstavili, kako smo se lotili omenjenega projekta, na kakšne težave smo pri tem naleteli, in kako smo jih rešili. Našo učno pot smo nato pretvorili v virtualno obliko s pomočjo brezplačnega spletnega orodja za izdelavo interaktivnih predstavitev ThingLink. V nadaljevanju bomo predstavili tudi korake izdelave omenjene virtualne učne poti ter končni rezultat našega dosedanjega dela, ki pa ga želimo v prihodnje še nadgraditi.

KLJUČNE BESEDE

Virtualna učna pot, občina Vrhnika, ThingLink

ABSTRACT

We are living in a digital era when educational work is becoming increasingly digitalised as well. Not long ago, our society was encouraged to digitalize by the use of distance learning. In order to make lessons as interesting as possible, teachers and students are turning to various digital tools and programmes. At the Anton Martin Slomšek Vrhnika Primary School, we have taken on a project to create an educational trail to present to the general public on the occasion of the 20th anniversary of our school the natural geographic and socio-geographic features of Vrhnika municipality. The project involved pupils from the sixth to the ninth grade, and their tutors. In this article, we are presenting the project start, the problems we encountered, and how these have been solved. In the end, we converted our educational trail into a virtual form by using ThingLink, the free computer software. In addition, we present the steps in creating the virtual educational trail, and the final results of our work so far, which we hope to expand in the future.

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KEYWORDS

Virtual educational trail, municipality of Vrhnika, ThingLink

1 UVOD

Pri vzgojno-izobraževalnem delu se vse pogosteje spogledujemo z digitalizacijo. K temu nas je v preteklem obdobju spodbudilo tudi šolanje na daljavo. Onemogočen je bil neposreden kontakt učiteljev in učencev. Vzgojno-izobraževalno se je tako rekoč čez noč prestavilo na splet. Pojavila se je potreba po sorazmerno hitrih prilagoditvah pouka, ki je vključeval informacijsko komunikacijsko tehnologijo ter računalniška orodja in programe, s katerimi si lahko pomagamo pri takšnem načinu dela.

Na osnovni šoli Antona Martina Slomška Vrhnika smo si ob dvajsetletnici naše šole zastavili cilj izdelati učno pot v fizični obliki, s katero bi širši javnosti predstavili naravne in kulturne značilnosti občine Vrhnika. Zamislili smo si, da jo uredimo v neposredni okolici naše šole, v šolskem arboretumu. Naše načrte pa je sredi dela prekrižalo šolanje na daljavo. Ta težava je nato postala naš izziv. Da bi naša učna pot vendarle ugledala luč sveta, smo se odločili, da jo pretvorimo v virtualno obliko in jo tako približamo še večjemu krogu ljudi.

V prispevku predstavljamo, kako smo se lotili projekta izdelave učne poti, korake izdelave naše učne poti v brezplačnem spletnem orodju za izdelavo interaktivnih predstavitev TrhingLink in končni rezultat našega dela.

2 PROJEKT IZDELAVE UČNE POTI

Na Osnovni šoli Antona Martina Slomška Vrhnika smo se že dlje časa poigravali z zamislijo, da bi uredili svojo učno pot. Obogatitev praznovanja dvajsetletnice naše šole na takšen način se nam je zdela odlična priložnost, da svojo zamisel uresničimo. Občina Vrhnika, kjer se nahaja naša šola, leži na stiku Ljubljanske kotline in kraškega sveta in tukaj je veliko naravnih znamenitosti. Prav tako se naša občina ponaša s številnimi znanimi osebnostmi, prireditvami, arhitekturnimi posebnostmi in drugimi kulturnimi znamenitostmi. Vse to je botrovalo k odločitvi, da bomo z našo učno potjo predstavili in promovirali prav naravne in kulturne znamenitosti domače občine.

Izdelava te učne poti je obsežnejši projekt, kamor smo vključili vse učence od šestega do devetega razreda in njihove mentorje, povezali pa smo se tudi z ostalimi prebivalci naše občine. Tako je to postal eden od dvajsetih projektov, s katerim smo obeležili dvajsetletnico naše šole.

Omenjeno učno pot smo si sprva zamislili kot fizično učno pot, ki bo speljana v neposredni okolici naše šole, v šolskem arboretumu. V mislih smo imeli izdelavo dvajsetih učnih tabel, ki v besedi in sliki prikazujejo naravne in kulturne znamenitosti našega domačega kraja z okolico.

Naš prvotni načrt pa nam je prekrižalo širjenje virusa Covid-19 in uvedba omejitvenih ukrepov. Ravno v času, ko smo zbrali vse podatke in izdelali plakate kot osnutke za izdelavo učnih tabel, se je pričelo izobraževanje na daljavo, ki ga Unesco [1] opredeljuje kot vzgojno-izobraževalni proces in sistem, v katerem pomemben delež pouka izvaja nekdo ali nekaj, ki je časovno in prostorsko odmaknjeno od učenca.

V našem prostoru je bila uporaba tehnologije za namene poučevanja do prvega vala epidemije raziskovana predvsem kot del pouka v živo [2]. Zato smo morali razmisliti o možnosti, kako bi učno pot vendarle lahko končali v novih okoliščinah. To je postalo naš izziv. Odločili smo se, da jo pretvorimo v virtualno obliko. V skladu s tem smo jo naslovili Virtualna učna pot naravnih in kulturnih znamenitosti občine Vrhnika.

3 OD IDEJE DO IZVEDBE

Ker smo s pomočjo naše učne poti želeli predstaviti naravne in kulturne znamenitosti občine Vrhnika, smo se najprej lotili raziskovanja naše naravne in kulturne dediščine. Raziskali smo dvajset različnih tem: barje, kras, Ljubljanico, razgledne in izletniške točke, stare obrti in znanja, prazgodovinsko Vrhniko, legende in zgodbe, kulinariko, javne in kultune ustanove, sakrakne objekte, arhitekturne posebnosti, spominska obeležja, književnike, slikarje, gospodarstvo, prireditve, šport, šolstvo na Vrhniki in Osnovo šolo Antona Martina Slomška.

Delo je potekalo v dvajsetih različnih skupinah in vsaka od skupin je raziskovala eno od naštetih tem. Cilj vsake skupine je bil oblikovati plakat (Slika 1), na katerem bi z besedo in sliko predstavili svojo raziskovalno temo.

Slika 1: Primer plakata

Nastali plakati pa bi služili kot osnutki za oblikovanje dvajsetih informativnih tablel za opremo naše učne poti.

Navodila so učenci in mentorji dobili že vnaprej, tako da so se lahko predhodno pripravili in dogovorili, kako si bodo razdelili delo, na kakšen način bodo raziskovali svojo temo ipd. Delo znotraj skupin je potekalo samostojno. Učenci so si sami izbrali metode dela (študij virov in literature, terensko delo, anketa, intervju ipd.), s katerimi so dobili zahtevane podatke, mentorji pa so jim pri tem svetovali in jih usmerjali.

Učenci so plakate nato opremili s povzetki svojih raziskav in slikovnim gradivom. Na koncu je vsaka izmed skupin svoj plakat še predstavila, vse predstavitve pa smo tudi posneli in dokumentirali.

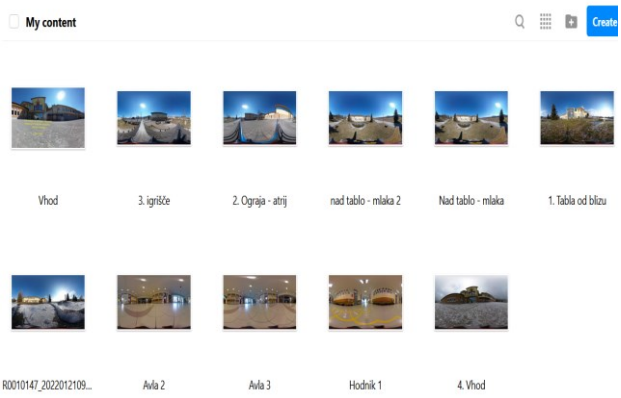
4 PRETVORBA V VIRTUALNO OBLIKO

Zadnji korak izdelave zamišljene učne poti je bil njena pretvorba v virtualno obliko. Pri pridobivanju podatkov, fotografiranju in oblikovanju besedil je bilo v ospredju samostojno delo učencev, pri pretvorbi v virtualno obliko pa so na pomoč priskočili mentorji.

Z našo virtualno učno potjo smo uporabnikom želeli ponuditi virtualni sprehod po neposredni okolici in delno tudi po notranjosti naše šole. Odločili smo se, da si pri tem pomagamo s 360-stopinskimi posnetki šole in njene okolice. Da bi se izognili težavam z avtorstvom, smo za slikovni del učnih tabel izbrali izključno avtorske fotografije, ki so nastale na terenskem delu oziroma so jih prispevali učitelji in učenci.

Po posvetovanju s šolskim računalničarjem smo se odločili, da našo virtualno učno pot oblikujemo v brezplačnem spletnem orodju za izdelavo interaktivnih predstavitev ThingLink [3], ki je relativno enostaven za uporabo, končni rezultat pa ustreza našim predhodnim predstavam o virtualni učni poti. Prednost tega orodja je tudi, da je izdelano virtualno učno pot možno v vsakem trenutku spremeniti oziroma nadgraditi.

Po oblikovanju uporabniškega računa je bilo v ThingLink najprej potrebno uvoziti 360-stopinjske posnetke notranjosti in okolice naše šole, ki smo jih izdelali s pomočjo šolske kamere (Slika 2). Posnetke smo naredili na več šolskih lokacijah z namenom, da bi uporabniki o njih dobili čim boljšo predstavo.

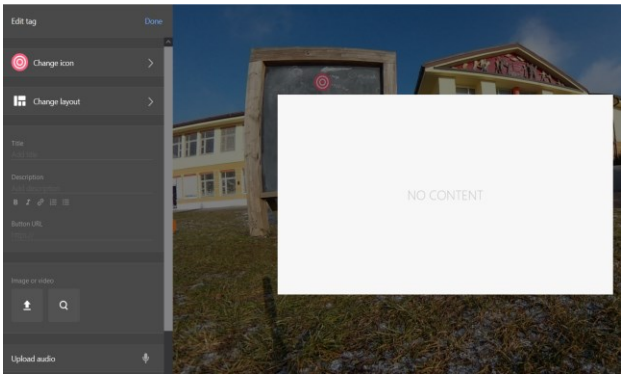


Slika 2: Uvoz 360-stopinjskih posnetkov v spletno orodje ThingLink

Izbrali smo najboljše posnetke, jih zložili po vrsti in med njimi uredili možne prehode tako, da smo nanje iz podanega nabora ikon v ThingLinku namestili izbrane ikone s puščicami (Slika 3). Ob kliku na posamezno ikono s puščico je tako možen sprehod med posameznimi 360-stopinjskimi posnetki. Na posnetke smo namestili tudi ikone, preko katerih uporabniki

dostopajo do predstavitev posameznih predstavljenih vsebin. Vsak 360-stopinjski posnetek smo opremili z več ikonami, pri tem pa se poskušali izogniti prenasičenosti in pazili na preglednost.

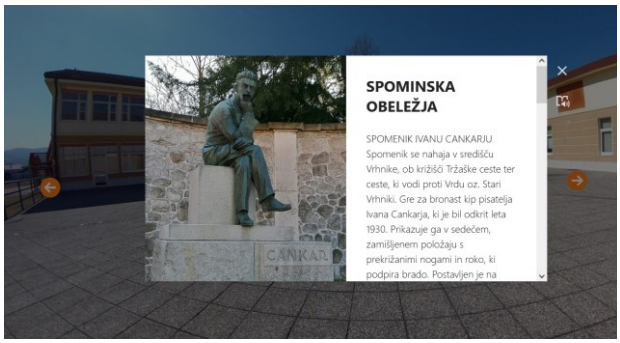
Slika 3: Naslovna stran Virtualne učne poti naravnih in kulturnih znamenitosti občine Vrhnika



Slika 4: Urejanje virtualne učne poti

Besedilo na plakatih, ki je bilo pretežno napisano na roko, smo pretipkali in uredili s pomočjo programa Microsoft Word. Sledil je jezikovni pregled. Nato smo besedilo uvozili na ustrezno mesto na virtualnih učnih tablah. Dodali smo tudi ustrezne avtorske fotografije.

Pri oblikovanju virtualnih učnih tabel v orodju TrhingLink smo lahko izbirali med več različnimi predlogami. Izbrali smo tiste, ki so najbolj ustrezale predstavljenim tematikam (Slika 4).



Slika 5: Primer virtualne učne table z besedilom in fotografijo

V vnaprej podane predloge smo v za to določena mesta vstavili besedilo in fotografije (Slika 5).

Ko smo vnesli vse fotografije in besedilo, je bilo potrebno urediti še dostop do izdelane virtualne učne poti. Na šolski spletni Osnovne šola Antona Martina Slomška Vrhnika [4] smo nato objavili še spletno povezavo [5], s pomočjo katere lahko dostopamo do nje.

5 REZULTATI

Virtualna učna pot naravnih in kulturnih znamenitosti občine Vrhnika je projekt učencev in učiteljev Osnovne šola Antona Martina Slomška Vrhnika, ki smo ga uresničili ob praznovanju dvajsetletnice naše šole. S tem, ko smo prvotno načrtovano fizično obliko naše učne poti spremenili v virtualno obliko, lahko do nje v vsakem trenutku dostopa še večji krog ljudi kot bi lahko do prvotno mišljene fizične postavitve. To pa je še ena od prednosti, ki jih ta učna pot ima. Je tudi relativno enostavna za uporabo, saj se lahko s preprostim klikom na posamezne ikone prosto sprehajamo med 360-stopinjskimi posnetki notranjosti šole in njene okolice ter si ogledamo predstavljene vsebine. Učenci so v veliki meri z zanimanjem sodelovali pri izdelavi naše učne poti. Seznanjanja z naravnimi in kulturnimi znamenitostmi svoje domače občine so se lotili samostojno, učitelji pa so jim pri tem nudili podporo in nasvete. Kot prednost takšnega dela so učenci izpostavili samostojno delo, kjer so imeli proste roke glede izbire metod in načinov dela pri pridobivanju podatkov in oblikovanju osnutkov za učne table. Pozitivno je tudi, da so sodelovali z drugimi, se med seboj povezovali, iskali skupne rešitve, logično razmišljali, bili iznajdljivi in ustvarjalni. Več podpore učiteljev pa so rabili pri pretvorbi učne poti v virtualno obliko.

6 ZAKLJUČEK

Virtualna učna pot naravnih in kulturnih znamenitosti Občine Vrhnike je izdelana, povezava do nje pa objavljena in prosto dostopna na spletni strani Osnovne šole Antona Martina Slomška Vrhnika. Po omenjeni učni poti se lahko virtualno sprehodi širši krog ljudi, primerna pa je tudi za uporabo v šolskem vsakdanu (npr. uporaba vsebin za različne predstavitve pri pouku, utrjevanje znanja o domačem kraju in okolici, umestitev v dneve dejavnosti, šolske prireditve ipd.). Izdelana je v prostodostopnem spletnem orodju za izdelavo interaktivnih predstavitev ThingLink, ki je relativno enostavno za uporabo in omogoča tudi spremembe in njeno nadgradnjo. Tudi to je dobra lastnost tega orodja, saj želimo obstoječo virtualno učno pot v prihodnje še nadgraditi z dodatnimi vsebinami oziroma že obstoječe vsebine prevesti v različne tuje jezike, ki jih poučujemo na naši šoli, da bo ta pot dostopnejša še večjemu krogu uporabnikov.

LITERATURA IN VIRI

[1] Burns, M. 2011. Distance Education for Teacher Training: Modes, Models, and Methods. Washington, DC: Education Development Center, Inc.

[2] Tanja Rupnik Vec, Branko Slovar, Renata Zupanc Grom et. Al. 2020. Analiza izobraževanja na daljavo v času prvega vala epidemije Covid-19 v Sloveniji. Dostopno na nasovu: https://www.dlib.si/stream/URN:NBN:SI:DOC-X3BSQ9IN/d1f7defb-e0fa-4ad5-a9c5-975068de1020/PDF (9. 8. 2022)

[3] Računalniški program ThingLink. Dostopno na naslovu: https://www.thinglink.com (9. 8. 2022)

[4] Spletna stran Osnovne šole Antona Martina Slomška Vrhnika. Dostopno na naslovu: https://www.osams.si/2022/05/30/virtualna-ucna-pot-naravnih-in-kulturnih-znamenitosti-obcine-vrhnika/ (9. 8. 2022)
[5] Virtualna učna pot naravnih in kulturnih znamenitosti občine Vrhnika. Dostopno na naslovu: https://www.thinglink.com/video/1587877622233169922 (9. 8. 2022)

Dileme in rešitve poučevanja na daljavo

Dilemmas and Solutions of Distance Learning

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POVZETEK

V tretjem tednu pouka na daljavo aprila 2020 učitelji še nismo dobili nobenih konkretnih navodil za poučevanje na daljavo. Na Osnovni šoli Antona Martina Slomška Vrhnika je pouk potekal po spletni strani šole, kar pomeni, da smo učitelji nalagali navodila in naloge na spletno stran šole. Pred nami je bil problem, kako zastaviti tako zanimivo nalogo, da bi se je učenci lotili z veseljem in hkrati ne bili preveč obremenjeni. Tukaj je treba poudariti, da niso še vsi učenci imeli enake možnosti digitalnih komunikacij. Cilj naloge je bil vsekakor slediti učnemu načrtu, vzdrževati raven bralne pismenosti in obdržati učence pri rednem vsakodnevnem delu za šolo. Odlomek iz berila za 7. razred je bil izhodišče naše naloge. Sledili smo navodilom v berilu in izpostavili zanimivo nalogo ustvarjalnega pisanja. Nastale so zanimive zgodbe – »podajanke«, ki so jih učenci pisali tako, da so si podajali odlomke, in sicer po elektronski pošti. Učenec je nadaljeval tam, kjer je je njegov sošolec končal. Določili smo aktualno temo – čas corona virusa. Odzvali so se posamezniki. Pri takem načinu dela so se učenci, sošolci povezali med seboj, začeli so z dopisovanjem; povezali so se tudi s starši, saj so nekateri oblikovali zgodbe skupaj s starši. Izdelke učencev smo objavili v šolskem glasilu, nov način dela pa nas je vzpodbudil, da smo se v prihodnje lotili tudi drugih projektov »na daljavo«.

KLJUČNE BESEDE

Slovenščina, ustvarjalno pisanje, povest – podajanka, corona, dopisovanje preko elektronske pošte

ABSTRACT

In the third week of distance learning in April 2020, teachers have not yet received any concrete instructions for remote teaching. At the Anton Martin Slomšek Vrhnika Elementary School, classes were held on the school's website, which means that the teachers uploaded instructions and assignments to the school's website. The challenge in front of us was how to set such an interesting task so that the students would tackle it with pleasure and at the same time not be too burdened. It should be emphasized here that not all students have had the same opportunities for digital communications.The goal of the assignment was definitely to follow the curriculum, maintain the level of reading literacy and keep the students in regular daily work for the school. The extract from the 7th grade literature textbook was the starting point for our assignment. We followed the instructions in the reading material and highlighted the interesting task of creative writing. Interesting stories were created – "handouts", which the students wrote by sending each other excerpts via e-mail. The student continued where his classmate left off. We decided on a current topic – the time of the corona virus. Individuals responded. With such a way of working, students, classmates connected with each other, they started correspondence; they also connected with their parents, as some created stories together with their parents.We published the students' products in the school newsletter, and the new way of working encouraged us to tackle other "remote" projects in the future.

KEYWORDS

Slovene, creative writing, short story – handout, corona, E-mail correspondence

1 UVOD

Drugačen način šolskega dela je v novonastalih razmerah in ob tehnoloških primanjkljajih pri učiteljih in učencih zahteval nov, drugačen pristop.

Ob danem učnem načrtu in z ustrezno motivacijo je bilo potrebno pridobiti učence za delo na daljavo.

Učitelji se zelo dobro zavedamo težav, ki so jih imeli naši učenci pri obvladovanju vseh šolskih obveznostih v okoliščinah dela na daljavo, posebej zaradi izgube jasnega vpogleda v kontinuirani napredek učenja in pridobivanja znanja.

Zato smo se lotili ustvarjalnega pisanja, s katerim smo poskušali vzpostaviti ustvarjalno komunikacijo z učenci. To je bil eden od poskusov premostitve pomanjkljivosti uporabljene tehnologije pri delu na daljavo.

2 POUK NA DALJAVO

V tretjem vzgojno-izobraževalnem obdobju [1, str.32] pri učencih na področju književnosti razvijamo recepcijske zmožnosti z branjem, poslušanjem, gledanjem uprizoritev umetnostnih besedil in z govorjenjem ter pisanjem o njih [1, str. 39].

Na spletni strani šole so učenci dobili navodilo, da preberejo odlomek iz berila za 7. razred, in sicer odlomek iz mladinske povesti »Bela past« Bogdana Novaka [2].

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Sedmošolci so izbrani odlomek prebrali in odgovorili na vprašanja ter odgovore v celih stavkih zapisali v zvezek za književnost. Postopek odgovarjanja je bil učencem znan že od prej, saj na ta način vadimo pravilen besedni red v povedi in krepimo naše izražanje. Učenci so odgovore na vprašanja poslali v vpogled na učiteljičin elektronski naslov. Vse naloge – odgovore je učiteljica prebrala in pregledala ter napisala komentar. Tako je vsak učenec prejel povratno informacijo učiteljice, hkrati pa se je tudi učiteljica prepričala, da so besedilo razumeli. Pomembno je, da učenci razumejo in vidijo, kje so delali napake in kakšne so bile. Na ta način ohranjamo določen nivo bralne pismenosti in rednega dela.

Učni načrt za slovenski jezik v nadaljevanju predvideva, da učenci doživljajo, razčlenjujejo, vrednotijo različne književne zvrsti in vrste; opazujejo in predstavijo vlogo slogovnih prvin v umetnostnem besedilu; najdejo primere, s katerimi ponazorijo, kaj je opis, oris, oznaka, pripoved [1, str. 41, 42]. Vse to smo preskočili in se že v prvotnem navodilu [6] usmerili v ustvarjalno pisanje – razvijanje zmožnosti sprejemanja in tvorjenja proznih besedil [1, str. 43]. Sledili smo didaktičnemu instrumentariju v berilu [2, str. 107], ki vzpodbuja k pisanju povesti – »podajanke«. Učenci so tudi s pomočjo učbenikov sledili navodilu za ustvarjalno pisanje. Določili sem temo – čas corona virusa in posledic položaja in okoliščin, v katerih smo se znašli vsi – učenci, učitelji in starši.

Nenavadne življenjske situacije vzbudijo v človeku nenavadna dejanja, spremenijo se medsebojni odnosi – in v tem sta si vsebina odlomka in novo zastavljena tema podobni.

Odlomek iz berila »Bela past« govori o medsebojnih odnosih odraščajoče mladine. Nevarni položaj se v povesti uspešno razreši, ko glavni junak javno prizna svojo napako. Prijatelji ga razumejo in mu oprostijo.

2.1 Povest

Z brskanjem po različnih virih so učenci ugotovili, da je povest krajše, vsebinsko in izrazno manj zahtevno pripovedno delo, navadno v prozi [3]. Profesor Miran Hladnik razlaga, da je povest v šolski poetiki umetniško manj pomembno delo v prozi s poudarkom na zgodbi [4]. Opisuje predvsem zunanje dogodke, v katerih nastopa več oseb, avtor v ospredje postavi eno ali dve osebi, vendar se vanju ne poglablja pretirano. Pripoved je usmerjena v zgodbo samo. Povest je napisana preprosto in nazorno, konec je predvidljiv in navadno srečen. Povest je namenjena preprostemu človeku in ga kratkočasi pa tudi etično vzgaja. Avtor to doseže navadno tako, da ponazori kako misel z zgledom iz življenja in nato moralno jedro dokaže z zgodbo. Glede na to, da so povesti po vsebini različne (mladinske, kmečke, zgodovinske), so učenci ugotovili, da je odlomek iz berila odlomek iz mladinske povesti. Značilno za povest je predvsem to, da sledi dogajanju – zgodbi, kar je učencem uglavnem tudi uspelo [5].

V navodilu so bili učenci opozorjeni na pisateljev »recept«, kako naj pišejo, kaj vse naj upoštevajo – kako naj »iz testa in nadeva naredijo dobro potico«, ki ga je zaupal pisateljici Berti Golob v knjigi »Do zvezd in nazaj« [2, str. 107] in se nahaja v berilu kot motivacija za pisanje.

Na navodilo na spletni strani šole so se odzvali posamezni učenci. En učenec se je povezal kar s svojo mamo, ker je izgubil stike s sošolci. Povezala sta se še dva para sošolk in nastale so zgodbe – »podajanke«. Eden začne in drugi nadaljuje.

2.2 Podajanka

V virih smo poskušali poiskati razlago pojma podajanka. Ustrezne razlage nismo našli. V »Slovarju novejšega besedja slovenskega jezika« izraza ni zaslediti. Pojem izhaja iz besede *podajanje*, kar je glagolnik od podajati. Izraz je razširjen na področju športa: napake pri podajanju žoge in streljanju. Pogosta je besedna zveza: naravno podajanje besedila, kar pomeni, da govorec lepo, sproščeno pripoveduje ali bere besedilo. V SSKJ najdemo pojem *podaja*, kar je glagolnik od podati. Zopet tipična raba v športu: namesto meta na koš se je odločil za podajo; točna podaja ali podaja s krila [3].

V »Predlogu učnega načrta za pouk slovenščine v tretjem triletju« piše, da učenci pišejo realistično povest in realistični roman s tematiko iz vsakdanjega življenja; pustolovsko povest, kriminalno povest, kriminalni roman. V skupini sodelujejo pri pisanju podajanke. Svojo kolektivno povest postopoma dograjujejo, vsak pisec pa nadaljuje tam, kjer je predhodnik zaključil [11].

Zasledili smo, da se pojem pojavlja kot branje po odlomkih.

V razvojni nalogi Zavoda za šolstvo z naslovom »Uvajanje informativnega spremljanja in inkluzivne paradigme« je opisan primer »knjige podajanke« - celoletnega procesa v oddelku 9. razreda. S tem projektom učiteljica krepi sodelovanje, kritično razmišljanje učencev, v ospredju je ustvarjanje in kreativno pisanje. Med sošolci ves čas krožijo povratne informacije. Učenci sami okvirno določijo žanr svoje knjige, oznake književnih oseb, določijo kraj in čas dogajanja. Razdelijo si vloge – kdo bo pisal, kdo ilustriral. Napisana poglavja sproti preberejo, se pogovorijo. Učiteljica poglavja slovnično sproti popravlja, z napakami seznani učence. Rezultati so izjemni, odzivi učencev pozitivni [10].

Podobno izkušnjo je doživela tudi naša skupina učencev, vendar pri pouku na daljavo!

2.3 Motivacija

Pouk književnosti je sestavljen iz več zaporednih korakov. Vsak korak ima svoje značilnosti in vsaka značilnost zahteva diferenciran pristop.

Učenci pri pouku književnosti literarno besedilo zaznavajo in doživljajo, razumejo in vrednotijo. Koraki šolske interpretacije literarnega besedila so: uvodna motivacija, najava besedila, umestitev v čas in prostor ter interpretativno branje; sledi premor po branju, izražanje doživetij ter analiza, sinteza in vrednotenje. Na koncu sledi ponovno branje in nove naloge.

Vseh teh korakov seveda nismo mogli izvesti pri naši uri »pouka na daljavo«. Kljub spremenjenemu načinu dela pa je treba poudariti pomen motivacije, za katero se je izkazalo, da je naš velik problem.

Motivacija je eden izmed najpomembnejših dejavnikov uspešnega učenja pa tudi poučevanja, saj vpliva na otrokovo pozornost, mišljenje, pomnenje in čustva ter jih usmeri v učenje. Se pravi, da gre za psihični proces, ki pa je nujen za vsa področja človekovega delovanja. Če učitelj dobro motivira učence, je opravil več kot polovico dela. Pomembne so besede, s katerimi bo učitelj pripravil učence k delu, učenju, besede, s katerimi bo pokazal, kako koristno je učenje, vredno in hkrati prijetno, zabavno. Za to je potreben osebni stik. Kako naj to dosežemo na daljavo?

Izkušnje so nas, učitelje, naučile, da mora biti motivacija stalnica pouka, vendar glede na populacijo učencev različna in različno dolga. Vsaka motivacija mora biti načrtovana.

Predvidevamo, da se bodo učenci odzvali na dano nalogo, se pravi, da bodo motivirani, če se bodo počutili sposobne narediti tisto, kar se od njih pričakuje; za nekatere učence vemo, da imajo radi slovenščino kot šolski predmet in jim tudi je bilo takoj jasno, kaj želimo; nekateri so zvedavi in imajo radi novosti, kot je recimo pisateljev »recept« za dobro pisanje. Za pisanje povesti – podajanke so imeli učenci dovolj časa, da so lahko razmislili in razvili svojo domišljijo.

Pri motivaciji je treba ločevati med uvodno in učno motivacijo. Uvodno motivacijo smo lahko delno izvedli, učna motivacija pa je bila v tistem trenutku onemogočena. Učna motivacija je ožji pomen in pomeni motivacijo v procesu učenja, ki pa ga mi sploh nismo mogli razviti.

Učno uro »na daljavo« smo začeli z navodilom na spletni strani šole – branje odlomka iz berila, nadaljevali smo z odgovori na vprašanja, s katerimi smo preverili njihovo razumevanje, doživljanje in vrednotenje literarnega odlomka. Dodatna motivacija, s katero smo želeli obdržati nek redni šolski ritem, je bila ustvarjalna naloga, ki jo je ponujalo berilo samo [7].

Odziv učencev ni bil velik, vendar je bil pozitiven. Po zaključku tega malega projekta smo bili veseli, zadovoljni, saj smo delali drugače, bilo nam je zanimivo, zraven smo se zabavali in hkrati tudi nekaj naučili. Učenci so začeli z dopisovanjem tudi na drugih predmetnih področjih, mobilni telefoni so za trenutek stopili v ozadje.

S pisanjem podajanke smo nevede ponovno vzpostavili vrstniško sodelovanje, ki je bilo čez noč prekinjeno. Na poseben način se je oblikovalo timsko delo, saj so se učenci skupaj z učiteljico povezali v skupino s skupnim namenom, za uresničitev skupnega cilja, in sicer nastanek zgodbe – podajanke. Učenci so se sami organizirali, sprejeli nalogo, medse razdelili vloge; komunikacija je potekala samo preko elektronske pošte, preko katere so prejemali učiteljičine usmeritve in povratno informacijo, in to vsak posebej. Skupaj smo dosegli cilj – nove zgodbe, podajanke. Verjamem, da je med sošolci vladalo posebno razpoloženje, saj jim je bila naloga zanimiva in so bili pripravljeni delati več kot sicer.

Vemo, da je timsko delo skupinsko delo samostojnih članov. Vsak član ima svoje znanje, ideje in odločitve, ki pa so podrejene skupnemu cilju neke naloge. Vse člane obvezuje delovna naloga. Med sabo so različni, vendar prav ta različnost jih povezuje in ustvarja kreativne rešitve. Prav to se je zgodilo tudi pri našem pouku na daljavo. Na tem mestu moramo spet opozoriti, da so sošolci sodelovali med sabo samo preko elektronske pošte.

Tim je skupina ljudi z istim ciljem, ki ga dosežejo z delitvijo nalog. Vsi člani skupine si prizadevajo doseči isti cilj tako, da delijo znanje, naloge izkušnje in pomoč [8].

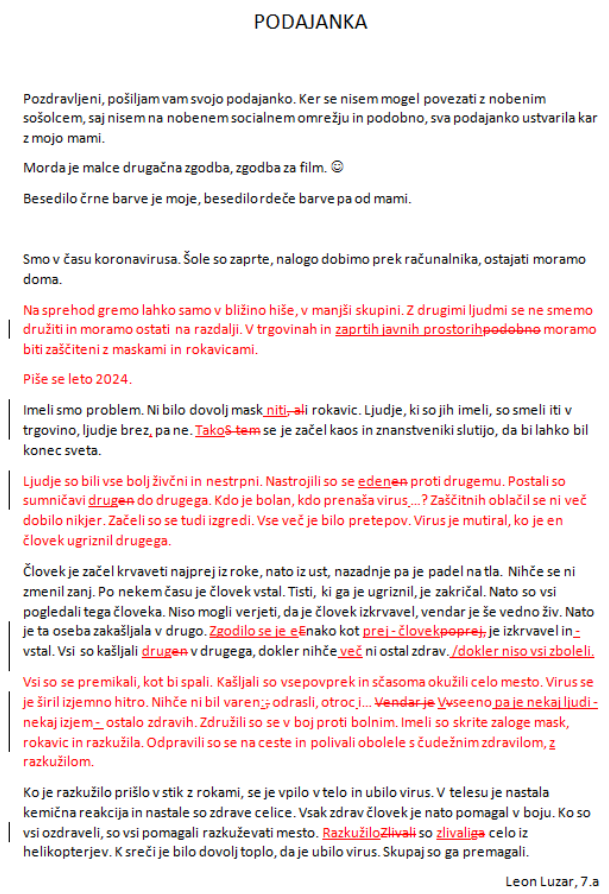
Skupinska dinamika ima pomembno vlogo v razredu, v učilnici, na čelu katere je učitelj, ki želi z učenci opraviti določeno nalogo. Delovanje skupine je seveda odvisno od osebnosti članov, ki sestavljajo skupino. Naša skupina učencev je očitno vzpostavila uspešno sodelovanje. Naloga se jim je zdela nenavadna in zanimiva, počutili so se varne, ker so razumeli navodila in so lahko načrtovali svoje delo. Bili so sprejeti od sošolca/sošolke oz. soavtorice in so lahko izražali svoje misli, čustva in občutke. Postali so bolj samozavestni, saj so doživeli potrditev s strani sošolcev in s strani učiteljice, saj so uspešno opravili svoj del naloge [9].

Med učenci je potekala uspešna komunikacija, saj so večkrat poudarili, da so se ob pisanju zabavali, vsakič z nestrpnostjo pričakovali nove odlomke, na katere bodo pripeli svoje odlomke.

Izdelke učencev smo upoštevali pri tisti eni oceni, ki smo jo morali učitelji pridobiti v drugem polletju šolskega leta 2019/2020. Nagrada v obliki dobre ocene je učence še posebej razveselila. Ob koncu šolskega leta 2020 smo izdelke objavili v šolskem glasilu.

3 PRISPEVKI UČENCEV

Podajanka učenca, ki se je povezal z mamo, se začne v času začetka corona virusa in se po maminem nadaljevanju nadaljuje v leto 2024. Fant jo le zaključi, s srečnim koncem, saj so ljudje združili moči in premagali virus. Čutiti je vpliv novodobnih grozljivk.



PODAJANKA

Pozdravljeni, pošiljam vam svojo podajanko. Ker se nisem mogel povezati z nobenim sošolcem, saj nisem na nobenem socialnem omrežju in podobno, sva podajanko ustvarila kar z mojo mami.

Morda je malce drugačna zgodba, zgodba za film. ☺

Besedilo črne barve je moje, besedilo rdeče barve pa od mami.

Smo v času koronavirusa. Šole so zaprte, nalogo dobimo prek računalnika, ostajati moramo doma.

Na sprehod gremo lahko samo v bližino hiše, v manjši skupini. Z drugimi ljudmi se ne smemo družiti in moramo ostati na razdalji. V trgovinah in zaprtih javnih prostorihpodobno moramo biti zaščiteni z maskami in rokavicami.

Piše se leto 2024.

Imeli smo problem. Ni bilo dovolj mask niti, ali rokavic. Ljudje, ki so jih imeli, so smeli iti v trgovino, ljudje brez, pa ne. TakoŠ tem se je začel kaos in znanstveniki slutijo, da bi lahko bil konec sveta.

Ljudje so bili vse bolj živčni in nestrpni. Nastrojili so se edenen proti drugemu. Postali so sumničavi drugen do drugega. Kdo je bolan, kdo prenaša virus,...? Zaščitnih oblačil se ni več dobilo nikjer. Začeli so se tudi izgredi. Vse več je bilo pretepov. Virus je mutiral, ko je en človek ugriznil drugega.

Človek je začel krvaveti najprej iz roke, nato iz ust, nazadnje pa je padel na tla. Nihče se ni zmenil zanj. Po nekem času je človek vstal. Tisti, ki ga je ugriznil, je zakričal. Nato so vsi pogledali tega človeka. Niso mogli verjeti, da je človek izkrvavel, vendar je še vedno živ. Nato je ta oseba zakašljala v drugo. Zgodilo se je enako kot prej - človekpoprej, je izkrvavel in - vstal. Vsi so kašljali drugen v drugega, dokler nihče več ni ostal zdrav. /dokler niso vsi zboleli.

Vsi so se premikali, kot bi spali. Kašljali so vsepovprek in sčasoma okužili celo mesto. Virus se je širil izjemno hitro. Nihče ni bil varen; odrasli, otroci... Vendar je Vseeno pa je nekaj ljudi - nekaj izjem - ostalo zdravih. Združili so se v boj proti bolnim. Imeli so skrite zaloge mask, rokavic in razkužila. Odpravili so se na ceste in polivali obolele s čudežnim zdravilom, z razkužilom.

Ko je razkužilo prišlo v stik z rokami, se je vpilo v telo in ubilo virus. V telesu je nastala kemična reakcija in nastale so zdrave celice. Vsak zdrav človek je nato pomagal v boju. Ko so vsi ozdraveli, so vsi pomagali razkuževati mesto. RazkužiloZlivali so zlivaliga celo iz helikopterjev. K sreči je bilo dovolj toplo, da je ubilo virus. Skupaj so ga premagali.

Leon Luzar, 7.a

Slika 1: Podajanka – učenec Leon Luzar

Druga podajanka dveh učenk je postavljena v vaško okolje.V ospredju sta dve različni družini. Ena je skrbna, pazi nase, ne hodi ven med ljudi, vse si pridelajo doma, izogibaju se druženju – se pravi, sledijo navodilom »oblasti«. Druga družina se obnaša in živi bolj svobodno, mogoče celo nepremišljeno in ravno te zadane corona virus. Tri pikice na koncu zgodbe očitno napovedujejo, da bi se podajanka lahko nadaljevala – mogoče prav z moralno noto, ki je prisotna v povesti »Bela past«, in sicer,

da vsakemu lahko ponudimo še eno, novo, priložnost. Kljub namigu učenka ni nadaljevala.

» PODAJANKA »

Nekje na vasi sta živeli dve družini. V to vasico se je ravno vselil mali virus, ki ga ne moremo videti, lahko pa zaradi njega zbolimo.

Obe družini sta bili zelo srečni in predvsem zdravi. Družina Kovač je čas preživljala za zaprtimi vrati skupaj v bližini domačih. Hrano so pridelovali sami na svojem polju. Vedno, ko je prišlo, do trenutka, da bi s prijatelji odšli na igrišče so se rajši odločili, da ostanejo doma. Imeli pa so sosede Novakove, ki so vedno zunaj, hodijo po trgovinah... Družini sta izvedeli, da je v njihovi vasici prvi potrjen primer z okužbo koronavirus. Takrat je družino Kovač zgrabila panika. Spraševali so se, kaj če bom jaz nasledi, ki bom okužen? Nervoza in panika se je vsak dan bolj in bolj stopnjevala. Novakove pa zato ni prav nič skrbelo. Nekega dne so Novakovi odšli na igrišče. Hčerka Lia se je začela slabo počutiti. Odšli so k zdravniku, kjer ji je vzel bris. Ugotovili so, da ima Lia koronavirus. Takrat so se šele zavedali kako resno bi morali vzeti vsa navodila. Nihče si ni tako pogosto umival rok ter skrbel za nego kot Kovačevi. Še slabše je pa bilo, da je Lia najboljša prijateljica od Lane Kovač. Ko je Lana izvedela, da je Lia v bolnici na bolnišnični postelji in ima koronavirus se ji je srce kar zaustavilo. Ni morala verjeti. Najhuje ji je bilo pa to, da trenutno ne more iti do nje in jo močno objeti. Napočil je čas, da Lia dobi zdravilo proti virusu.

Ker je koronavirus šele izbruhnil in žal še niso imeli zdravila, se je napetost v družini Novak še povečala. Najhuje je bilo, ker je bila Lia v bolnišnici čisto sama v izolacijski sobi, kamor ni smela vstopiti niti njena družina. Novakovi so bili čisto iz sebe, saj so se počutili, kot da so jim njihovo deklico vzeli, vendar pa so razumeli, da je bila to v tem času edina rešitev, da se pozdravi in seveda ne okuži še svoje družine. Lia je bila še najstnica, zato je to okužbo kar dobro prenašala in v bolnišnici so jo obdržali samo zato, ker niso vedeli, ali se ji bo stanje poslabšalo. Starša sta vsak dan večkrat tudi klicala zdravnike in spraševala po njenem zdravju. Med tem časom, ko je bila v bolnišnici, je cela vasica, kjer je živela Lia, še bolj trepetala za svoje zdravje, saj so na poročilih zasledili, ko so poročali o prvi smrtni žrtvi. Seveda pa so vsi z dolgimi pogovori stali ob strani tudi njeni družini, še posebej pa družina Kovač.

V naslednjih dneh so v tem kraju zabeležili še nekaj primerov okužbe s koronavirusom. Med njimi je bil tudi Liin oče, ki so mu okužbo potrdili v zdravstvenem domu. Dobil je navodila, da mora domov v samoizolacijo. Precej slabe volje se je oče odpravil proti domu. Ko je vstopil v hišo, ni niti pozdravil, ampak se je samo zaprl v spalnico in čez vrata povedel mami za svojo okužbo. V vsem tem času pa so se Kovačevi še vedno držali po svoje, pridno obdelovali svoj vrt ter veliko hodili v hribe in, seveda, skrbeli za svojo higieno.

Dobra novica v družini Novak pa je bila, ko so zdravniki poklicali starše, da lahko pridejo po Lio, saj se je deklici zdravje izboljšalo. Na poti domov je mama Lii previdno povedala, kaj se dogaja z očetom. Lia je planila v jok, saj se je spomnila vseh tistih odraslih v bolnišnici, kaj vse so doživljali. Želela je čim prej k svojemu očetu. Ob prihodu domov se je usedla pred vrata njegove spalnice in ga z nežnim glasom poklicala ….

TIA FILIPIČ IN NEŽA DOVJAK 7.a

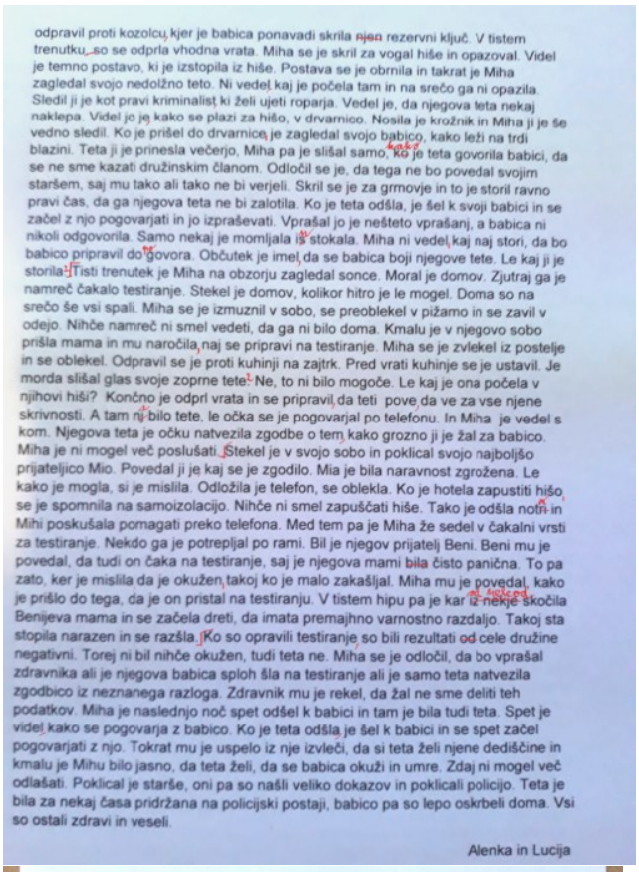
Slika 2: Podajanka – učenki Tia Filipič, Neža Dovjak

Miha, junak tretje podajanke, se v novi situaciji dolgočasi, življenje se mu obrne na glavo, v nobeni stvari ne najde smisla. V zgodbi svojo energijo in zvedavost usmeri v odkrivanje pohlepa pri svoji teti, ki izkoristi novonastalo situacijo in si zaželi materine dediščine. Zgodba ima srečen konec, saj Miha pravočasno odkrije tetine naklepe in pokliče

policijo. Pri tej podajanki prehodi od ene do druge avtorice niso ravno dobro razviti – težko jima je bilo slediti dogajanju, vsekakor pa sta hoteli ustvariti napeto zgodbo, ki bi bila lahko resnična.

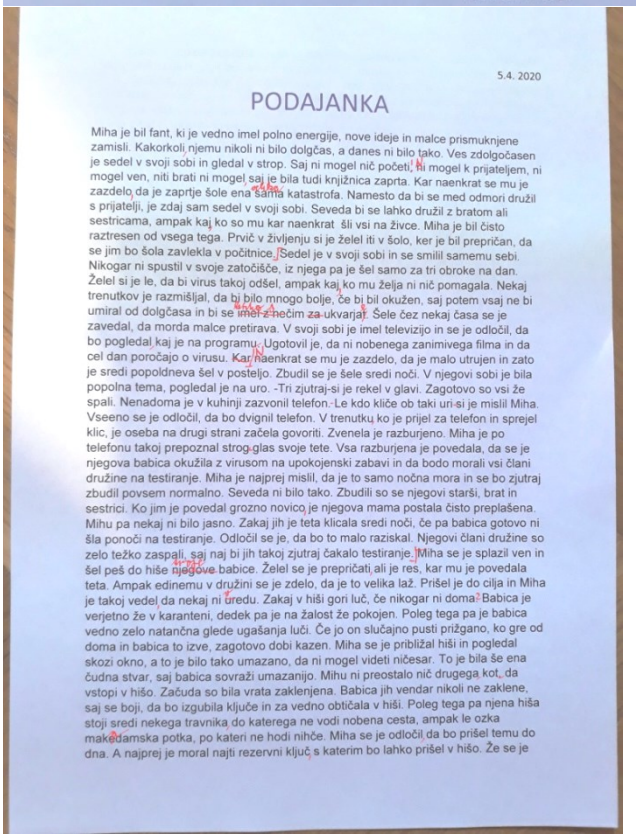
Učenci so svoje zgodbe pošiljali po odlomkih, tako kot so si jo podajali. Odlomki so bili sproti lektorirani, obenem so si učenci v komentarjih pomagali z manjšimi namigi. Na tem

mestu je potrebno ponovno poudariti, da je vse potekalo po elektronski pošti, med nami ni bilo nobenih drugih stikov.



odpravil proti kozolcu, kjer je babica ponavadi skrila njen rezervni ključ. V tistem trenutku, so se odprla vhodna vrata. Miha se je skril za vogal hiše in opazoval. Videl je temno postavo, ki je izstopila iz hiše. Postava se je obrnila in takrat je Miha zagledal svojo nedolžno teto. Ni vedel kaj je počela tam in na srečo ga ni opazila. Sledil ji je kot pravi kriminalist ki želi ujeti roparja. Vedel je, da njegova teta nekaj naklepa. Videl je, kako se plazi za hišo, v drvarnico. Nosila je krožnik in Miha ji je še vedno sledil. Ko je prišel do drvarnice je zagledal svojo babico, kako leži na tleh blazini. Teta ji je prinesla večerjo, Miha pa je slišal samo, ko je teta govorila babici, da se ne sme kazati družinskim članom. Odločil se je, da tega ne bo povedal svojim staršem, saj mu tako ali tako ne bi verjeli. Skril se je za grmovje in to je storil ravno pravi čas, da ga njegova teta ne bi zalotila. Ko je teta odšla, je šel k svoji babici in se začel z njo pogovarjati in jo izpraševati. Vprašal jo je nešteto vprašanj, a babica ni nikoli odgovorila. Samo nekaj je momljala iz stokala. Miha ni vedel kaj naj stori, da bo babico pripravil do govora. Občutek je imel, da se babica boji njegove tete. Le kaj ji je storila? Tisti trenutek je Miha na obzorju zagledal sonce. Moral je domov. Zjutraj ga je namreč čakalo testiranje. Stekel je domov, kolikor hitro je le mogel. Doma so na srečo še vsi spali. Miha se je izmuznil v sobo, se preoblekel v pižamo in se zavil v odejo. Nihče namreč ni smel vedeti, da ga ni bilo doma. Kmalu je v njegovo sobo prišla mama in mu naročila, naj se pripravi na testiranje. Miha se je zvlekel iz postelje in se oblekel. Odpravil se je proti kuhinji na zajtrk. Pred vrati kuhinje se je ustavil. Je morda slišal glas svoje zoprne tete? Ne, to ni bilo mogoče. Le kaj je ona počela v njihovi hiši? Končno je odprl vrata in se pripravil, da teti pove, da ve za vse njene skrivnosti. A tam ni bilo tete, le očka se je pogovarjal po telefonu. In Miha je vedel s kom. Njegova teta je očku natvezila zgodbe o tem, kako grozno ji je žal za babico. Miha je ni mogel več poslušati. Stekel je v svojo sobo in poklical svojo najboljšo prijateljico Mio. Povedal ji je kaj se je zgodilo. Mia je bila naravnost zgrožena. Le kako je mogla, si je mislila. Odložila je telefon, se oblekla. Ko je hotela zapustiti hišo, se je spomnila na samoizolacijo. Nihče ni smel zapuščati hiše. Tako je odšla noter in Mihi poskušala pomagati preko telefona. Med tem pa je Miha že sedel v čakalni vrsti za testiranje. Nekdo ga je potrepljal po rami. Bil je njegov prijatelj Beni. Beni mu je povedal, da tudi on čaka na testiranje, saj je njegova mami bila čisto panična. To pa zato, ker je mislila da je okužen, takoj ko je malo zakašljal. Miha mu je povedal, kako je prišlo do tega, da je on pristal na testiranju. V tistem hipu pa je kar iz nekje skočila Benijeva mama in se začela dreti, da imata premajhno varnostno razdaljo. Takoj sta stopila narazen in se razšla. Ko so opravili testiranje so bili rezultati od cele družine negativni. Torej ni bil nihče okužen, tudi teta ne. Miha se je odločil, da bo vprašal zdravnika ali je njegova babica sploh šla na testiranje ali je samo teta natvezila zgodbico iz neznanega razloga. Zdravnik mu je rekel, da žal ne sme deliti teh podatkov. Miha je naslednjo noč spet odšel k babici in tam je bila tudi teta. Spet je videl kako se pogovarja z babico. Ko je teta odšla je šel k babici in se spet začel pogovarjati z njo. Tokrat mu je uspelo iz nje izvleči, da si teta želi njene dediščine in kmalu je Mihu bilo jasno, da teta želi, da se babica okuži in umre. Zdaj ni mogel več odlašati. Poklical je starše, oni pa so našli veliko dokazov in poklicali policijo. Teta je bila za nekaj časa pridržana na policijski postaji, babico pa so lepo oskrbeli doma. Vsi so ostali zdravi in veseli.

Alenka in Lucija



5.4. 2020

PODAJANKA

Miha je bil fant, ki je vedno imel polno energije, nove ideje in malce prismuknjene zamisli. Kakorkoli njemu nikoli ni bilo dolgčas, a danes ni bilo tako. Ves zdolgočasen je sedel v svoji sobi in gledal v strop. Saj ni mogel nič početi, ni mogel k prijateljem, ni mogel ven, niti brati ni mogel, saj je bila tudi knjižnica zaprta. Kar naenkrat se mu je zazdelo, da je zaprtje šole ena sama katastrofa. Namesto da bi se med odmori družil s prijatelji, je zdaj sam sedel v svoji sobi. Seveda bi se lahko družil z bratom ali sestricama, ampak kaj, ko so mu kar naenkrat šli vsi na živce. Miha je bil čisto raztresen od vsega tega. Prvič v življenju si je želel iti v šolo, ker je bil prepričan, da se jim bo šola zavlekla v počitnice. Sedel je v svoji sobi in se smilil samemu sebi. Nikogar ni spustil v svoje zatočišče, iz njega pa je šel samo za tri obroke na dan. Želel si je le, da bi virus takoj odšel, ampak kaj, ko mu želja ni nič pomagala. Nekaj trenutkov je razmišljal, da bi bilo mnogo bolje, če bi bil okužen, saj potem vsaj ne bi umiral od dolgčasa in bi se imel z nečim za ukvarjat. Šele čez nekaj časa se je zavedal, da morda malce pretirava. V svoji sobi je imel televizijo in se je odločil, da bo pogledal kaj je na programu. Ugotovil je, da ni nobenega zanimivega filma in da cel dan poročajo o virusu. Kar naenkrat se mu je zazdelo, da je malo utrujen in zato je sredi popoldneva šel v posteljo. Zbudil se je šele sredi noči. V njegovi sobi je bila popolna tema, pogledal je na uro. -Tri zjutraj-si je rekel v glavi. Zagotovo so vsi že spali. Nenadoma je v kuhinji zazvonil telefon. Le kdo kliče ob taki uri-si je mislil Miha. Vseeno se je odločil, da bo dvignil telefon. V trenutku, ko je prijel za telefon in sprejel klic, je oseba na drugi strani začela govoriti. Zvenela je razburjeno. Miha je po telefonu takoj prepoznal strog glas svoje tete. Vsa razburjena je povedala, da se je njegova babica okužila z virusom na upokojenski zabavi in da bodo morali vsi člani družine na testiranje. Miha je najprej mislil, da je to samo nočna mora in se bo zjutraj zbudil povsem normalno. Seveda ni bilo tako. Zbudili so se njegovi starši, brat in sestrici. Ko jim je povedal grozno novico je njegova mama postala čisto preplašena. Mihu pa nekaj ni bilo jasno. Zakaj jih je teta klicala sredi noči, če pa babica gotovo ni šla ponoči na testiranje. Odločil se je, da bo to malo raziskal. Njegovi člani družine so zelo težko zaspali, saj naj bi jih takoj zjutraj čakalo testiranje. Miha se je splazil ven in šel peš do hiše njegove babice. Želel se je prepričati, ali je res, kar mu je povedala teta. Ampak edinemu v družini se je zdelo, da je to velika laž. Prišel je do cilja in Miha je takoj vedel, da nekaj ni v redu. Zakaj v hiši gori luč, če nikogar ni doma? Babica je verjetno že v karanteni, dedek pa je na žalost že pokojen. Poleg tega pa je babica vedno zelo natančna glede ugašanja luči. Če jo on slučajno pusti prižgano, ko gre od doma in babica to izve, zagotovo dobi kazen. Miha se je približal hiši in pogledal skozi okno, a to je bilo tako umazano, da ni mogel videti ničesar. To je bila še ena čudna stvar, saj babica sovraži umazanijo. Mihu ni preostalo nič drugega, kot, da vstopi v hišo. Začuda so bila vrata zaklenjena. Babica jih vendar nikoli ne zaklene, saj se boji, da bo izgubila ključe in za vedno obtičala v hiši. Poleg tega pa njena hiša stoji sredi nekega travnika, do katerega ne vodi nobena cesta, ampak le ozka makedamska potka, po kateri ne hodi nihče. Miha se je odločil, da bo prišel temu do dna. A najprej je moral najti rezervni ključ, s katerim bo lahko prišel v hišo. Že se je

Slika 3: učenki Alenka Verbič, Lucija Vrhovec

4 ZAKLJUČEK

Dilema učiteljice je bila, kako oblikovati navodila za delo, za pouk na daljavo, pri tem pri učencih vzbuditi zanimanje, slediti učnemu načrtu, ne zapostaviti branje in pisno izražanje oz. pridobiti učence za redno vsakdanje šolsko delo in jih pri vsem tem ne preveč obremenjevati. Dilema je bila toliko večja, kolikor je bila digitalna komunikacija še nerazvita oz. neosvojena s strani učencev in učiteljev.

Učiteljica je v tistem času našla primerno rešitev, saj so bili učenci, ki so se odzvali, zadovoljni, bili so zaposleni z drugačnim delom, uspešno so sledili navodilom. Pri tem so se zabavali, povezali med seboj, zgodbe so snovali tudi skupaj s starši in na koncu bili še nagrajeni za svoje delo.

Učiteljici je v novo nastali situaciji uspelo navezati stike z učenci, se dopisovati z njimi. Letos so se ti isti učenci brez zadrege obračali na elektronske naslove učiteljev in vprašali vse, kar jim ni bilo jasno, izražali svoja mnenja, pošiljali

naloge v pregled. Letos so zaključili devetletno osnovno šolo in ta generacija učencev je na Nacionalnem preverjanju znanja dosegla nadpovprečen rezultat. Izkazalo se je, da je bilo zelo

pomembno vzdrževati stike z učenci, pa čeprav samo preko elektronske pošte.

Ti borni začetki so bili velika vzpodbuda, da se lahko vsi še veliko naučimo. Tako smo že ob naslednjem »zaprtju« šole pripravili radijsko igro »Pehar suhih hrušk« Ivana Cankarja, pripravili proslavo ob 20. obletnici šole, skupaj s pesniško zbirko učencev, ki je nastajala na enak način, na daljavo, in pripravili še marsikatero virtualno prireditev.

Učitelji smo bili deležni različnih izobraževanj, da bi bili čim bolj usposobljeni za poučevanje na daljavo. Kaj pa je z učenci? Mogoče ne bi bilo napačno razmišljati o rednem predmetu informatike in računalništva v osnovni šoli?!

LITERATURA IN VIRI

[1] Program osnovna šola, Slovenščina, Učni načrt [posodobljena izdaja], 2018. Dostopno na naslovu

[2] https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/obvezni/UN_slovenscina.pdf (1. 6. 2018), 32, 39, 41, 42, 43.

[3] Berilo za sedmi razred devetletne osnovne šole »Sreča se mi v pesmi smeje«, 2002. Založba Mladinska knjiga, 104-107.

[4] Povest. Dostopno na naslovu https://fran.si/iskanje?View=1&Query=povest Različica 9.0 (3. 12. 2021)

[5] Miran Hladnik, Povest. Dostopno na naslovu http://lit.ijs.si/povest.html (10. 11. 2004)

[6] Povest. Dostopno na naslovu https://sl.wikipedia.org/wiki/Povest (3. 2. 2021)

[7] Navodilo s spletne strani šole OŠ Antona Martina Slomška Vrhnika. Dostopno na naslovu https://www.osams.si/2020/03/19/slovenscina-7-a-2-prispevek/ (19. 3. 2020)

[8] Leonida Novak, 2016. Spodbujanje razvoja bralne kompetence na literarnem področju v prvem triletju. Pouk književnosti in motivacija. Dostopno na naslovu https://core.ac.uk/download/pdf/79462288.pdf (6. 6. 2016), 175, 176, 177.

[9] Nataša Tovornik, 2016. Kaj je timsko delo. Dostopno na naslovu https://www.datalab.si/blog/kaj-je-tim-in-timsko-delo/ (19. 7. 2016)

[10] Skupinska dinamika. Dostopno na naslovu https://sl.wikipedia.org/wiki/Skupinska_dinamika (8. 6. 2018)

[11] Uvajanje informativnega spremljanja in inkluzivne paradigme, 2022. Zavod RS za šolstvo. Knjiga podajanka. Dostopno na naslovu

[12] https://www.zrss.si/wp-content/uploads/2022/02/razvojna_naloga_uvajanje_FS-1.pdf (28. 2. 2022), 93, 94.

[13] Predlog učnega načrta za pouk slovenščine v tretjem triletju, 1997/98. Jezik in slovstvo, kazalo letnika 43. Dostopno na naslovu https://www.jezikinslovstvo.com/ff_arhiv/lat1/043/12c06.htm (26. 3. 1999)

Podpora staršem in učencem pri šolanju na daljavo s pomočjo spletnega orodja Weebly

Support to Parents and Pupils in Distance Schooling Using the Weebly Online Tool

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POVZETEK

V prispevku so predstavljeni nekateri izzivi, s katerimi smo se srečali v času izolacije in naše spopadanje z njimi. Gre predvsem za aktivno preživljanje prostega časa v času izolacije, organizacijo dela, zmanjševanje in obvladovanje čustvenih stisk, sproščanje, ohranjanje motivacije za učenje ter pomoč staršem v novonastali situaciji. S kolegicami v svetovalni službi smo ustvarile spletno stran, na kateri smo na enem mestu zbrale različne aktivnosti in dejavnosti, ki so učencem in njihovim staršem olajšale dneve preživete v izolaciji. Spletno stran je bila ustvarjena s pomočjo spletnega orodja Weebly. Na njej se lahko najdejo različne ideje, kako si organizirati svoj čas, kako se učiti ter kako preživeti prosti čas. Poleg tega lahko učenci posegajo tudi po dodatni razlagi snovi, dodatnih gradivih in vajah. Starši pa lahko najdejo povezave do različnih člankov, vezane na družinsko življenje v času izolacije. Vsebine na spletni strani so pripravljene tako, da so bile aktualne v času izolacije, veliko aktivnosti pa s pridom uporabljamo tudi v šoli.

KLJUČNE BESEDE

Izolacija, prosti čas, motivacija, organizacija, podpora, weebly

ABSTRACT

The paper presents some of the challenges we encountered during the isolation and our struggle dealing with them. It is mainly about active leisure pursuits in times of isolation, organising work, reducing and managing emotional distress, relaxing, maintaining motivation to learn and helping parents in a new situation. Together with our colleagues at the school counselling service we have created a website that brings together in one place a variety of activities that have helped to make the days spent in isolation easier for pupils and their parents. The website was created using the Weebly web tool. On the website you can find different ideas on how to organize your time, how to study and how to spend your free time. In addition, students can also find additional explanations, additional materials and exercises. Parents, however, can find links to various articles tied to family life during isolation. The content on the website is designed to be relevant during the isolation period and many of the activities are being used at school as well.

KEYWORDS

Isolation, free time, motivation, organisation, support, weebly

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1 UVOD

Izobraževanje na daljavo je predstavljalo velik izziv za vse učitelje na naši šoli. Vsak izmed nas je iskal načine, kako izpeljati učinkovit pouk in čimbolj kvalitetno in trajnostno predstaviti vsebine svojega predmeta. Novembra 2020 smo bili že vsi bolj ali manj vpeljani in smo na novo pridobljene izkušnje že z veliko manj stresa uporabljali v novem obdobju šolanja na daljavo. Skupaj in en drugemu v podporo smo poskrbeli za kvaliteten pouk ob uporabi različnih spletnih orodij. Ko je delo kolikor toliko gladko steklo, pa smo se začeli spraševati, kaj še lahko naredimo, da v dejavnosti čimbolj aktivno vključimo res vse učence. Sodelavke v svetovalni službi smo začele opažati, da so učenci in starši v vedno večjih stiskah zaradi izolacije, motivacija za učenje je zaradi izrednih razmer začela padati, še posebej pa so bili izpostavljeni učenci s posebnimi potrebami in tisti z učnimi težavami, ki samostojnega učenja ne zmorejo in potrebujejo prisotnost in nadzor odrasle osebe. Tako se je porodila ideja o nekoliko drugačni spletni strani, kjer bi našli različne vsebine na enem mestu, kjer bi imeli možnost komunikacije in kamor bi imeli lahek dostop tudi starši, za katere pa bi prav tako pripravili material za pomoč pri šolanju na daljavo. Spletna stran je bila v prvi vrsti namenjena učencem z dodatno strokovno pomočjo, izkazalo pa se je, da je bila koristna za prav vse učence, saj jim je nudila nekoliko drugačno podporo in pokrivala še ostala področja njihovega življenja.

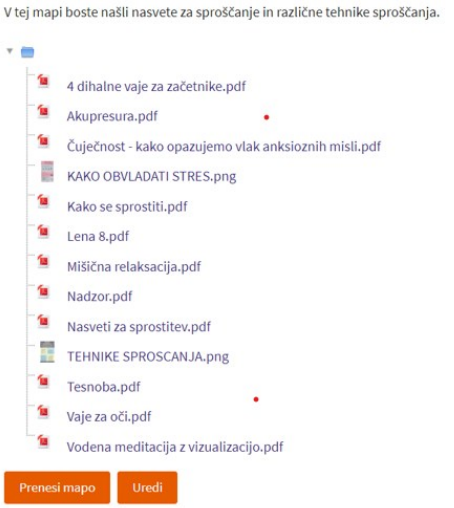
2 PODPORNE DEJAVNOSTI ŠOLANJA NA DALJAVO – spletno orodje WEEBLY

Izobraževanje na daljavo je oblika izobraževanja, kjer sta učitelj in učenec med poučevanjem prostorsko ločena, komunikacijo med njima ter komunikacijo med učenci samimi pa omogočajo različne vrste tehnologij. Učinkovito izobraževanje na daljavo zahteva strukturirano načrtovanje, dobro strukturirane učne enote, specialne didaktične strategije ter komunikacijo preko elektronskih in drugih tehnologij. Unesco poudarja, da izobraževanje na daljavo zahteva »visok nivo samouravnavanja in veščin učenja, kar naj bi učitelji podprli z novimi poučevalnimi, učnimi in usmerjevalnimi strategijami«.[1]

Učitelji smo se najprej usmerili predvsem v kvalitetno izvajan pouk na daljavo, saj smo se še sami morali veliko naučiti na tem področju. Analiza dela na daljavo iz šolskega leta 2019/2020 je pokazala, da so se učitelji trudili, da so delo organizirali tudi v skupinah ali dvojicah, vendar najbolj so učence spodbujali k samostojnemu, individualnemu delu. Individualno delo predstavlja obliko pouka, pri kateri vsak učenec sam izvaja določeno nalogo ali dejavnost in učencem omogoča, da tempo dela prilagajajo svojim sposobnostim. Je pa za uspešno realizacijo samostojnega dela v praksi pomembno, da imajo učenci razvite tudi sposobnosti načrtovanja, organiziranja, vodenja, kontroliranja in prilagajanja lastnega procesa učenja[2].

Ugotavljali smo, da zaradi daljšega trajanja izolacije ni bilo več dovolj le kvalitetno izvajan pouk, temveč je bilo potrebno delati tudi na ostalih področjih razvoja. Učenci so bili namreč veliko časa prepuščeni sami sebi, saj so tudi starši morali svoj način dela prilagoditi novim razmeram in je to terjalo čas, ki bi ga sicer lahko namenili svojim otrokom. Čisto naravno so učenci začeli izkoriščati to novo svobodo in kmalu je bila učinkovitost pouka veliko manjša.

Svetovalna služba na naši šoli si je zato zadala novo nalogo in sicer učencem ponuditi dejavnosti za čas, ko učenci niso aktivno delali za šolo. Torej, kako aktivno in zdravo preživeti prosti čas v okviru omejitev, ki jih je prinesla izolacija ter tako ohraniti energijo in motivacijo za ostalo delo. Na naši šoli uporabljamo Arnes Učilnice (moodle)[3] in videokonferenčno okolje Teams. Vsak razred od četrtega razreda naprej je imel svojo spletno učilnico, znotraj vsakega razreda pa je bila učilnica razdeljena po predmetih. Najprej smo si omislile svoj kotiček v vsaki posamezni spletni učilnici, torej razdelek, ki smo ga poimenovale *Razredna ura*. V ta razdelek smo nalagale material predvsem s področja, kako se učiti, sprostiti ter ideje, kako lahko učenci kvalitetno preživijo svoj prosti čas. Material smo oblikovale s pomočjo spletnega orodja Canva[4], saj so izdelki, izdelani v tem programu barviti, zanimivi in pritegnejo pozornost. Spodaj je na sliki 1 prikazana mapa SPROŠČANJE iz spletne učilnice sedmega razreda razdelka RAZREDNA URA, kamor smo na začetku shranjevale dopolnilne aktivnosti za učence. Tako smo opremile spletne učilnice za vse razrede. Ugotovile smo, da učenci poleg vseh ostalih vsebin, ki jih morajo dnevno pregledati in obdelati, ne posegajo po tem razdelku in zelo malo uporabljajo ponujene aktivnosti. Poleg tega so bile spletne učilnice vedno bolj polne in tudi ne več tako pregledne kot na začetku.



Slika 2: Razdelek RAZREDNA URA, mapa SPROŠČANJE

Zato smo razmišljale naprej ter s pomočjo spletnega orodja weebly[5] ustvarile veliko bolj zanimivo in bolje organizirano spletno stran, ki smo jo predstavile učencem s posebnimi potrebami, s katerimi smo delale in učiteljem, ki so jo potem naprej predstavili svojim učencem, nekateri pa so jo tudi sami s pridom uporabljali. Poimenovale smo jo *DODATNA STROKOVNA POMOČ[7]* in jo postavile na vidno mesto na šolski spletni strani. Na tej strani je pod razdelkom *SVETOVALNICA*. Razdeljena je po naslednjih področjih.

2.1 Domov

Naslovna stran ali Domov je prva stran naše spletne kreacije. Na tej strani smo se predstavile, kdo smo, kaj delamo in zapisale, kako je organizirana dodatna strokovna pomoč v času dela na daljavo.

2.2 Organizacija dela

V tem delu smo pripravile aktivnosti, ki učencem omogočajo lažjo organizacijo dela v času šolanja na daljavo. Vseboval je podporo in ustvarjalne ideje, kako si samostojno in z vizualnimi pripomočki organizirati delo skozi cel dan ter tako dneve osmisliti in čimbolj zdravo in aktivno preživeti.

2.3 Učenje učenja

V tretjem razdelku smo učencem ponudile različne učne strategije, s katerimi lahko izboljšajo svoje učenje, si ga naredijo zanimivejšega, predvsem pa je učenje s pomočjo teh strategij učinkovitejše. Zavedamo se, da se različni učenci učijo na različne načine ter da vsaka strategija ni primerna za vsa področja, zato smo učencem pripravile različne vsebine s tega področja. Na sliki 2 je nekaj vsebin iz te strani. Če učenec klikne na *Strategije učenja-ČINKVINA*, se mu odpre na kratko in barvito opisana metoda učenja, ki jo lahko takoj enostavno preizkusi na svojem gradivu. Če mu metoda odgovarja, jo še kdaj uporabi. Če ne, preizkusi kakšno drugo.

Slika 2: Učenje učenja

2.4 Motivacija

Tukaj se nahaja veliko didaktičnih iger, s katerimi si učenci lahko zapolnijo vmesni čas med učenjem. Igre so zanimive, učencem predstavljajo izziv, nekatere pa so tudi interaktivne. Učencem ponujajo zabavo, hkrati pa z njimi razvijajo tudi druge veščine, na primer pozornost, koncentracijo, vidno-motorično

koordinacijo in še kaj. Pri urah dodatne strokovne pomoči smo te aktivnosti s pridom uporabljali tudi, ko smo se izobraževali v šoli.

2.5 Šolanje na domu

V tem delu lahko učenci najdejo veliko gradiv, koristnih pri šolanju na daljavo. Na začetni strani se nahaja nekaj povezav in idej za prostočasne aktivnosti, posnetki lutkovnih predstav ter interaktivne igre. Za mlajše smo zbrali dejavnosti v podporo začetnemu opismenjevanju in računanju, starejši pa posegajo po dodatni razlagi snovi, e-učbenikih po predmetnih področjih ter dodatnih gradivih za učenje.

2.6 Sprostitev

Ta razdelek je namenjen aktivnostim, ki učencem nudijo sprostitev po učenju. Za mlajše so pripravljeni posnetki pravljic, vodenih meditacij, lutkovnih predstav in animiranih serij. Starši in starejši otroci pa lahko dobijo kakšno idejo, kako preživeti svoj prosti čas z otrokom v družinskem krogu.

2.7 Gradiva za starše

Zaradi vse večjih stisk staršev in njihovih otrok pa smo del naše spletne strani namenile tudi staršem, ki imajo možnost posegati po aktualnih člankih na teme povezane s trenutno situacijo, vzgojo svojih otrok in ohranjanjem svojega lastnega zdravja.

3 SOCIALNI VIDIK IN KOMUNIKACIJA S STARŠI

Seveda je res, da je bila spletna stran ustvarjena z najboljšim namenom. Poskrbljeno je za barvitost, raznolikost aktivnosti in področij. Vsak lahko najde kaj zase, tako učenci, kot tudi starši in ostali učitelji. Potrudile smo se, da je stran sistematična, organizirana in pregledna. Vendar je to še vedno vsebina na računalniku in je njena uporabnost omejena.

Rezultati raziskave SI-PANDA so pokazali, da je pandemija covida-19 med otroki povzročila okrnjene stike s sovrstniki, kar se je nadaljevalo tudi v obdobju po sprostitvi ukrepov. Prav tako se je med mladostniki povečal čas, preživet pred ekrani. Veliko staršev je tudi poročalo, da se otroci tudi po pandemiji niso toliko vključevali v obšolske dejavnosti.[6]

Zavedamo se, da čustvenih stisk zaradi preobremenjenosti in osamljenosti ne moremo reševati le s pomočjo spletnih vsebin, zato smo staršem in učencem preko te spletne strani omogočili tudi stik in komunikacijo s šolsko svetovalno službo preko spletnega orodja TEAMS. Na vsakem razdelku je možnost *KONTAKT*, kjer lahko starši ali učenci vpišejo svoje podatke, na kratko opišejo težavo ozirom izziv, ki bi ga želeli razreševati s katero izmed nas in tako se začne komunikacija med nami. Enkrat tedensko (po vnaprej določenem urniku) pa je bila tudi možnost vstopa v konferenčno okolje TEAMS, kjer smo bile na voljo v živo in smo prav tako odgovarjale na vprašanja, starši so imeli možnost posveta ali pogovora v zvezi s svojimi otroki. Pravzaprav so bile to nekakšne govorilne ure svetovalne službe, kjer so imeli možnost stika z nami tako učenci kot starši. Urnik in predstavitev spletne strani staršem je potekala preko sporočila v eAsistentu in učiteljev, katerim smo me predstavile dejavnosti na eni izmed tedenskih srečanj vseh učiteljev. Sam obisk te možnosti (govorilne ure) sicer ni bil zelo obsežen, vendar verjamemo, da je že sam občutek, da smo na voljo, staršem in učencem dajal varnost in jim olajšal vsakodnevne izzive, ki jih je prinesla izolacija.

4 ZAKLJUČEK

Verjamem, da je bilo v času izolacije veliko stisk, osamljenosti, čustvenih motenj, depresij, malodušnosti tako med otroki kot med odraslimi. Vloga nas učiteljev je kljub izrednim razmeram še vedno izredno pomembna. Edino prav je, da učitelji v vsakršnih razmerah iščemo rešitve in nove možnosti, da pridemo v stik s svojimi učenci in jih vodimo ter spremljamo pri njihovem razvoju. Aktivnosti in vsebine na spletni strani so bile pripravljene z namenom ohraniti duševno zdravje otrok. Glede na odzive učencev in staršev lahko rečemo, da smo svoj namen dosegli. Še posebej so bili navdušeni učenci s posebnimi potrebami, s katerimi smo skupaj pregledali vsebine, se z njimi tudi na učni uri kaj poigrali, pokazali smo jim razdelke, ki so za njih še prav posebej koristni ter jih načrtno usmerile na delo s pomočjo spletne strani tudi po naši uri. Prednost podajanja vsebin na takšen način pred klasičnimi spletnimi učilnicami je tudi dostopnost, saj z lahkoto in brez kakršnihkoli gesel lahko do nje dostopajo učenci, starši in učitelji. Vse je na enem mestu in vsak lahko hitro poišče vsebine, ki ga zanimajo. Veliko vsebin in aktivnosti je tudi po vrnitvi v šolo še vedno aktualnih in jih z učenci pogosto uporabljamo. Spletno orodje *Weebly* je enostavno za uporabo, na voljo je veliko različnih možnosti, ki ti jih program tudi jasno in sproti predstavi. Spletna stran se lahko dopolnjuje z materialom, pripravljenim v različnih oblikah, nalagati je možno videoposnetke, fotografije, različne internetne povezave, ustvariti je možno tudi interaktivne aktivnosti. Znotraj programa je možna tudi uporaba videokonferenčnega okolja ali komunikacija preko elektronske pošte. Poleg tega je uporaba tega programa brezplačna.

VIRI IN LITERATURA

[1] T. Rupnik Vec, S. Preskar, B. Slivar, R. Zupanc Grom, S. Kregar, A. Holcar Brunauer, V. Bevc, M. Mithaus, M. Grmek, K. Musek Lešnik. (2020). Analiza izobraževanja na daljavo v času epidemije Covid-19 v Sloveniji, delno poročilo [Online]. Ljubljana: Zavod Republike Slovenije za šolstvo. Dosegljivo: www.zrss.si/pdf/analiza_izobrazevanja_na_daljavo.pdf [28. 7. 2022].

[2] S. Kustec, V. Logaj, M. Krek, A. Flogie, P. Truden Dobrin, M. Ivanuš Grmek. (2020). Vzgoja in izobraževanje v Republiki Sloveniji v razmerah, povezanih s covid-19, Modeli in priporočila [Online]. Ljubljana: Zavod Republike Slovenije za šolstvo. Dosegljivo: www.zrss.si/pdf/modeli_in_priporocila.pdf [28. 7. 2022].

[3] Arnes Učilnice. Dosegljivo: https://sio.si/vodici/moodle/#kompilacija-sio-MDL-VOD

[4] Canva for windows. Dosegljivo: https://www.canva.com

[5] Weebly. Dosegljivo: https://www.weebly.com

[6] A. Grom Hočevar, T. Truden Dobrin, A. Belščak Čolaković, T. Pibernik, M. Rehberger, D. Lavtar, J. Kožar, S. Dravec. (2022). »Kako je pandemija covida-19 vplivala na življenjski slog otrok in mladostnikov v Sloveniji?« Mladostnik na prepihu časa: zbornik prispevkov in izvlečkov: VIII. kongres šolske, študentske in adolescentne medicine Slovenije: Medicinska fakulteta Maribor, 17. in 18. 6. 2022. [Online]. Dosegljivo: PDF (dlib.si) [27. 7. 2022].

[7] Dodatna strokovna pomoč. Dosegljivo:https://dspospvmb.weebly.com

Digitalna zbirka kamišibajev

A Digital Collection of Kamishibai

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POVZETEK

Na Osnovni šoli Antona Martina Slomška Vrhnika želimo, da so učenci pri pouku ustvarjalni, inovativni in samostojni. Pri pouku slovenščine lahko to najlažje dosežemo pri obravnavi in analizi literarnih del. Vsako leto opažamo, da imajo učenci težave z razumevanjem starejših književnih besedil, zato damo poudarek na razlagi in razumevanju vsebine besedila. To se je pokazalo pri sedmošolcih, ko smo obravnavali ljudsko pesnitev Pegam in Lambergar. Odločili smo se, da pesnitev spremenimo v kamišibaj. Pri ustvarjanju in oblikovanju kamišibaja so se učenci naučili sodelovanja, hkrati pa so bili tudi likovno ustvarjalni. Delo jih je navdušilo, zato smo se odločili, da poskušamo čim več knjižnih del spremeniti v kamišibaj, zgodbo posneti in tako ustvariti digitalno zbirko kamišibajev, ki bo v pomoč kasnejšim generacijam za razumevanje vsebine književnih besedil.

KLJUČNE BESEDE

Slovenščina, kamišibaj, gledališče, digitalna zbirka

ABSTRACT

At the Anton Martin Slomšek Vrhnika Primary School, we want students to be creative, innovative and independent in their lessons. In Slovenian language classes, this can be achieved most easily in the consideration and analysis of literary works. Every year, we notice that students have problems with understanding older literary texts, so we emphasize the interpretation and understanding of the content of the text. This was evident in seventh-graders when we discussed the Pegam and Lambergar folk poem. We decided to change the poem into kamishibai. In the creation and design of the kamishibai, the students learned to cooperate, and at the same time they were also artistically creative. They were impressed by the work, so we decided to try to turn as many book works as possible into kamishibai, record the story and thus create a digital collection of kamishibai, which will help later generations to understand the content of literary texts.

KEYWORDS

Slovene, kamishibai, theatre, digital collection

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1 UVOD

V Učnem načrtu za slovenščino [1] so zapisana besedila, ki jih moramo pri pouku slovenščine obravnavati v določenem razredu. Med obvezna besedila v 7. razredu sodi tudi ljudsko besedilo Pegam in Lambergar.

Vsako besedilo, ki ga obravnavamo, najprej glasno prebere učiteljica. Po prvem branju najprej strnemo prve vtise, razložimo neznane besede in vsebino besedila, nato besedilo še enkrat glasno berejo učenci. Pri vsakem besedilu določamo temo, dogajalni kraj in čas ter napišemo kratko obnovo besedila. Če je besedilo pesem, določimo tudi zunanjo in notranjo zgradbo pesmi ter poiščemo pesniška sredstva, ki jih je avtor uporabil v besedilu. Za urjenje domišljije in tehnike pisanja na določena besedila poustvarjamo. Letošnji sedmošolci so zelo vedoželjni. Poskušamo jih vključiti v proces načrtovanja pouka. Po obravnavi besedila smo učence vprašali, kako bi lahko besedilo Pegam in Lambergar preoblikovali oz. kako bi poustvarjali. Ena od učenk je predlagala kamišibaj, ki ga je videla v splošni knjižnici in se ji je zdel zanimiv. Nihče od ostalih učencev za kamišibaj še ni slišal, zato so morali za domačo nalogo raziskati, kaj to je. Naslednji dan so bili vsi navdušeni in so se veselili ustvarjanja.

Jenko [2] piše, da zaman iščemo strokovne izraze, povezane s kamišibajem, v različnih slovarjih, saj so ti pojmi na Slovenskem novejši od zadnje slovarske izdaje. Tominc [3] pravi, da je kamišibaj v Slovenijo pripeljal Igor Cvetko in je v naši državi prisoten od leta 2013. Cvetko [4] razloži, da kamišibaj izvira z Japonske. Beseda »kami« pomeni papir, »shibai« pa gledališče, torej bi dobesedni prevod pomenil papirnato gledališče. Gre za način pripovedovanja zgodb ob slikah v malem lesenem odru, ki se imenuje butaj. Butaj je sestavljen iz okvirja, vratc in prostora, v katerega vložimo ilustracije. Osebi, ki se ukvarja s kamišibajem, rečemo kamišibajkar.

2 PEGAM IN LAMBERGAR

2. 1 Obravnava besedila

Besedilo Pegam in Lambergar je najprej glasno prebrala učiteljica. Prvi vtisi na prebrano so bili zmedeni, saj so učenci trdili, da besedila niso razumeli. Začeli smo z razlago. Klicali smo učence, da je vsak prebral eno kitico in jo poskušal s svojimi besedami razložiti. Besedilo smo še enkrat glasno prebrali in razumevanje je bilo boljše.

V drugem delu smo se ukvarjali z besedilom. Izpisovali smo glavne in stranske osebe, določali temo, dogajalni kraj in čas ter

pesniška sredstva. Določilo smo tudi vrsto in zvrst besedila. Z učenci smo se začeli pogovarjati, kaj bi lahko poustvarjali na temo obravnavanega besedila. Učenka je predlagala kamišibaj, ki ga je videla v splošni knjižnici in se ji je zdel zanimiv. Nihče od sošolcev za besedo kamišibaj še ni slišal, zato so morali za domačo nalogo raziskati pomen te besede. Nad idejo so bili navdušeni, zato smo se takoj lotili dela.

2. 2 Izdelava kamišibaja

Na začetku so se vse stvari zdele zelo preproste. Ko smo začeli z načrtovanjem, smo hitro ugotovili, da bo potrebno veliko sodelovanja in usklajevanja, da bomo s končnim izdelkom zadovoljni. Učenci so najprej načrtovali, iz koliko slik bo kamišibaj, in kaj mora slika glede na besedilo vsebovati (Slika 1).

Slika 1: Načrt za ilustracije

Učenci so načrtovali osem slik, zato so se razdelili v osem skupin. Ugotovili so, da preden začnejo z delom po skupinah, se morajo dogovoriti, kakšen bo izgled junakov in predmetov, ki jih na risbah upodabljajo, saj ne more biti na vsaki sliki isti junak drugačen. Na spletu so poiskali ilustracije določenih junakov in predmetov, s katerimi so si pomagali pri risanju. Svoje risbe so pobarvali z barvicami (Slika 2).

Vsaka skupina je svojo ilustracijo opremila z besedilom, ki ga je ilustracija predstavljala. Ko so besedilo napisali, so se vodje skupin med seboj uskladili, da je bilo besedilo vsebinsko ustrezno.

Vsaka skupina je izbrala svojega predstavnika, ki je ob risbi, ki so jo narisali in pobarvali, povedal besedilo. Za zaključek smo pripovedovanje celotne zgodbe v tehniki kimišibaj tudi posneli ter analizirali svoj izdelek.

Pri snemanju smo naleteli na več težav. Med sabo so se morali uskladiti, saj mora eden od učencev iz butaja premikati sličice. Na začetku so učenci snemali s svojimi telefoni in so ugotovili, da je kvaliteta posnetka slaba. Učiteljica jim je predlagala, da zgodbo posnamejo s šolsko kamero. Učenci so morali do učitelja računalništva, ki jih je najprej naučil rokovanja s kamero. Učenci so bili zadovoljni šele s petim posnetkom, ki so ga nato oblikovali v video urejevalniku Filmora, ki jih ga je naučil uporabljati učitelj računalništva.

)

Slika 2: Barvanje ilustracij

3 IDEJA O DIGITALNI ZBIRKI KAMIŠIBAJEV

Danes smo ljudje navajeni, da do podatkov dostopamo preko spleta. Na spletu najdemo Digitalno knjižnico Slovenije, v kateri najdemo različne knjige, periodiko, rokopise, slike, glasbo, zemljevide …

Prišli smo na idejo, da bi na naši šoli ustvarili svojo digitalno zbirko posnetkov kamišibajev. Digitalno zbirko bi hranili na računalniku v šolski knjižnici. Do zbirke bi lahko dostopali učitelji. S posnetki bi lahko popestrili pouk učencem, ki prihajajo v višje razrede, in jim tako olajšali razumevanje prebranega.

Učence je izdelava kamišibaja navdušila. Po analizi dela in ogledu posnetka so učenci prišli na idejo, da lahko izdelamo kamišibaj za več literarnih besedil, ki jih pri pouku obravnavamo, in ga posnamemo, s čimer bi učenci lažje razumeli vsebino literarnih besedil.

Učenci so takoj pričeli z iskanjem novega besedila, ki bi ga preoblikovali v kamišibaj. Na naši šoli vsako leto organiziramo kulturni teden, na katerega povabimo tudi starše in vse obiskovalce, ki si želijo ogledati naše prireditve. Učenci se predstavijo na različne načine. Tudi s svojim razredom smo iskali ideje, kako bi lahko na kulturnem tednu sodelovali. V letu 2022 mineva 100 let od rojstva Ele Peroci, zato so se učenci odločili, da bo drugo literarno delo v naši digitalni zbirki njena pravljica *Moj dežnik je lahko balon.*

Učenci so knjigo prebrali in izdelali načrt za ilustracije. Vsako jutro so zahajali v knjižnico, kjer so ustvarjali in izdelali kamišibaj. Pri delu so jih opazovali tudi učenci drugih razredov, predvsem z razredne stopnje, ki so hodili v knjižnico. Vse je zanimalo, kaj počnejo. Učenci so jim razložili in vzbudili v njih zanimanje. Spodbudili smo jih, da svojim učiteljicam predlagajo izdelavo svojega kamišibaja.

Učenci so se skrbno pripravljali na nastop v tednu kulture. Svojo predstavitev so urili tudi tako, da so odšli na razredno stopnjo k prvošolčkom in jim predstavili pravljico, ki jo obravnavajo tudi pri pouku slovenščine. Bili so konstruktivni kritiki, ki so jim pomagali izboljšati nastop.

Slika 3: Nastop učenk na šolski prireditvi

4 ZAKLJUČEK

Vsako leto znova nas preseneti, ko učenci ne razumejo prebranega besedila, če pa je besedilo starejše, je razumevanje še toliko slabše. Prav zato smo učitelji primorani iskati nove rešitve, nove načine obravnav literarnih besedil, pri čemer želimo, da so učenci samostojni in kreativni.

Pri pouku slovenščine obravnavamo različne vrste besedil: poezijo, prozo in dramatiko. Vsako besedilo večkrat preberemo, ga razložimo in poustvarjamo. Učence smo vključili v načrtovanje pouka. Sami so predlagali izdelavo kamišibaja.

Po opravljenem delu smo se pogovarjali ter analizirali svoj izdelek in ugotovili, da so morali učenci pri izdelavi kamišibaja veliko sodelovati in se usklajevati. Med risanjem in barvanjem so se učenci zelo zabavali, saj zelo radi ustvarjajo. Dogovorili smo se, da končni izdelek posnamemo, da bodo lahko tudi naslednje generacije gledale in si lažje predstavljale romanco Pegam in Lambergar.

Z izdelavo kamišibaja smo pri učencih krepili različne sposobnosti. Spodbujali smo umetniško ustvarjalnost, ko so risali in barvali ilustracije, krepili jezikovno ustvarjalnost, ko so morali zapisati besedilo oz. povzetek literarnega besedila za vsako ilustracijo, javno nastopanje in govorjenje, ko so pred razredom povedali zgodbo, in krepili odnose v razredu, saj je delo od njih zahtevalo veliko usklajevanj in dogovarjanj, da smo prišli do končnega izdelka.

Na koncu pa vedno največ pomenijo nasmejani obrazi in zadovoljstvo učencev, ko si skupaj ogledamo posnetek. Učenci ne bodo nikoli pozabili, kaj je kamišibaj, in vsi bodo do podrobnosti poznali vsebino besedila Pegam in Lambergar. Na koncu so prišli do ideje, da skupaj izdelamo digitalno zbirko kamišibajev, ki jo bomo vsako leto dopolnjevali in bodo v pomoč tako učiteljici kot učencem pri razumevanju vsebine. Učenci bodo obiskali različne razrede in jim predstavili idejo, da bo naša digitalna zbirka kmalu obsegala večje število literarnih besedil.

LITERATURA IN VIRI

[1] Učni načrt, Slovenščina. 2018. Ljubljana: Ministrstvo za izobraževanje, znanost in šport, Zavod Republike Slovenije za šolstvo. Dostopno na naslovu: https://www.gov.si/teme/programi-in-ucni-nacrti-v-osnovni-soli/ (Pridobljeno 10. 8. 2021).

[2] Jenko S. (2019). Kamišibaj v znamenju kakovosti in umetnosti. Amfiteater: revija za teorijo scenskih umetnosti. Letn. 7, št. 1, 100–105 https://www.slogi.si/wp-content/uploads/2019/12/Amfiteater-7_1_TB_Jenko_Sitar_SI.pdf (Pridobljeno 10. 8. 2021)..

[3] Tominc M. (2021). Japonsko pripovedovanje zgodb je priljubljeno tudi v Sloveniji. Časoris. https://casoris.si/japonsko-pripovedovanje-zgodb-je-priljubljeno-tudi-v-sloveniji/ (Pridobljeno 10. 8. 2021).

[4] Cvetko I. (2018). Slovenski kamišibaj v luči kulturne antropologije. V M. Čepeljnik (ur.), Umetnost kamišibaja. Zbornik prispevkov, Mednarodni simpozij Umetnost kamišibaja: Beseda podobe in podoba besede (str. 33–34). Ljubljana: Slovenski gledališki inštitut.

Uporaba aplikacije Nexto pri terenskem delu na področju likovne umetnosti

The Use of Application Nexto in Fieldwork in Art Classes

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POVZETEK

Uporaba različnih aplikacij pri pouku likovne umetnosti velikokrat pritegne širšo skupino učencev. Velikokrat tudi tiste, ki niso posebno likovno nadarjeni. Zato smo se ob obeleževanju Plečnikovega leta odločili, da za delo na terenu uporabimo aplikacijo Nexto Ljubljana. Na ta način smo raziskovali Plečnikove neuresničene projekte v Ljubljani. Ogledali smo si seveda tudi obstoječe. Aplikacija je učence vodila od spomenika do spomenika našemu velikemu arhitektu. S pomočjo izzivov, ki so jih reševali s pomočjo namigov v realnosti, so opravili naloge in se tako poučili o slogu in ambicijah Plečnika. Učenci so samostojno raziskovali, razvijali sposobnosti in na ta način gradili svojo samozavest ob uporabi novih aplikacij. Aplikacija je zasnovana zelo široko in uporabniku dopušča individualne odstope od zasnovane poti. Učenci so spoznali, da je primerno izbrana in predstavljena informacijsko-komunikacijska tehnologija uporabna tudi v izobraževalne namene. Učitelji pa, da imajo učenci manj predsodkov pri uporabi raznih aplikacij. Pri tem je pomembno, da jim tudi v šolskem prostoru nudimo možnost uporabe različnih novosti, a jih hkrati učimo prepoznati uporabne in koristne aplikacije.

KLJUČNE BESEDE

IKT, aplikacija Nexto, likovna umetnost

ABSTRACT

The use of various applications in art classes often attracts a wider group of students. Often even those who are not particularly artistically talented. That's why we decided to use the Nexto Ljubljana application for field work in commemoration of Plečnik's year. In this way, we researched Plečnik's unrealized projects in Ljubljana. Of course, we also looked at the existing ones. The app guided students from monument to monument of our great architect. With the help of challenges, which were solved with the help of clues in reality, they completed the tasks and thus learned about the style and ambitions of Plečnik. Students independently researched, developed skills and in this way built their self-confidence when using new applications. The application is designed very broadly and allows the user individual deviations from the designed path. The students realized that appropriately selected and presented information and communication technology is also useful for educational purposes. Teachers learned that students have fewer prejudices when using various applications. Here, it is important that we offer them the opportunity to use various innovations in the school environment, but at the same time we teach them to recognize applicable and useful applications.

KEYWORDS

ICT, application Nexto, art

1 UVOD

V sodobni šolski situaciji se učitelji, učenci in drugi udeleženci učnega procesa srečujemo z invazijo ponudbe različnih aplikacij, ki spodbujajo učenčevo vključenost v učni proces. Slednji je postal zelo pester v času epidemije, ko je veliko ustvarjalcev ponujalo informacijsko-komunikacijo tehnologijo kot pomoč pri izvajanju pouka na daljavo. Pouk tako postaja vse bolj dinamičen, vključujoč in predvsem za učenca zelo stimulativen.

Z aktivnim sodelovanjem in manjšim deležem frontalne oblike dela so učenci soočeni z novimi situacijami, v katerih razvijajo samostojnost uporabe različnih aplikacij. V kolikšni meri so izpostavljeni novim izkušnjam, zavisi od učiteljeve pripravljenosti raziskovanja in preizkušanja novosti na njegovem lastnem področju. Velikokrat se pri uvajanju novih aplikacij pojavi strah pred neizkušenostjo učitelja, saj so učenci velikokrat spretnejši pri uporabi le-teh. Odgovornost za uporabo in nudenje možnosti spoznavanja novosti na področju informacijsko-komunikacijske tehnologije učencem tako nosi vsak učitelj sam.

Aplikacija Nexto Ljubljana je za uporabo pri terenskem delu v šoli zelo primerna, saj na učencem zanimiv in interaktiven način približa umetnost, predvsem pa pokaže možnosti, ki jih realna situacija na terenu ne more. Učenci s pomočjo aplikacije spontano raziskujejo okolico, v svojem tempu opravljajo naloge in tako širijo ter poglabljajo svoje znanje. Aplikacija od njih ne zahteva likovne nadarjenosti, kar pripomore k njeni širši uporabi.

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2 INFORMACIJSKO-KOMUNIKACIJSKA TEHNOLOGIJA V ŠOLI

Informacijsko-komunikacijska tehnologija (IKT) je že nekaj desetletij sestavni in nepogrešljivi del procesa poučevanja in učenja v tehnološko razvitih državah [1].

Sodobna tehnologija dopolnjuje tradicionalno izobraževanje z interaktivnimi vajami in dejavnostmi, povezanimi z IKT-jem. Učitelj lahko z uporabo IKT-ja približa pouk in snov učencem na zanimivejši način [2].

Z uporabo IKT v šoli učencem omogočimo izkustveno učenje in učenje praktičnih veščin, ki jih lahko prenašajo tudi v druga spletna okolja. Na ta način pridobijo izkušnje v različnih aplikacijah in spletnih okoljih. S tem gradimo njihovo IKT pismenost in samozavest uporabe novih spletnih okolij ter zmožnost prepoznave kvalitetnih in uporabnih aplikacij.

2.1 Platforma Nexto

Nexto je platforma za kulturno angažiranje, ki omogoča ustvarjanje in dostavo interaktivnih lokacijskih pripovedi, ki obiskovalcem spremenijo doživetje kulturnih turističnih destinacij (muzeji, naravni parki, zgodovinska mesta, arheološka najdišča ...) v igrifikacijske dogodivščine z elementi razširjene realnosti.

Je edinstvena kombinacija racionaliziranega pogovornega vmesnika, mehanika igre, ki temelji na lokaciji, tehnike igrafikacije in najnovejši napredek v navidezni resničnosti [3].

Aplikacija Nexto je spletno orodje, ki nam omogoča spoznavati kulturne in krajevne znamenitosti.

Omogoča več funkcij:

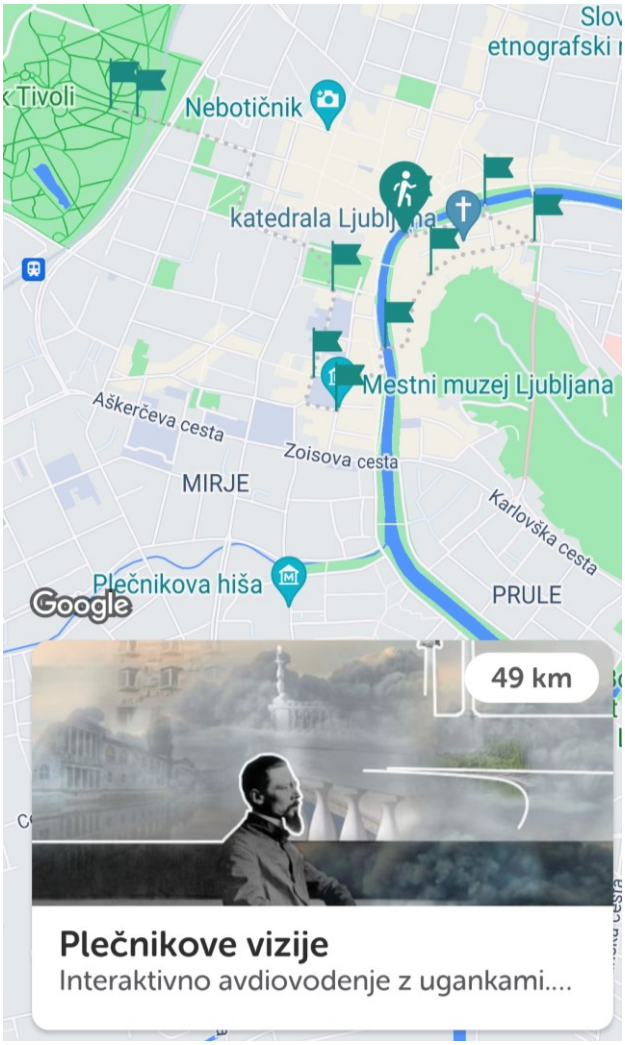
- ustvarjanje vsebine v več jezikih,
- dodajanje zvočne pripovedi v zgodbe,
- podpira uporabo brez povezave,
- različne možnosti monetizacije,
- podporo notranjim izkušnjam,
- osem različnih možnosti mini igre in štetje,
- ustvarjanje razvejanih zgodb z več možnostmi,
- podporo za videoposnetke in gif-e,
- integracijo filtrov razširjene resničnosti Facebooka, Instagrama in Snapchata,
- integracija izkušenj z razširjeno resničnostjo po meri, zgrajenih v enotnosti,
- povezavo do videoposnetkov na youtube ter
- dostop v trgovini Apple App Store in Trgovini Google Play [4].

Zaradi zgornjih značilnosti aplikacije Nexto uporablja vedno večje število upraviteljev večjih muzejev, galerij in ostalih kulturnih in naravnih znamenitosti Slovenije, npr. Mesto Ljubljana, Ljubljanski grad, Bled, Piran, Portorož, Narodna galerija … Če povzamemo zelo preprosto, aplikacija Nexto uporabniku daje bistvene informacije o njegovi neposredni okolici. Mobilna naprava informacije sprejema prek posebnih oddajnikov Bluetooth, ki z njo začnejo komunicirati, ko se jim uporabnik dovolj približa. Nexto je zaradi tega kot nalašč za uporabo med obiski muzejev in naravnih znamenitosti ali pa raziskovanjem novih krajev [5].

2.2 Aplikacija Nexto v mestu Ljubljana

V mestu Ljubljana lahko sledimo več ločenim doživetjem. Aplikacije nas vodi po Ljubljanskem gradu, Arhitekturnih biserih, pričaramo si lahko Sproščen dan v Ljubljani, se Sprehodimo ob reku Ljubljanici in nabiramo nova znanja v paketu Za radovedne raziskovalce … Vsako od teh doživetij nas vodi po mestu in približa različne kulturne znamenitosti. O znamenitostih si lahko preberemo opise, rešimo uganke in druge zanimive igre in izzive.

3. UPORABA NEXTO LJUBLJANA PRI DELU NA TERENU



Slika 1: Plečnikove vizije - aplikacija Nexto

Na raziskovanje Ljubljane smo se s pomočjo aplikacije Nexto Ljubljana odpravili v Plečnikovem letu. Ob 150. obletnici so v Nexto Ljubljana ustvarili program Plečnikove vizije, ki nas vodi po Plečnikovih neuresničenih projektih v Ljubljani (Slika 1).

V aplikaciji si sledijo kulturne znamenitosti, razdeljene na postaje Tromostovje, Mesarski most, Novi magistrat, Magistratni vhod, Čevljarski most in Novi trg, Križanke, Vegova ulica in NUK, Kongresni trg, Katedrala svobode.

3.1 Pridobitev aplikacije

Aplikacija je dosegljiva v trgovini Apple App Store in Trgovini Google Play. Za uporabnika je brezplačna. Naložbo sofinancirata Republika Slovenija in Evropska unija iz Evropskega sklada za regionalni razvoj [6].

Za uporabo potrebuješ telefon z operacijskim sistemom Android 5.0 ali novejši in možnost uporabe Bluetootha. Dostop do interneta oziroma mobilne podatke potrebuješ le za nakup aplikacije. Za samo uporabo aplikacije spletne povezave ne potrebuješ.

Učenci so se razdelili v skupine, saj vsi učenci niso imeli mobilnih naprav. Nato so aplikacijo naložili na telefone in sledili korakom prijave. Prijava je enostavna, zato veliko dodatnih navodil učitelja skoraj niso potrebovali.

3.2 Uporaba aplikacije

Uporaba aplikacije je zasnovana zelo enostavno. Postaje so vnesene v Google zemljevid, s pomočjo katerega sledimo posameznim postajam na poti. S pomočjo Google zemljevida se orientiramo v samem mestu. Ko se s telefonom približamo posamezni postaji, opremljeni z oddajniki Bluetooth, prejmemo razlago oziroma nalogo. Uporabnik sledi navodilom avatarja »mojstra«, ki te vodi s pomočjo ugank in nalog od ene do druge mojstrovine. (Slika 2)

Ogledali smo si: Tromostovje, Mesarski most, Novi magistrat, Magistratni vhod, Čevljarski most in Novi trg, Kongresni trg ter Vegovo ulico z NUK.

Po poti si v aplikaciji ogledamo neuresničene projekte v tridimenzionalni obliki, ki v realnosti nikoli niso bili izvedeni. Tako je za nas narisan Mesarski most, Novi magistrat, Magistratni vhod, Katedrala svobode. Stavbe na ekranu lahko zavrtimo okoli osi in si jih ogledamo z vseh strani.

Na Čevljarskem mostu, Križankah in Kongresnem trgu nas čaka izziv, ki nam pomaga poiskati pot naprej. Podoba mojstra nam je v aplikaciji postavila naloge, s pomočjo katerih smo še podrobneje spoznali Plečnikova dela in njegov slog. Naloge so zasnovane tako, da poiščeš podatke na sami lokaciji – preštej, najdi, razišči …, ki jih potem vpišeš v samo aplikacijo. Zaradi zadanih nalog so si učenci podrobneje ogledali arhitekturo in tako samostojno ugotavljali posamezne lastnosti Plečnikovega stila. Zaradi lastne izkušnje in truda, ki so ga morali vložiti v rešitev uganke ali naloge, je njihovo znanje kvalitetnejše in bolj poglobljeno.

Zaradi pomankanja časa si nismo ogledali Križank in Katedrale svobode, kar aplikacije ni zmotilo. Lahko se držimo predvidene poti s strani ustvarjalcev, saj si sledijo v nekem smiselnem zaporedju. Lahko pa znamenitosti obiskujemo tudi v naključnem vrstnem redu, kar nam omogoča uporaba Google zemljevidov. Po opravljeni nalogi na posamezni postaji se na zemljevidu pojavi zelena kljukica, neopravljene naloge pa so zaznamovane z rdečim klicajem. Tako imamo tudi ob neupoštevanju predvidene poti izvrsten pregled nad že opravljenimi postajami.

Če ne zaključimo celega doživetja v enem dnevu, se naš napredek v aplikaciji shrani in neopravljene postaje lahko opravimo ob drugi priložnosti.

Učenci so imeli največ težav na začetku uporabe aplikacije. Ko so ugotovili, na kakšen način je zasnovana, večjih težav z uporabo niso imeli. Posamezne težave smo z učenci reševali individualno.

Slika 2: Uporaba aplikacije Nexto

4 ZAKLJUČEK

Uporaba aplikacije Nexto je bila za učence zelo stimulativna. Kot smo ugotovili že v uvodu, je uporaba sodobne tehnologije in spoznavanje novih aplikacij, ki so zasnovane kvalitetno in primerno starosti učencev, za učence zelo pomembna. Na ta način umetnost približamo tudi manj likovno nadarjenim učencem. Pridobili so izkušnjo uporabe mobilnega telefona za izobraževalne namene, gradili samozavest in zavedanje, da nam sodobna informacijska tehnologija lahko nudi več kot le zabavo.

Samostojno oziroma z le nekaj usmeritvami učitelja so naložili aplikacijo na svoje telefone in se seznanili z njenim delovanjem. S pomočjo Google zemljevidov so se samostojno orientirali po mestu. Poglobili so znanje o Plečniku in spoznali njegovo genialnost ter velike vizije za mesto Ljubljana.

Učenci so bili nad uporabo aplikacije navdušeni, saj je bila uporaba le-te povezana z delom na terenu. Nekateri so poskušali naloge zaobiti in z ugibanjem priti do rešitev. To jim ni uspelo, saj so bile uganke in izzivi zasnovani precej eksplicitno in so se res morali poglobiti v arhitekturo Plečnika, da so lahko opravili izzive aplikacije.

ZAHVALA

Posebna zahvala velja gospe Andreji, naši šolski knjižničarki, ki s svojim svežim pristopom in stalno pripravljenostjo pomagati, spodbuja k preizkušanju in uporabi novih aplikacij.

LITERATURA IN VIRI

[1] Biljana Mišič Ilič in Ljiljana Mihajlović. 2013. Try IT! Using information and communication Technology in an English Classrom. Filozofski Fakultet Univerziteta u Nišu

[2] Irena Gole in Mateja Hadler. 2015. Učenje s tablicami na razredni stopnji. Primeri iz prakse. V: Kaj nam prinaša e-Šolska torba: zbornik zaključne konference projekta e-Šolska torba. Ljubljana: Zavod RS za šolstvo. Dostopno na naslovu https://www.zrss.si/pdf/kaj-nam-prinasa-esolska-torba.pdf (3. 8. 2022)

[3] Spletna stran agencije Proxima. Dostopno na naslovu https://proxima.si/project/nexto/ (2. 8. 2022)

[4] Spletna stran Nexto. Dostopno na naslovu https://nexto.io (2. 8. 2022)

[5] Spletna stran Siol. Nexto slovenska aplikacija, ki lahko zamenja turističnega vodiča. Dostopno na naslovu: https://siol.net/digisvet/novice/nexto-slovenska-aplikacija-ki-lahko-zamenja-turisticnega-vodnika-62593 (15. 9. 2022)

[6] Spletna stran Visit Ljubljana. Plečnikova Ljubljana. Dostopno na naslovu: https://www.visitljubljana.com/sl/obiskovalci/odkrivajte/dozivetja/znamenitosti/clanek/plecnikova-ljubljana (3. 8. 2022)

“International Masterclasses” iz fizike osnovnih delcev

“International Masterclasses” in Particle Physics

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POVZETEK

V eksperimentalni fiziki osnovnih delcev raziskujemo lastnosti najmanjših gradnikov snovi in reakcije med njimi. Za razumevanje redkih procesov potrebujemo veliko količino podatkov, da lahko iz njih izluščimo statistično signifikantne rezultate. Za obdelavo tako zajetih podatkov, so potrebni kompleksni rekonstrukcijski algoritmi in računalniška orodja. V prispevku so predstavljene delavnice International Masterclasses, ki želijo z nazornimi predstavitvami in prilagojenimi in poenostavljenimi analizami udeležencem predstaviti cilje in metode dela v fiziki osnovnih delcev.

KLJUČNE BESEDE

IPPOG, Belle II, ATLAS, outreach, International Masterclasses

ABSTRACT

In the experimental particle physics, we investigate the properties of the smallest building blocks of matter and the interactions between the constituents. To understand rare processes, we need a large amount of data in order to extract statistically significant results from them. Complex reconstruction algorithms and computer tools are needed to process such collected data. The paper presents the International Masterclasses workshops, which aim to present the goals and methods of work in elementary particle physics to the participants with graphic presentations and sensible and simplified analyses.

KEYWORDS

IPPOG, Belle II, ATLAS, outreach, International Masterclasses

1 UVOD

»International Masterclasses« so mednarodne delavnice za srednješolske učence, ki za en dan želijo postati raziskovalci fizike osnovnih delcev [1,2]. Delavnice potekajo enkrat letno na univerzah in raziskovalnih inštitutih v 60 državah, kjer se skupaj zbere 13000 učencev. Delavnice vključujejo dopoldanske predstavitve o osnovah fizike osnovnih delcev, zaznavanju delcev in raziskovalnih metodah ter popoldanski praktični del, kjer pridobljeno znanje tudi uporabijo pri izvajanju meritev na pravih podatkih iz eksperimentov osnovnih delcev. Delavnice vzporedno potekajo na različnih institucijah v maternem jeziku, po koncu praktičnega dela pa se učenci preko videokonference povežejo s tremi do petimi sodelujočimi institucijami, kjer na mednarodni ravni predstavijo in razpravljajo o svojih rezultatih v angleškem jeziku.

Delavnice organizira mednarodna kolaboracija namenjena širjenju znanja o fiziki osnovnih delcev »International Particle Physics Outreach Group« (IPPOG / https://ippog.org/), katere glavni cilj je vzgajati in spodbujati spoštovanje temeljnih znanstvenih raziskav; vzpostaviti razumevanje znanstvenega procesa in sklepanja, ki temelji na dokazih, gradnja zaupanja s širokim in raznolikim naborom svetovnih skupnosti in informiranje ter motiviranje prihodnjih generacij znanstvenikov in državljanov. International Particle Physics Outreach Group si že od leta 1997 usklajeno in sistematično prizadeva za predstavitev in popularizacijo fizike delcev vsem občinstvom in starostnim skupinam.

Glavni cilj International Particle Physics Outreach Group je čim bolj povečati učinek izobraževanja in prizadevanj za ozaveščanje v zvezi s fiziko delcev. Kolaboracija prispeva h globalnim prizadevanjem pri krepitvi kulturne zavesti pri razumevanju in podpori fizike delcev in sorodnih ved, pri dvigovanju znanstvene pismenosti v družbi, izobraževanju javnosti o vrednotah temeljnih raziskav ter pri razvoju in usposabljanju naslednje generacije raziskovalcev, znanstvenikov in inženirjev.

Člani kolaboracije so države in mednarodne kolaboracije v visokoenergijski fiziki, ki predstavljajo delo raziskovalcev na področju visoko energijske fizike, strokovnjaki za znanstveno komunikacijo iz različnih mednarodnih raziskovalnih institutov, univerz in laboratorijev, ki so vključeni pri raziskovanju fizike osnovnih delcev. Sodelujoči eksperimenti in tematike delavnic, ki jih učenci lahko spoznajo, so: ATLAS, ALICE, CMS, LHCb, Belle II, MINERvA in Particle Therapy.

Znanstveniki za raziskovanje osnovnih delcev uporabljamo pospeševalnike delcev, kjer delce pospešimo do skoraj svetlobne hitrosti in zelo visoke energije, in trkalnike, kjer delce trčimo med seboj. Ob trku se sprosti velika količina energije, ki se lahko pretvori v maso novo nastalih delcev. Ti so zelo nestabilni in zelo hitro razpadejo na bolj dolgožive delce, ki jih nato zaznamo in lahko pomerimo njihove lastnosti.

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Dva eksperimenta, pri katerih sodelujemo in organiziramo delavnice na odseku za eksperimentalno fiziko osnovnih delcev Instituta Jožefa Stefana, sta Belle II v Cukubi na Japonskem [3] in ATLAS v Ženevi v Švici [4].

Eksperiment Belle II se nahaja na inštitutu za visoko energijsko fiziko KEK. Postavljen je bil z namenom raziskovanja redkih razpadov mezonov B, D in leptonov tau, ki jih ustvarjamo s trkanjem pozitronov in elektronov v pospeševalniku SuperKEKB. Z merjenjem in analizo razpadnih produktov želimo poiskati odstopanja od teoretičnih napovedi, ki jih napoveduje Standardni model. Ta model je zelo uspešen pri opisu osnovnih delcev in njihovih medsebojnih interakcij, ki jih imenujemo elektromagnetna, šibka in močna jedrska sila.

Ker pri trkih visokoenergijskih delcev nastaja ionizirajoče sevanje, je dostop do detektorja med delovanjem pospeševalnika prepovedan. Za kontrolo delovanja vseh detektorskih sklopov skrbijo kontrolni sistemi, ki omogočajo oddaljeno priklapljanje in odklapljanje delov detektorja in nadzor napajalnih napetosti in tokov. Šele ko vsi sistemi usklajeno delujejo, je mogoč zajem podatkov.

ATLAS je ravno tako eksperiment za odkrivanje in razumevanje osnovnih delcev in se nahaja v velikem hadronskem trkalniku (LHC) na inštitutu za jedrske raziskave CERN. Za razliko od eksperimenta Belle II, tam trkamo protone v protone pri bistveno višjih energijah in z manjšo pogostostjo.

Pri obeh eksperimentih poteka zajem podatkov s spektrometrom, ki obdaja mesto trka (interakcijska točka). Spektrometer sestavljajo različni detektorski podsistemi s specifičnimi nalogami, kot so merjenje trajektorije, gibalne količine ali energije delcev.

Razumevanje procesov v fiziki osnovnih delcev in obvladovanje standardnih orodji za analizo je dolgotrajen in kompleksen proces saj zahteva določena predznanja iz fizike, statistike in računalništva. »International Masterclasses« smo izoblikovali tako, da na razumljiv način predstavimo osnovne fizikalne koncepte in analitske metode, zato da jih lahko tudi učenci sami uporabijo v praktičnem delu delavnice tako, kot to počnejo raziskovalci pri svojem raziskovalnem delu. Vsebina delavnic je dovolj poenostavljena, da učenci osvojijo novo znanja v enem dnevu.

V delavnicah tako združujemo vsa zgoraj našteta področja. Na ta način skušamo ponazoriti izjemno pomembno komponento sodelovanja v mednarodnih raziskovalnih skupinah, kjer pri pripravi eksperimenta, zajemanju podatkov in analizi sodeluje od nekaj sto do nekaj tisoč raziskovalcev različnih strokovnih profilov. Temelj usklajenega delovanja predstavlja učinkovit in večinoma prost pretok informacij znotraj raziskovalne skupine, ki vključuje večino elementov odprte znanosti, ki temelji na skupnih prizadevanjih in novih načinih razširjanja znanja ter izboljšuje dostopnost do rezultatov raziskav in njihovo ponovno uporabo s pomočjo digitalnih tehnologij in novih orodij za sodelovanje.

S prenosom delavnic v slovenski prostor želimo slovenskim srednješolcem omogočiti enakopraven dostop do izobraževalnih vsebin, ki jih ponuja IPPOG. Poudariti je potrebno, da so delavnico Belle II za celotno mednarodno raziskovalno skupino pripravili slovenski raziskovalci in je doživela izjemno pozitiven sprejem v številnih državah.

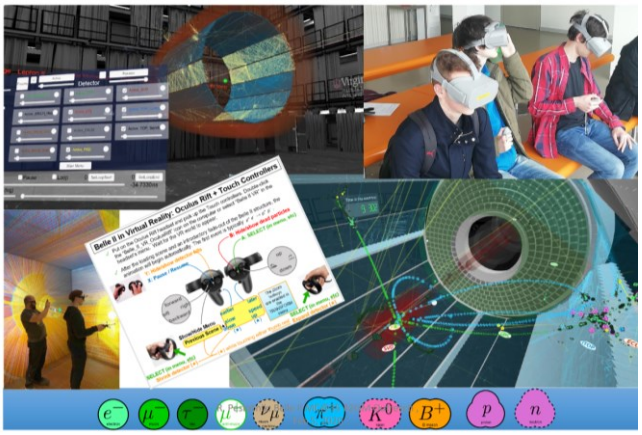
2 METODE DELA

Struktura delavnic International Masterclasses je podobna, v nadaljevanju se bomo osredotočili na primer delavnice Belle II. Delavnice so razdeljene na dva dela. V dopoldanskem času potekajo 45 minutna predavanja, popoldan pa se udeleženci preizkusijo v praktičnem raziskovalnem delu. Dogodek oglašujemo s pomočjo sistema za načrtovanje in organizacijo dogodkov indico, ki je v skupnosti za eksperimentalno fiziko osnovnih delcev zelo razširjen. Primer strukture letošnjega dogodka je predstavljen na naslovu https://indico.ijs.si/event/1412/.

Po registraciji udeležencev začnemo z uvodno predstavitvijo, kjer predstavimo fiziko osnovnih delcev. Udeležence seznanimo z razumevanjem osnovnih gradnikov skozi čas in o tem, kako jih opisujemo s Standardnim modelom danes. Seznanimo jih z odprtimi vprašanji, s katerimi se ukvarjamo. Standardni model osnovnih delcev je skorajda popoln. Vse meritve na spektrometrih se z njim skladajo, eksperimentalni fiziki osnovnih delcev si prizadevajo, da bi odkrili procese, kjer Standardni model narave ne opiše zadovoljivo. Za tako iskanje imamo več kot dobro osnovo. Standardni model ne vključuje ene od osnovnih šol - gravitacije, poleg tega pa posredne meritve iz astrofizike kažejo na obstoj temne snovi in energije, o kateri ne vemo nič, predstavlja pa 95% mase vesolja.

V nadaljevanju predstavimo pristope, kako trkamo med seboj gruče delcev in nato razložimo eksperimentalne metode, ki jih uporabljamo pri opazovanju trkov in razpadov delcev: kako opišemo trke, kakšne naprave potrebujemo in kako delujejo. Osnovne delce, ki jih raziskujemo, proizvedemo s trkanjem visokoenergijskih curkov delcev v pospeševalniku. Nastali delci so večinoma kratkoživi in razpadejo zelo blizu mesta nastanka na lažje delce, ki jih lahko zaznamo v detektorjih za osnovne delce, ki zaznavajo delce preko interakcij z okoliško snovjo. Nastali delci odletijo na vse strani, zato je detektor podoben čebuli, detektorski sistemi pa si tesno eden za drugim sledijo v lupinah. Notranje lupine detektorja obdaja močan superprevodni magnet, ki poskrbi, da se pot nabitih delcev ukrivi in da lahko iz nje določimo gibalno količino in naboj delcev. Milijone električnih signalov iz detektorja je potrebno najprej pretvoriti v digitalno obliko, zato da jih lahko potem z računalniškimi algoritmi obdelujemo. Iz zajetih podatkov na prvi stopnji analize rekonstruiramo sledi, izmerimo gibalno količino, določimo naboj in identiteto zaznanih delcev. Tako rekonstruirane delce lahko potem z različnimi metodami kombiniramo med sabo in pogledamo, iz katerega visokoenergijskega delca so nastali. Pri zajemu, rekonstrukciji in analizi podatkov uporabljamo različne kompleksne tehnologije. Hitrost trkanja delcev med seboj je nepredstavljiva. Na velikem hadronskem trkalniku gruče delcev trkajo med seboj vsakih 25 ns, kljub najsodobnejši tehnologiji je potrebno podatke čimprej ločiti na take, kjer je verjetnost, da se je zgodil razpad, ki ga želimo opazovati, večja, in preostale, ki jih zavržemo. Ta selekcija poteka na več nivojih, kjer se kompleksnost opazovanih spremenljivk povečuje. Začetno selekcijo večinoma opravimo že na manjših delih detektorja v elektronskih vezjih na detektorjih. Kasneje poteka selekcija na programskem nivoju. V zadnjem času na različnih delih obdelave podatkov uporabljamo metode strojnega učenja, ki občutno izboljšajo izkoristke.

V nadaljevanju se udeleženci s pomočjo aplikacije za navidezno resničnost (slika 1) in virtualnimi očali Oculus Rift ter Oculus GO sprehodijo po detektorju Belle II [5]. V aplikaciji si lahko od blizu ogledajo njegovo notranjost in posamezne sestavne dele ter tako pridobijo predstavo o njegovem delovanju. Aplikacija omogoča tudi predvajanje in vizualizacijo posameznih dogodkov oziroma trkov elektrona s pozitronom ter novo nastale delce, ki med preletom interagirajo z detektorji. Med sprehodom lahko udeleženci podrobno preučijo detektorske sisteme in senzorje, za vsak nastali delec pa si lahko pogledajo, kakšne so njegove lastnosti in kakšen odziv pusti v detektorju.



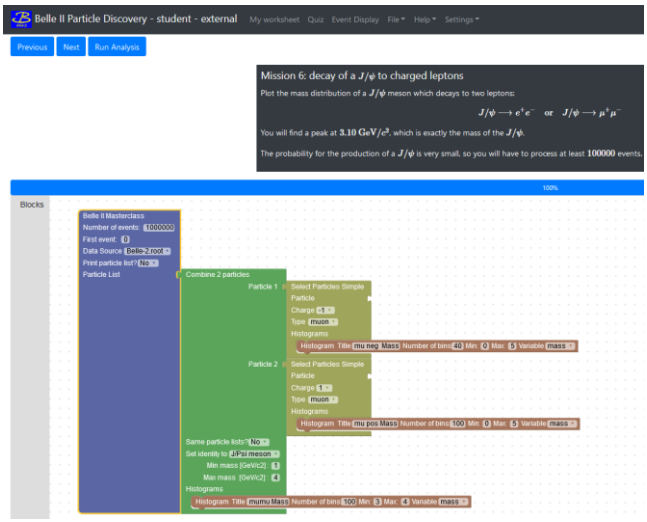
Slika 1: Interaktivna aplikacija za navidezno resničnost Belle II detektorja.

Zadnje predavanje dopoldanskega dela je namenjeno uvodu v analizo podatkov v eksperimentalni fiziki, kjer predstavimo nekaj osnovnih relativističnih enačb, eksperimentalnih količin in statističnih konceptov. S pridobljenim znanjem so udeleženci pripravljeni na popoldanski praktični del analize podatkov.

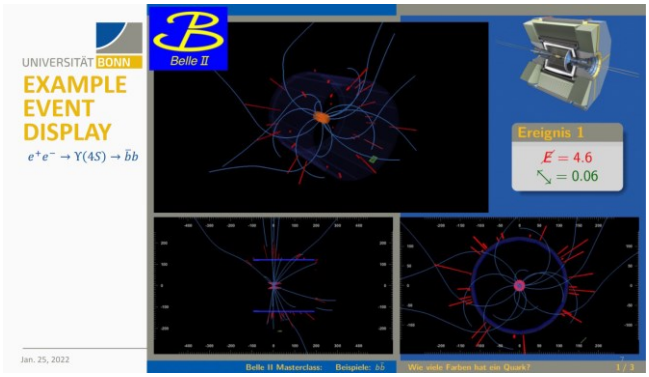
Pri delavnici iz eksperimenta Belle II sta na voljo dve različici analize izmerjenih podatkov, ki jih je dala mednarodna raziskovalna skupina Belle II v prosto uporabo.

Prva je analiza podatkov preko spletne aplikacije Belle II Lab [6], ki je uporabniku prijazna saj je bila namensko razvita, da ni potrebno nobeno znanje o programiranju (slika 2). Aplikacija uporablja grafični uporabniški vmesnik Blockly JavaScript, kjer uporabnik interaktivno izbere in poveže funkcionalne gradnike za nadzor analize in opis fizikalnih procesov. Naloga učencev je, da po navodilih rekonstruirajo nekaj najbolj zanimivih razpadov in jih iz histogramov tudi razberejo. Rezultati in uporabljena konfiguracija blokov se shranjuje lokalno na osebnem računalniku in na strežniku, kjer je dostopna tudi za tutorje v primeru težav.

Druga je analiza posameznih trkov in nastalih sledi (slika 3), da eksperimentalno določimo število možnih barv kvarkov [7]. S poznavanjem osnov oblike dogodka, udeleženci kategorizirajo več setov 50 trkov in vpišejo opažanja v spletno razpredelnico dostopno vsem sodelujočih. Tekom analize učenci spoznajo, da večje število podatkov pripomore k natančnosti končnega rezultata. Na koncu so vsi vnosi avtomatsko prešteti in preračunani v končni rezultat, ki predstavlja število možnih barv kvarkov.



Slika 2: Aplikacija Belle II Lab.



Slika 3: Primer prikaza enega dogodka, ki ga udeleženci kategorizirajo.

Na koncu delavnice poteka še videokonferenca, na katero se priključimo udeleženci iz različnih univerz, raziskovalnih ustanov in institutov. Konferenco vodi moderator, ki povabi posamezne skupine, da predstavijo izbrano analizo in kaj so odkrili. Tekom spletne povezave se neposredno povežemo tudi v kontrolno sobo z raziskovalci, ki nadzorujejo delovanje detektorja Belle II, in jih udeleženci direktno vprašajo kar jih zanima. Za zaključek in za sprostitev vsi priključeni rešujemo zabavni kviz o znanosti in življenju na Japonskem (slika 6).

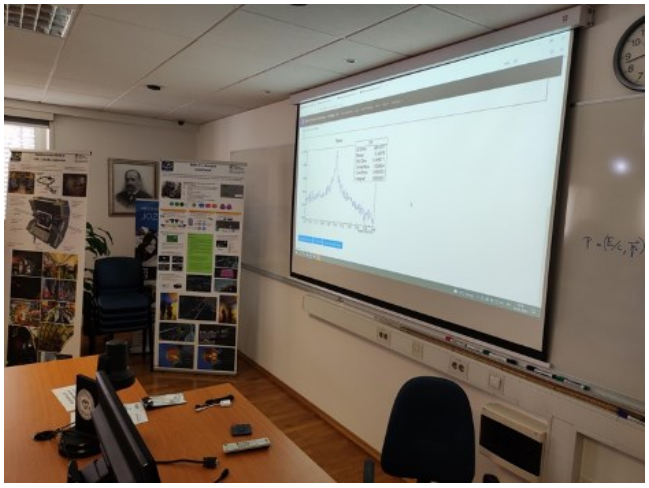
3 REZULTATI

Letos smo delavnico Belle II International Masterclasses izvedli v treh časovnih terminih na enajstih raziskovalnih ustanovah (IPHC, IFJ, INFN Padova, INFN Roma Tre, IJS, LMU, MPP, CUNI, HEPHY, CPPM in METU) iz osmih evropskih državah. Vzporedno na isti dan je sodelovale od tri do pet institucij, ki so se ob zaključku delavnice skupaj povezale na videokonferenco, na kateri so dijaki predstavili dogajanje tekom delavnice. Še posebej je bilo udeležencem zanimivo in v izziv, če so učenci iz druge ustanove predstavili analizo, ki je sami niso opravljali. Skupno se je delavnice udeležilo okrog 230 udeležencev, od tega so štirje bili iz Institutu Jožefa Stefana.

Pri praktičnem delu analize podatkov s spletno aplikacijo Belle II Lab so udeleženci iskali in rekonstruirali težje in kratkožive delce v pomerjenih Belle II podatkih. Skupaj so imeli za opraviti 9 nalog in poiskati 7 delcev. Prvi dve nalogi sta bili le spoznavanje delovanja spletne aplikacije, kjer so dijaki izpisovali različne lastnosti delcev (gibalna količina, energija, električni naboj in identiteta delca) in vizualizirali fizikalne količine s histogrami (slika 4). Vse nadaljnje naloge so zajemale rekonstruiranje težjih kratkoživih delcev kot so mezoni ϕ, K, D, B, … Prve tri naloge so dijaki izvedli po navodilih tutorjev in tako tudi spoznali potek analize v aplikaciji, preostale naloge pa so udeleženci reševali samostojno oz. v primeru težav so tutorji podali namige. Naloge so si sledile po zahtevnosti od najlažje do najtežje.

Prvi korak analize je bil, da so dijaki sestavili svojo "kodo" oziroma bloke, s katerimi so opisali željen razpad. Pomembno je bilo, da so pravilno izbrali končne stabilne delce, v katere je razpadel težji delec. Ta del jim ni predstavljal večjih težav, saj so si pomagali z enačbo razpada iz navodila naloge.

Nato je sledila računsko zahtevna rekonstrukcija težjega delca na podlagi različnih kombinacij izbranih stabilnih delcev, ki jo je izvedel centralni strežnik. Dijaki so spoznali, da redkejši kot je razpad nekega delca, več podatkov potrebujejo kar pa zahteva več časa za računanje. Pri najzahtevnejšem razpadu, kjer so uporabili vse podatke, so lahko čakali tudi do pet minut, kar pa je še vedno zelo hitro v primerjavi s tipičnim časom procesiranja podatkov raziskovalcev osnovnih delcev.



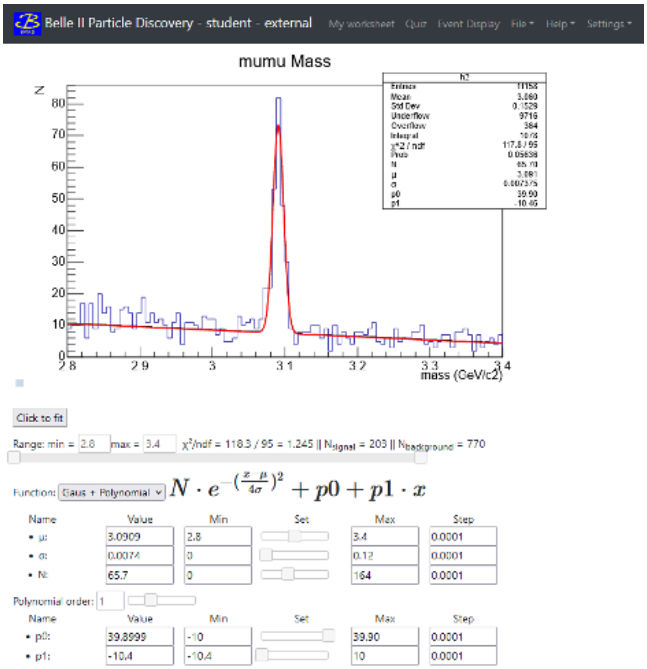
Slika 4: Prikaz enega izmed razpadnih kanalov.

Zadnji del analize, ko so dijaki iskali signalne dogodke, jim je bil najtežji, vendar so se po dveh ali treh nalogah navadili postopka. V tem delu so morali iz porazdelitev fizikalnih količin poiskati in prešteti signalne razpade in jih ločiti od dogodkov, ki so predstavljali ozadje. Najpreprostejši način je bil neposredno seštevanje vrednosti razdelkov v histogramu, za katerega se noben udeleženec ni odločil. Raje so uporabili bolj napredno metodo in to je prilagajanje grafa funkcije na histogram (slika 5). Metoda jim je bila na začetku dokaj tuja, saj so jo šele spoznali, in so na začetku potrebovali nekaj več pomoči s strani tutorjev. Na voljo so imeli Gaussovo in polinomsko funkcijo ter kombinacijo obeh. Gaussovo funkcijo so uporabili za opis kopaste strukture na histogramu, ta predstavlja signalne dogodke; polinomsko pa za opis položnega dela histograma, ki predstavlja dogodke iz ozadja. S pomikanjem drsnikov so dijaki spreminjali parametre funkcij in želeli doseči, da se je graf funkcije čim bolj prilegal histogramu. Pri tem so si pomagali tudi z računalniškim algoritmom prilagajanja, ki je implementiran v aplikaciji. Na koncu so iz parametrov izluščili, pri kateri masi se signalna struktura nahaja in tako določili maso rekonstruiranega delca.

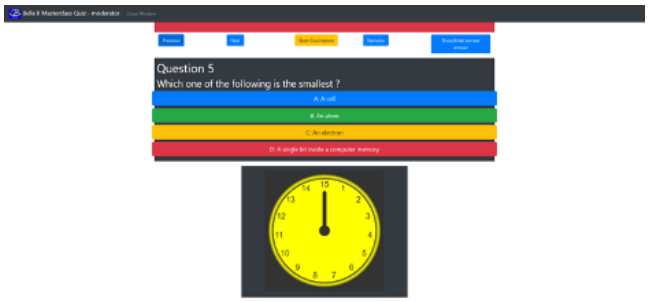
Po zaključku delavnice smo izvedli anonimno anketo, kjer so udeleženci podali kvantitativen odgovor, če se z vprašanjem strinjajo (5) ali ne strinjajo (1), in opisni odgovor kaj jim je bilo najbolj in najmanj všeč.

Na vprašanje ali so bili udeleženci zadovoljni z uvodnimi predstavitvami so se vsi strinjal (5) in na vprašanje, če so bile tudi razumljive, so trije odgovorili z oceno 5 in en z oceno 4. Popoldanski praktični del je bil vsem zanimiv (5), ampak le polovica jih je ocenilo, da jim je bila analiza razumljiva (5), druga polovica pa so ocenili s 4.

Dvema dijakoma sta bila najbolj všeč virtualni sprehod po Belle II detektorju in praktičen del analize podatkov, drugima dvema pa pogovor z raziskovalci in profesorji. En udeleženec je še izrazil, da mu je bila najbolj všeč tudi uvodna predstavitev. Na vprašanje kaj udeležencem ni bilo všeč, sta odgovorila le dva. Prvi je izrazil, da so bila predavanja dolga, drugi pa, da je, tekom video povezave s kontrolno sobo detektorja Belle II na Japonskem, potres prestrašil raziskovalca.



Slika 5: Analiza histograma in orodje za prilagajanje funkcije.



Slika 6: Zabavni kviz o fiziki osnovnih delcev in življenju na Japonskem.

4 ZAKLJUČEK

Delavnice International Masterclasses so bile pri vseh sodelujočih izredno pozitivno sprejete. Čeprav je sredstvo komunikacije znotraj mednarodnih raziskovalnih skupin večinoma angleški jezik, so delavnice zaradi lažje komunikacije zasnovane v jeziku domačega okolja, na skupni videokonferenci pa uporabljamo angleščino. Večinoma sodelujoči prihajajo iz Evrope, v naslednji letih načrtujemo, da bomo delavnice izvedli tudi v ZDA in v Aziji. V načrtovanje delavnic so vključeni raziskovalci s posameznih eksperimentov, ponekod je dobrodošla podpora komunikatorjev znanost. Pomembno je, da bi bilo brez sodobnih informacijskih tehnologij takšno sodelovanje med raziskovalci in dijaki dosti težje. Ker se dijaki z raziskovanjem univerzalnih vprašanj, kot so od kod prihajamo in kam gremo, kako smo zgrajeni mi in kako svet okoli nas, kako merimo stvari, ki jih ne vidimo, v povezavi s fiziko osnovnih delcev ne srečajo vsak dan, delavnice predstavljajo pomemben prispevek k izobraževanju.

VIRI IN LITERATURA

[1] IPPOG - International Particle Physics Outreach Group: https://ippog.org/
[2] International Particle Physics Outreach Group, International Masterclasses: https://physicsmasterclasses.org/
[3] Belle II collaboration: https://www.belle2.org/
[4] ATLAS collaboration: https://atlas.cern/
[5] Detektor Belle II v virtualni resničnosti https://store.steampowered.com/app/810020/Belle_II_in_Virtual_Reality/
[6] Delavnica Belle II Lab https://belle2.ijs.si/public/home/reconstruct-b-mesons/ in https://belle2.ijs.si/masterclass/
[7] Delavnica barve kvarkov: https://belle2.ijs.si/public/home/quark-colors/how-many-colors-does-a-quark-come-in/

Uporaba portala Franček v osnovni šoli

Use of the Franček Portal in Primary School

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POVZETEK

Učenci v osnovni šoli razvijajo sporazumevalno zmožnost, ki je pomemben del učnega procesa, ki se med šolanjem razvija sistematično in načrtno, na kar vpliva tudi raba slovarskih priročnikov. V slovenskem prostoru so že obstajala zbirna spletišča z jezikovnimi viri, portal Franček pa je prvo spletišče za uporabo slovarjev, prilagojeno posebej za učence in dijake. Njegove vsebine se povezujejo s cilji in standardi učnega načrta za slovenščino. V prispevku je prikazano, kako lahko učenci Frančka načrtno spoznavajo in praktično uporabljajo ter kakšna je njegova širša uporabnost, ne le pri pouku slovenščine. Sistematična raba portala Franček že pri najmlajših učencih in pri vseh šolskih predmetih učence navaja na uporabo slovarja in drugih jezikovnih priročnikov, kar prinaša koristi za vse življenje.

KLJUČNE BESEDE

Portal Franček, sporazumevalna zmožnost, šolski slovar, učenci

ABSTRACT

Students in in primary school develop communication skills, which are an important part of the learning process. This process develops systematically and planned during schooling, being also influenced by the use of dictionary manuals. In the past websites with language resources existed in Slovenia, however, the Franček portal is the first website for the use of dictionaries, adapted specifically for pupils and students. Its contents are linked to the goals and standards of the curriculum for learning slovenian. The article shows how the students can get to know Franček in a planned way and use it practically. It also shows its wider applicability - not only in the lessons of slovenian. The systematic use of the Franček portal starting with the youngest pupils and for all school subjects introduces students to the use of dictionaries and other language manuals - a skill, which brings benefits for a lifetime.

KEYWORDS

Franček portal, communication ability, school dictionary, students

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1 UVOD

Eden izmed temeljnih ciljev pouka slovenščine v osnovni šoli je razvijanje sporazumevalne zmožnosti. To je praktično in ustvarjalno obvladovanje vseh štirih sporazumevalnih dejavnosti (poslušanje, branje, govorjenje, pisanje) pa tudi jezikovnosistemskih temeljev [1]. Sporazumevalna zmožnost in v okviru te poimenovalna zmožnost je pomemben del učnega procesa, ki se med šolanjem razvija sistematično in načrtno, na kar vpliva tudi raba slovarskih priročnikov. V času šolanja bi zato učenci morali spoznati vlogo in načine uporabe različnih slovarskih priročnikov [2].

Opremljenost slovenščine z jezikovnimi viri, priročniki, orodji in svetovalnimi ter podpornimi storitvami je eden ključnih dejavnikov, od katerega je odvisno uresničevanje številnih ciljev jezikovne politike. Osnovno opremljenost na ravni opisa posameznega jezika predstavljata temeljni enojezični slovar in temeljna slovnica sodobnega knjižnega jezika, takoj za tem pa še raznovrstni specializirani jezikovni priročniki. Resolucija o nacionalnem programu za jezikovno politiko 2021–2025 narekuje, da mora biti opis sodobne slovenščine prilagojen za digitalno okolje in odprto dostopen. Viri morajo biti dostopni čim manj razpršeno. Različni primeri združenega dostopa do večjega števila virov za slovenščino so na primer spletišče Fran (https://www.fran.si/), stran z viri na spletišču Centra za jezikovne vire in tehnologije Univerze v Ljubljani (https://www.cjvt.si/viri-in-orodja/slovarji-in-leksikoni/), Predstavitveni portal spletnih jezikovnih virov za slovenščino na strani zavoda Trojina (https://viri.trojina.si/), Evroterm (https://evroterm.vlada.si/evroterm) ter Termania (https://www.termania.net/). Treba je razvijati tudi podobna zbirna spletišča z jezikovnimi viri, prilagojenimi za posebne ciljne skupine uporabnikov in uporabnic slovenščine, kot so šolarji ipd. [3]. Analiza učnih načrtov in šolskih gradiv je pokazala, da je delo s slovarji predvideno že na zgodnejših stopnjah osnovnošolskega šolanja, bolj izrazito (določeno tudi z učnimi načrti) pa v tretjem triletju osnovne šole in v srednji šoli. V preteklosti je bil na voljo edini splošni enojezični slovar slovenščine, tj. Slovar slovenskega knjižnega jezika, ki je bil zaradi svoje akademske zasnove v marsičem neprimeren za šolsko uporabo pa tudi gradivno zastarel [2]. Nato je obdobje pospešene digitalizacije prineslo novosti v obliki spletnih portalov jezikovnih virov, učitelj je lahko pri pouku uporabljal npr. portal Fran, kjer so na voljo vsi temeljni jezikovni priročniki za slovenščino. Prav posebej za učence ali dijake prilagojenega spletišča za uporabo slovarjev do nedavnega ni bilo na voljo.

2 PORTAL FRANČEK

Na Inštitutu za slovenski jezik Frana Ramovša ZRC SAZU so ob 30. obletnici samostojnosti Republike Slovenije objavili nov portal Franček (https://www.xn--franek-l2a.si/grade_selection?target=%2F), ki je mlajši brat jezikovnega portala Fran. Namenjen je osnovnošolcem in dijakom. Zasnovan je tako, da omogoča razvijanje sporazumevalne zmožnosti. Vsebine, ki jih ponuja, se povezujejo s cilji in standardi v učnem načrtu za slovenščino iz leta 2018. Hkrati ustreza didaktičnemu priporočilu, da naj učitelj pri pedagoškem delu načrtuje delo z informacijsko-komunikacijsko tehnologijo (IKT) in da naj vključuje kakovostne e-vsebine, med njimi tudi e-slovarje in druge jezikovne priročnike [4]. Elektronski dostop omogoča lažje in hitrejše iskanje pa tudi najrazličnejša zahtevnejša, zapletenejša in obsežnejša iskanja, s tem pa pridobivanje kvalitetnejših preglednih informacij o besedišču oziroma posameznih skupinah in množicah besed/besednih zvez [2]. Portal Franček je učencem prijazen učni pripomoček, ki predstavlja uvod v uporabo slovarja. Prav zaradi svoje raznovrstnosti je učni vir, katerega uporabo lahko učitelj načrtovano vključuje v obravnavo skozi večino učnih faz ali le v nekaterih fazah (npr. z uvodom ali zaključno ustvarjalno nalogo), še posebej ob ciljih, povezanih z razvijanjem poimenovalne, pravopisne in pravorečne pa tudi metajezikovne zmožnosti. Tako zaradi svoje vsebinske zasnove, ki omogoča večrazsežnostni pogled na izbrano geslo, kot zaradi prilagojenosti osnovno- in srednješolskemu naslovniku odpira številne nove možnosti neposredne uporabe pri pouku, ki jih dosedanji elektronski viri niso ponujali. Na besedo ne gleda le s stališča pomena in oblike, temveč se s predvidenimi položaji, v katerih jo uporabljamo, dotika tudi okoliščin oz. funkcije besede v njih, hkrati pa jo ob primerjavi z narečno rabo ter ob možnostih raziskovanja njenega izvora postavlja v širše prostorske in časovne jezikovne razsežnosti [4].

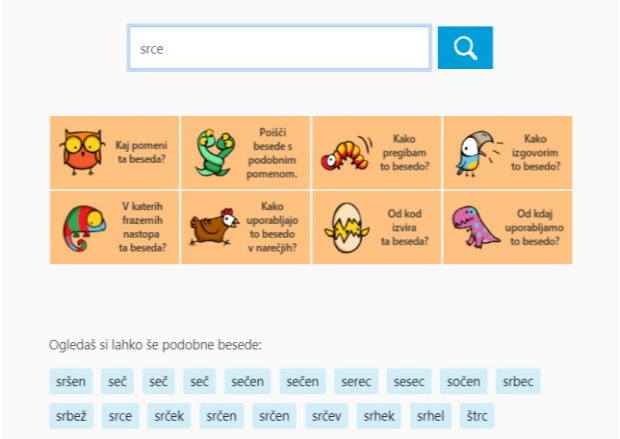
Vsebine na portalu so prilagojene starosti in jezikovnim zmožnostim učencev in dijakov. V skupini 1.–5. razred lahko učenci iščejo, kaj pomeni določena beseda, katere so besede s podobnim pomenom, kako pregibamo to besedo, in poslušajo, kako to besedo izgovarjamo v knjižnem jeziku. Ogledajo si lahko tudi podobne besede. V skupini 6.–9. razred učencem poleg že naštetih možnosti Franček ponuja še poizvedovanje po frazemih, v katerih nastopa iskana beseda, izvoru besede, času začetka uporabe besede. Učenci lahko izvejo, kako se beseda uporablja v drugih narečjih, pogledajo na zemljevidu, kje govorijo tako, ponujena pa jim je tudi interaktivna možnost, da sami posnamejo svojo narečno različico in jo pošljejo prek povezave. Prav tako si lahko ogledajo podobne besede (Slika). Enako je tudi v skupini srednja šola, le ikone so manj otroške.

Portal nam poleg osnovnega iskanja ponuja še spoznavanje jezikovnih značilnosti, če kliknemo na povezavo *Kje je kaj v slovnici?*. Tu so narejene povezave na šolski slovnici Kratkoslovnica (za osnovno šolo) ter Slovnica na kvadrat (za srednjo šolo) in vsebine, ki jih v njiju lahko najdemo (Slika 2. Slovnici opisujeta sodobni knjižni jezik [5].

To pa še ni vse. Pri vsaki temi si lahko ogledamo pogoste napake, vzete s korpusa Šolar. To je korpus besedil z učiteljskimi popravki, ki so jih učenci slovenskih osnovnih in srednjih šol samostojno tvorili pri pouku. V nadaljevanju lahko vidimo vsebine na izbrano temo, ki so se pojavile v jezikovni svetovalnici. Na voljo so tudi učni listi z vajami in rešitvami (Slika 3).

Portal vsebuje tudi Jezikovno svetovalnico za učitelje, kjer so zbrana vprašanja in odgovori na jezikovna vprašanja, po katerih lahko brskamo ali s pomočjo obrazca zastavimo novo vprašanje (Slika 4). Črkozmed omogoča učitelju, da hitro sestavi učne liste z nalogami iz slovenskega jezika (Slika 5). Izbrati mora vrsto naloge glede na učno vsebino, število primerov pri posamezni nalogi, lahko tudi prilagodi že dano navodilo za reševanje. Nato računalniški algoritem sestavi naloge, ki jih lahko učitelj ureja, dopolnjuje z dodatnimi primeri ali ustvari povsem nove primere, če z danimi ni zadovoljen. Na koncu lahko učni list izvozi v pdf obliki in ga shrani na računalniku ali pa ga ima shranjenega v aplikaciji in do njega dostopa ob vsakokratni prijavi, kjer ga lahko tudi naknadno ureja (Slika 6:).

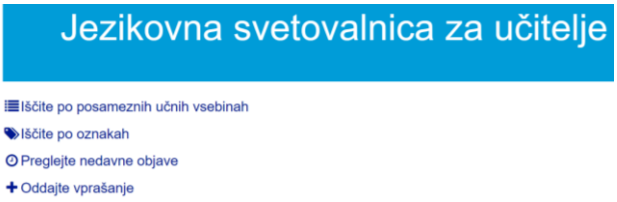
Na koncu je dodana tudi povezava na portal Fran.



Slika 1: Iskalnik za skupino 6.–9. razred

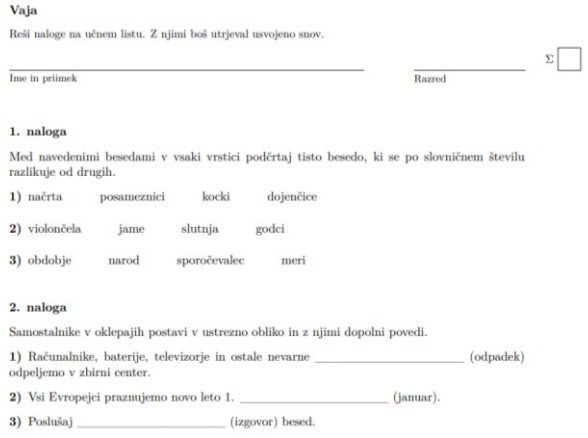
Slika 2: Kje je kaj v slovnici?

Slika 3: Še več možnosti



Slika 4: Jezikovna svetovalnica za učitelje

Slika 5: Črkozmed



Slika 6: Primer nalog, ustvarjenih z aplikacijo Črkozmed.

2.1 Besedoboj

Dodatek k portalu Franček je aplikacija Besedoboj, ki si jo lahko naložimo na pametne naprave (Slika 7). To je jezikovna igra, v kateri se pomerimo z iskanjem besed, ki se končajo ali začnejo na določeno črko, besed, ki imajo več kot 6 črk, besed, ki so samostalniki ipd. Tekmujemo lahko z znanimi umetniki, kot so France Prešeren, Ivan Cankar, Lili Novy, Valentin Vodnik, Zofka Kveder, Srečko Kosovel, ali z naključnim resničnim nasprotnikom iz omrežja. Igre se med seboj razlikujejo po načinu igranja in stopnji težavnosti. Neznane besede si lahko ogledamo na portalu Franček, do katerega je narejena povezava. V igri zbiramo cekine, ki jih lahko vložimo v nakup modnih dodatkov za svoj lik v aplikaciji [6].

Slika 7: Besedoboj

3 FRANČEK PRI POUKU SLOVENŠČINE

Učenci so že poznali portal Fran in ga uporabljali. Zlasti v sedmem razredu se v skladu z učnim načrtom podrobneje seznanijo z jezikovni priročniki, posebej s slovarjem slovenskega knjižnega jezika. Z zanimanjem pa so sprejeli novo pridobitev na področju jezikovnih virov, ki je prilagojena posebej njim in s tem enostavnejša za uporabo ter bolj všečna. Najprej jim Frančka predstavim in izpostavim možnosti, ki jih ta ponuja, nato ga raziskujejo sami. Po lastnem izboru v okviru že usvojene snovi in možnosti, ki jih Franček ponuja, jim pripravim naloge, ki zavzamejo širok nabor možnosti uporabe portala, ki jih lahko sami praktično preizkusijo in se tako seznanijo s Frančkom (Slika 9).

Učenci s pomočjo slovarja odkrivajo pomene neznanih besed, odkrivajo, koliko pomenov ima določena beseda, ugotavljajo izvor besed, iščejo sopomenke in si z njimi pomagajo pri odpravljanju ponavljajočih besed v že obstoječem besedilu ali pri tvorjenju le-tega. Lahko si pomagajo pri pregibanju besednih vrst ali pri ugotavljanju lastnosti besed. V besedilu odkrivajo pravopisne napake in jih odpravljajo. V pomoč so jim posnetki izgovorov, npr. pri ugotavljanju mesta naglasa v besedah. Odkrivajo frazeme, njihov pomen in s pomočjo slovarja naštevajo nove. S pomočjo povezave na slovnico, prilagojeno za osnovnošolsko raven, lahko prikličejo v spomin in ponovijo določene že obravnavane slovnične vsebine.

To je samo nekaj primerov pri načrtnem spoznavanju novo nastalega portala Franček, pri katerem učenci urijo poimenovalno, pravopisno, slovnično, slogovno in metajezikovno zmožnost. Učitelj lahko pripravi še več nalog različnih zahtevnosti ali za utrjevanje snovi uporabi že pripravljene, ki jih portal ponuja na mestu, kjer si o izbrani temi lahko več preberemo v slovnici (Slika 8). Frančka je smiselno uporabljati tudi naključno pri sprotnih jezikovnih in pomenskih dilemah, tako pri jezikovnem kot književnem pouku, pri tvorjenju in sprejemanju besedila, in sicer že pri najmlajših učencih, ki jim je ta posebej prilagojen. Na tak način bodo učenci seznanjeni s slovarjem in njegovo zgradbo, hkrati pa bodo ponotranjili pripomoček, ki jim bo tudi kasneje v pomoč pri razreševanju jezikovnih težav.

Učence za konec povabim k igri Besedoboj, ki bi jo lahko za popestritev kljub prepovedi uporabe telefonov odigrali tudi pri pouku na šolskih tablicah.

Slika 8: Že pripravljene vaje

3.1 Širša uporabnost Frančka

Franček je s svojim slovarjem uporaben tudi pri drugih šolskih predmetih, ne samo pri slovenščini, in sicer pri odkrivanju pomena neznanih besed z različnih predmetnih področij, ki jih

pokriva. Poleg tega skrb za slovenščino in bralna pismenost nista le stvar učitelja slovenščine, zato bi morali vsi učitelji spodbujati k uporabi slovarja in slovnice in s tem k učinkovitejši rabi strokovnega jezika in k poglabljanju splošne sporazumevalne zmožnosti [7]. Raba jezikovnih portalov, kot je Franček, pri pouku različnih predmetov pripomore k boljšemu in globljemu razumevanju snovi, hkrati pa prispeva k širjenju besedišča. Ta vpliva na učenčev uspeh in večjo bralno pismenost.

Lahko je v pomoč učencem z izrazitejšimi narečji. Kadar učitelj opazi, da učenci določeno besedo izgovarjajo drugače, kot je v knjižnem jeziku, jih lahko spodbudi, da sami preverijo izgovor v slovarju [4].

Franček je uporaben tudi pri pouku na daljavo, pri katerem je manj interakcije med učiteljem in učenci. Ti lahko sami poiščejo razlage določenih novih pojmov, ki jih usvajajo pri pouku, ali tistih, ki so jim neznani. Prav tako pa je pri delu na daljavo ali v učilnici koristen tudi za učence, ki jim je slovenščina drugi oz. tuji jezik, saj jim poleg opisanega pomena besed omogoča tudi poslušanje pravilnega izgovora, preverjanje pravilnih oblik pri pregibanju različnih besednih vrst ali drugih jezikovnih lastnosti v šolski slovnici. Pri posamezni temi, razloženi v slovnici, so jim na voljo tudi preproste vaje z rešitvami.

4 ZAKLJUČEK

V slovenskem prostoru do sedaj nismo imeli podobnega jezikovnega vira, prilagojenega posebej za osnovno- in srednješolce. Zlasti ne za najmlajše učence. Mladi dandanes odraščajo v svetu digitalizacije in pametnih naprav, ki jim v vsakem trenutku ponujajo na stotine bolj ali manj relevantnih informacij ter različnih oblik animacije in zabave. Knjižnih virov se poslužujejo vedno manj. Franček jim na simpatičen in všečen način približa orodje, ki jih uvaja v svet spletnih jezikovnih virov, ki so zamenjali slovarje in priročnike v fizični obliki. Če se bodo učitelji različnih predmetnih področij zavzeli za njegovo sistematično in načrtno uporabo, ga bodo učenci ponotranjili in bili deležni koristi, ki jim ta prinaša. Tako bodo tudi v odrasli dobi posegali po zapletenejših virih, ki jim bodo ponujali odgovore na njihove jezikovne dileme.

LITERATURA IN VIRI

[1] Učni načrt za slovenščino. 2018. Ljubljana: Zavod Republike Slovenije za šolstvo.

[2] Stabej, M. idr. 2008. Jezikovni viri pri jezikovnem pouku v osnovni in srednji šoli. Dostopno na naslovu: https://www.trojina.si/wp-content/uploads/2019/08/StabejRozman.pdf (5. 7. 2022)

[3] Resolucija o nacionalnem program za jezikovno politiko 2021–2025 (ReNPJP21–25). 2021. Dostopno na naslovu http://www.pisrs.si/Pis.web/pregledPredpisa?id=RESO123# (5. 7. 2022)

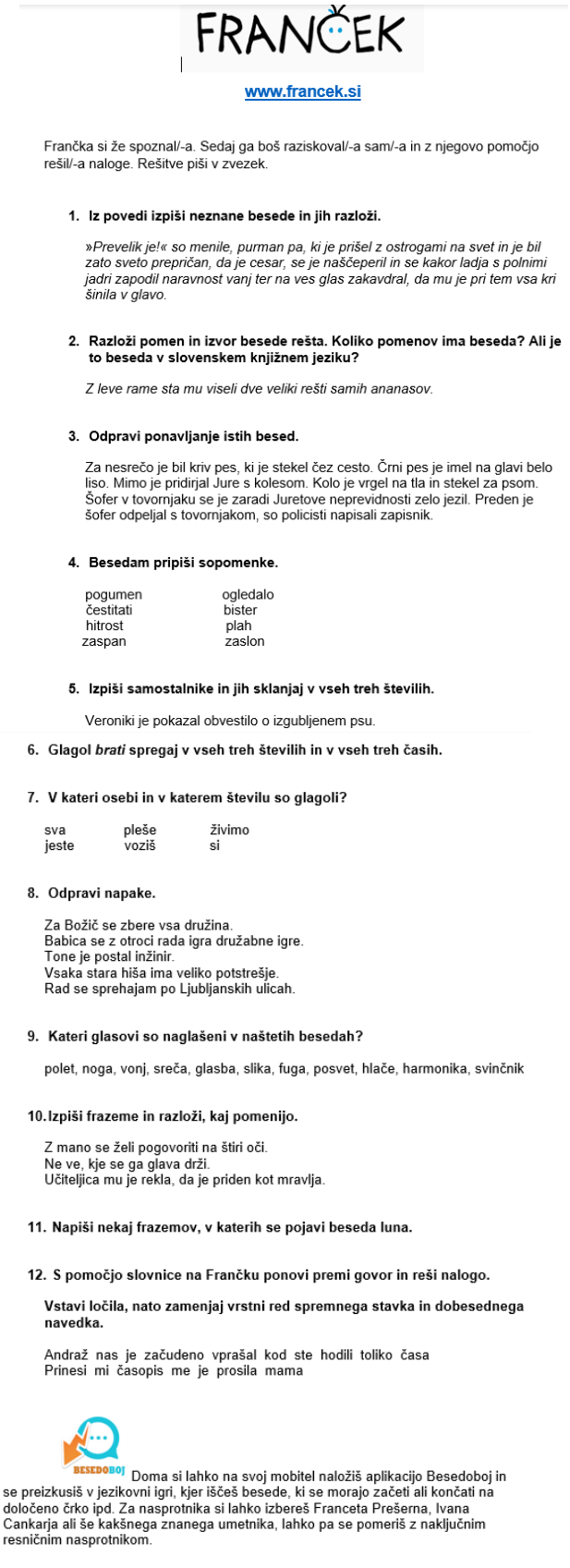
[4] Strateški dokument na področju prožnih oblik učenja. 2021. Dostopno na naslovu https://www.scv.si/wp-content/uploads/2021/09/Strateski_dokument_prozne_oblike_ucenja_cistop is.pdf (5. 7. 2022)

[5] Ahačič, K. (2018). Kratkoslovnica. Ljubljana: Založba Rokus Klett

[6] Ahačič, K. (2018). Slovnica na kvadrat. Ljubljana: Založba Rokus Klett.

[7] O igri besedoboj. Dostopno na https://www.youtube.com/watch?v=GfawzDcKAF8 (8. 7. 2022)

[8] Franček, kaj pa slovnica pri matematiki? Dostopno na https://sio.si/2020/05/11/francek-kaj-pa-slovnica-pri-matematiki/ (25. 7. 2022)



FRANČEK

www.francek.si

Frančka si že spoznal/-a. Sedaj ga boš raziskoval/-a sam/-a in z njegovo pomočjo rešil/-a naloge. Rešitve piši v zvezek.

1. **Iz povedi izpiši neznane besede in jih razloži.**

   »*Prevelik je!*« *so menile, purman pa, ki je prišel z ostrogami na svet in je bil zato sveto prepričan, da je cesar, se je naščeperil in se kakor ladja s polnimi jadri zapodil naravnost vanj ter na ves glas zakavdral, da mu je pri tem vsa kri šinila v glavo.*

2. **Razloži pomen in izvor besede rešta. Koliko pomenov ima beseda? Ali je to beseda v slovenskem knjižnem jeziku?**

   Z leve rame sta mu viseli dve veliki rešti samih ananasov.

3. **Odpravi ponavljanje istih besed.**

   Za nesrečo je bil kriv pes, ki je stekel čez cesto. Črni pes je imel na glavi belo liso. Mimo je pridirjal Jure s kolesom. Kolo je vrgel na tla in stekel za psom. Šofer v tovornjaku se je zaradi Juretove neprevidnosti zelo jezil. Preden je šofer odpeljal s tovornjakom, so policisti napisali zapisnik.

4. **Besedam pripiši sopomenke.**

pogumen	ogledalo
čestitati	bister
hitrost	plah
zaspan	zaslon

5. **Izpiši samostalnike in jih sklanjaj v vseh treh številih.**

   Veroniki je pokazal obvestilo o izgubljenem psu.

6. **Glagol *brati* spregaj v vseh treh številih in v vseh treh časih.**

7. **V kateri osebi in v katerem številu so glagoli?**

sva	pleše	živimo
jeste	voziš	si

8. **Odpravi napake.**

   Za Božič se zbere vsa družina.
   Babica se z otroci rada igra družabne igre.
   Tone je postal inžinir.
   Vsaka stara hiša ima veliko potstrešje.
   Rad se sprehajam po Ljubljanskih ulicah.

9. **Kateri glasovi so naglašeni v naštetih besedah?**

   polet, noga, vonj, sreča, glasba, slika, fuga, posvet, hlače, harmonika, svinčnik

10. **Izpiši frazeme in razloži, kaj pomenijo.**

    Z mano se želi pogovoriti na štiri oči.
    Ne ve, kje se ga glava drži.
    Učiteljica mu je rekla, da je priden kot mravlja.

11. **Napiši nekaj frazemov, v katerih se pojavi beseda luna.**

12. **S pomočjo slovnice na Frančku ponovi premi govor in reši nalogo.**

    Vstavi ločila, nato zamenjaj vrstni red spremnega stavka in dobesednega navedka.

    Andraž nas je začudeno vprašal kod ste hodili toliko časa
    Prinesi mi časopis me je prosila mama

BESEDOBOJ Doma si lahko na svoj mobitel naložiš aplikacijo Besedoboj in se preizkusiš v jezikovni igri, kjer iščeš besede, ki se morajo začeti ali končati na določeno črko ipd. Za nasprotnika si lahko izbereš Franceta Prešerna, Ivana Cankarja ali še kakšnega znanega umetnika, lahko pa se pomeriš z naključnim resničnim nasprotnikom.

Slika 9: Učni list z vajami za spoznavanje Frančka

Kvalitetno učenje na daljavo – izziv za učitelja in učenca

Quality Distance Learning – A Challenge for Teacher and Student

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POVZETEK

Ta prispevek predstavlja priložnosti, kot tudi kritičen pogled na družbeno situacijo v kateri smo se znašli učitelji osnovnošolskih programov skupaj z našimi učenci ob pandemiji COVID-19, ki jo je povzročil korona virus in ki je zmotila normalno delovanje vseh družbenih sistemov ter tako tudi posledično zapletla dogajanja v izobraževalnih osnovnošolskih procesih.

Znotraj izobraževalnega sistema je treba poiskati rešitve za nadomestitev pomanjkljivosti učenja na daljavo, kar se nanaša predvsem na zmanjšano možnost socializacije otrok. V tem letu smo osnovne šole imele že vzpostavljene dobre komunikacijske kanale in na voljo številna IKT orodja namenjena pospeševanju sodelovanja učečih v obliki virtualnih učilnic in drugih orodij, ki so nam v njih na voljo. Kljub temu je veliko učečih (učenci, učitelji, starši) še naprej nezadovoljnih, učni rezultati niso vedno zadovoljujoči. Pojavljajo se problemi ne poznavanja uporabe orodij ali na splošno različni vzroki zakaj deležniki učnega procesa ne morejo ali si ne upajo poskusiti krmariti po virtualnem okolju.

Zato poleg predstavljanja morebitnih težav, na katere lahko naletijo učitelji ali učenci pri svojem delu pri izobraževanju na daljavo v prispevku ponujam tudi predloge za reševanje teh težav, ki sem jih skupaj s svojimi sodelavci in učenci poskusila zbrati v obliki infografik.

KLJUČNE BESEDE

Pouk na daljavo, osnovnošolsko izobraževanje, učenci, učitelji, digitalna orodja

ABSTRACT

This contribution presents opportunities, as well as a critical view of the social situation in which we found ourselves as teachers of elementary school programs together with our students during the COVID-19 pandemic, which was caused by the corona virus and which disrupted the normal functioning of all social systems, and thus also as a result complicated events in educational primary school processes.

Within the education system, solutions must be found to compensate for the shortcomings of distance learning, which mainly refers to the reduced possibility of children's socialization. This year, our elementary schools already had good communication channels established and a number of ICT tools available to promote student participation in the form of virtual classrooms and other tools available to us in them. Despite this, many students (students, teachers, parents) are still dissatisfied, learning results are not always satisfactory. There are problems of not knowing how to use the tools or, in general, various reasons why the participants of the learning process cannot or do not dare to try to navigate the virtual environment.

Therefore, in addition to presenting potential problems that teachers or students may encounter in their work in distance education, in the paper I also offer suggestions for solving these problems, which I tried to collect together with my colleagues and students in the form of infographics.

KEYWORDS

Distance learning, primary education, students, teachers, digital tools

1 UVOD

Izobraževanje na daljavo je spletno učenje, lahko mu rečemo tudi e-izobraževanje. Gre za učenje na daljavo, učenje preko interneta, učenje v virtualnih učilnicah ... Na prvi pogled se sliši zelo dobro načrtovano, vendar se postavlja vprašanje, koliko učencev in učiteljev se dejansko potrudi ... Je učenje na daljavo prezahtevno? Ali vsi preživimo enako časa s knjigo kot prej? Koliko časa, truda in živcev je bilo dejansko vloženega v določene naloge in projekte? Ali vsi učenci, kot tudi učitelji pri zastavljanju določenih nalog, delajo enako dobro ali nekateri delajo malomarno? Kaj bo potem, ko se učenci vpišejo v srednje šole? Kakšna znanja bodo učenci odnesli naprej? Kaj je smisel tovrstnega poučevanja? Kaj bodo pridobili učenci prve triade, ki ob vstopu v osnovnošolske klopi šele začnejo oblikovati svoje delovne in socialne navade, kaj šele, da se prebijajo skozi izzive virtualnih nalog. Ali učitelji morajo delovati timsko pri zahtevah do učencev in ali lahko popolnoma ohranijo svoj individualizem pri podajanju snovi, zastavljanju nalog … Katera orodja in metode naj uporabijo, da bo pouk na daljavo kakovosten za vse (Slika)?

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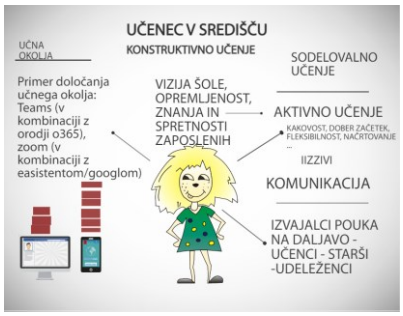


Slika 1: Učenec v središču [2]

2 NAČRTOVANJE POUKA

Pri študiju na daljavo se razvijajo številne kompetence učencev. Podobno bi lahko rekli tudi za učitelje. Učeči sam ureja svoje učenje in organizira svoj čas (odloči se kdaj, koliko in na kakšen način se bo učil). Učenec se samostojno uči, raziskuje s samostojnim učenjem in z iskanjem informacij na internetu. Učenec se nauči kako poiskati informacije, ki jih potrebuje in na kakšen način mu najbolj ustreza. Ta koncept poučevanja spodbuja raziskovanje in študij ter strukturiranje v smiselno celoto. Razvija se učenčeva digitalna kompetenca, učenec se nauči poiskati informacije, ki jih potrebuje.

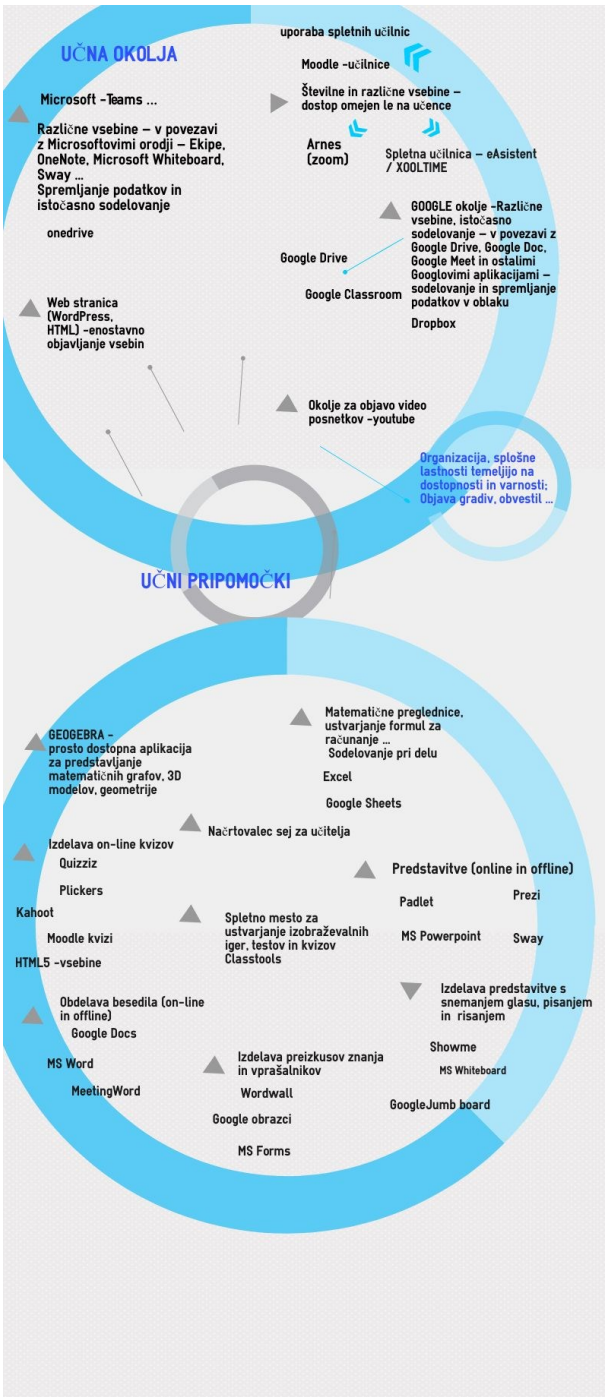
V tem procesu uporabimo jezik kot orodje, ki lahko pomaga pri gradnji znanja posameznega učenca, zavedajoč se, da si vsak ustvari svoje znanje glede na njegove izkušnje [1]. Spodbujajo se tudi raziskovalne sposobnosti učečih, tehnične veščine in sposobnosti kritične analize.

Učitelj je tudi pred izzivom: kaj želi, da učenci znajo, kako bodo dosegli načrtovane cilje, kako bodo merili in preverjali doseganje zastavljenega, kako bodo vključili učeče strukture in katera orodja bodo ustrezna? Tudi učitelj mora poiskati kakovostne podatke, ki jih bo posredoval učečim. Podatke mora pravilno in primerno oblikovati. Temelj učiteljevega dela je dobra komunikacija in dobro vzpostavljeni komunikacijski kanali (Slika). V osnovni šoli je vsekakor pomembna kakovostna komunikacija tudi s starši. Učitelj k pouku na daljavo predvsem mora pristopiti brez predsodkov, izvajati na učečega usmerjen pouk in vsekakor poiskati dobra in ustrezna orodja za izvedbo takšnega pouka.

3 ORGANIZACIJA POUKA

3.1 Pogled učečega

Kaj pa učenci menijo o tovrstnem konceptu poučevanja, ali se sploh zavedajo njegovih prednosti? Ko učence vprašamo, kaj menijo o pouku na daljavo, bodo skoraj vsi odgovorili, da sploh ni zadovoljiv, da je prezahteven in da jim vzame preveč časa. Kaj se pravzaprav skriva za vsemi temi informacijami?



Slika 2: Učna okolja in učni pripomočki [3]

No, za začetek, pri pouku na daljavo (govorim predvsem o osnovnih šolah) večinoma učencev nismo dovolj privzgojili takšnega samostojnega načina dela. Roko na srce, v osnovni šoli je to zelo zahtevno. Osnovna šola je sama po sebi zelo pomembna prelomnica za naše najmlajše. Ob vstopu v osnovno šolo se večinoma otroci prvič soočajo z nalogami organizacije samega sebe, lastnega časa in dela (sedenje, pisanje, poslušanje, organiziranje zvezka, delovnih navad …). In kaj se dogaja v slovenskih šolah? V času, ko je pandemija COVID-19 motila normalno delovanje vseh družbenih sistemov se je izobraževalni sistem čez noč preselil na splet in pričakovalo se je od učiteljev

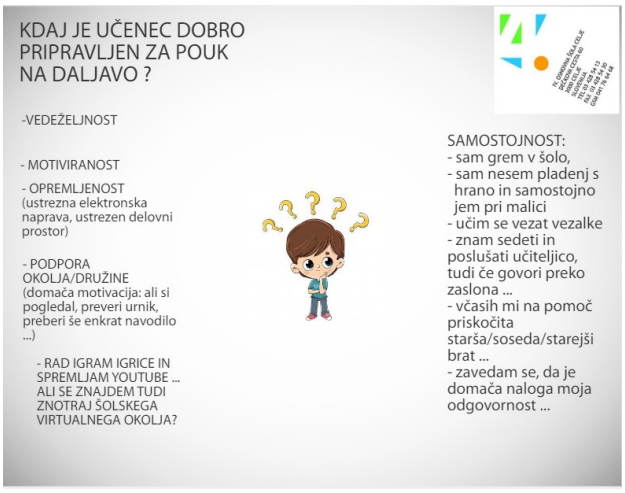
in učečih, da te osnovne veščine poizvedujejo na daljavo. Učenci morajo predelati snov, ki bi jo sicer razložili učitelji v šoli, sami pa bi le prepisali »nekaj zapiskov« s table v svoje zvezke. Učeči trdijo, da je nalog veliko, a če bi vsi dobili natančna navodila, razlago in ustrezna učna gradiva, bi jih hitro in lažje končali, pa tudi več naučili. Vsekakor se več časa porabi za samostojno učenje iz učnih gradiv, a razlog za to je ravno samostojno učenje. Ne smemo pozabiti, da pri običajnem pouku tudi domače naloge samostojno delamo doma. Koliko so pri tem otroci uspešni in ažurni danes? Statistika delanja domačih nalog je v osnovnem šolstvu zadnja leta vse slabša. Opozorimo, da na kvalitetno učenje vpliva še efektivno izkoriščen čas, v katerem smo fizično prisotni dopoldan na šoli napram spremljanju pouka na daljavo po video konferenci.

Večina mlajših učencev osnovnih šol še niso vajeni rutin učenja, ker šele pridobivajo te veščine in posledično težje delajo na daljavo. Za učence drugega in tretjega triletja pri šolskih nalogah in projektih se zahteva veliko, vendar se učitelji trudijo čim bolje razložiti, kako delati. Pri testih je majhna težava. Najpogosteje odličnjak iz razreda prvi reši test in pošlje rešitve ostalim v razredu. Na ta način učenci, ki običajno nimajo odličnih ocen, uspejo izboljšati svoje povprečje, a kljub temu ne razumejo ničesar. Pogosto se vsi iz razreda povabijo preko določene spletne klepetalnice in tako rešujejo test - skupinsko. Domače naloge pa odličnjaki pišejo in pošiljajo drugim (Slika).

Ostali le malo spremenijo koncept in ga pošljejo učiteljem. Nekateri učitelji sploh ne pogledajo kaj učenci pošljejo in to vedoč, učenci potem pošljejo enako domačo nalogo nekoga drugega. Zato učenci niti ne poskušajo prepisovati, samo pošljejo tujo domačo nalogo s slikami. Ko pridemo do nacionalnega preverjanja znanja na koncu šolskega leta smo splošno v zagati in učitelji in učenci. Starši, kot tudi en izmed pomembnih deležnikov šolskega sistema postanejo razburjeni do skrajnosti ali popolnoma nezainteresirani in indiferentni. Prvi so takšni, ker bi želeli vplivati in pomagati, vendar ne vidijo globlje sistemske napake, zaradi katerih to žal ni možno. Vsaj ne na način, kot bi oni želeli, ker je pogosto njihova gonilna sila le lastni interes. Drugi pa so indiferentni zaradi nepoznavanja, ki ga priznajo ali zaradi primanjkljaja časa, socialnih in drugih razmer ipd.

Pouk na daljavo ima svoje prednosti, a tudi slabosti. Za učence, ki sicer delajo samostojno in vložijo veliko truda, živcev, energije in časa za opravljanje nalog, je to samo dodatek za nadaljnje izobraževanje. Ti učenci bodo lažje spremljali pouk v srednji šoli, v morda težjih in zahtevnejših razmerah, kasneje v življenju se bodo lažje spopadali s težkimi situacijami. Tisti učenci, ki delajo po »starem sistemu« – s prepisovanjem in goljufanjem, si delajo medvedjo uslugo in bodo v zahtevnejših razmerah težje sledili snovi, pri nadaljnjem izobraževanju pa se bodo izgubili.

Pred kakšne izzive je po drugi strani postavljen učitelj?



Slika 3: Učenec in pouk na daljavo [2]

3.2 Pogled učitelja

Priča smo, da so se šole ob izbruhu epidemije in ob pojavu nujnega prehoda na izobraževanja na daljavo hitro znašle – organizirale so dodatne sestanke in vzpostavile najprej zasilna, potem ustrezna spletna okolja in spletna orodja, prisluhnile in upoštevale nasvete in modele različnih pomembnih inštitucij (MIZŠ, ZRSŠ), kot tudi različne inštitucije s katerimi je šola v nenehnem ozkem sodelovanju. Osnovna šola je morala upoštevati navodila mestne občine, kot šolsko ustanoviteljico, ter tudi prisluhniti navodilom NIJZ, kot tudi podjetjem vezanim na šolski sistem, kot so easistent, Microsoft, različne založbe – ponudnice e-gradiv in pripomočkov... Učitelji so poleg časovno in organizacijsko zahtevnega izvajanja pouka na daljavo bili pahnjeni še v nenehna izobraževanja in različne IKT projekte od strani omenjenih inštitucij ali različnih tržnih ponudnikov.

Zanimivo je, da so najbolj uporabljena digitalna orodja v šolah po večini PowerPoint, Wordwall, Kahoot, online orodja iz Microsoft paketa o365 ter komunikacijska digitalna orodja Microsoft Teams, Gmail (Google) in Zoom srečanje, medtem, ko veliko število drugih digitalnih orodij še vedno ostaja neizkoriščenih (Slika 4).

Slika 4: Načrtovanje in organizacija pouka na daljavo [2]

4 ZAKLJUČEK

Pouk na daljavo vsekakor poglobi učenčeve in učiteljeve sposobnosti in spretnosti, le malo dobre volje je treba imeti za delo. Največje prednosti takšnega dela so izključno učenje zase, urejanje lastnega učnega procesa in razvijanje učnih kompetenc (Slika). Nekje vmes pa se je zataknilo pri razvoju etičnih kompetenc in moralnih vrednot, kar pravzaprav vodi v glavni problem naše družbe, to je, da se učenci učijo za ocene, ne zase in za življenje. Menim, da je ta koncept težko spremeniti in zagotovo izhaja večinoma iz močnih pričakovanj sodobnih staršev in družbenega okolja.

ZAHVALA

Zahvaljujem se sodelavcem na IV. osnovni šoli, ki so me v prejšnjem šolskem letu toplo sprejeli v svoje vrste, kot pomočnico ravnateljice in učiteljico matematike in računalništva. Zahvala tudi gre mojim učencem, ki so mi v tem šolskem letu pomagali s svojimi mnenji glede epidemije in prispevali nastale inografike [2, 3].

LITERATURA IN VIRI

[1] Hua Liu in Matthews, 2005. Vygotsky's philosophy: Constructivism and its criticisms examined. International Education Journal 6(3), 386-399

[2] Inografike učencev IV. osnovne šole, 2022. Dostopno na povezavi: https://www.easel.ly/infographic/xl5iti

[3] Inografike učencev IV. osnovne šole, 2022. Dostopno na povezavi: https://www.easel.ly/infographic/r3aw80

KIZ na prostem

KIZ Outdoors

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POVZETEK

V osnovnih in srednjih šolah izvajamo tudi pouk Knjižnično informacijskih znanj. Gimnazije imajo določeno število ur, ki se izvedejo v tem sklopu in za organizacijo ter izvedbo ponavadi poskrbijo knjižničarji in učitelji informatike. Ta znanja se povezujejo tudi z digitalno pismenostjo in so pomembna, da znamo priti do informacij in podatkov, ki jih iščemo. Ker je bilo šolsko leto 2021/22 še vedno nesigurno zaradi covida, smo predvsem razmišljala kako naj zasnujemo dejavnosti, na način, da se bodo lahko izvedle kljub omejitvam. Seveda tako, da bodo dejavnosti načrtovane in izvajane na prostem, tako da se lahko izvedejo tudi samostojno. Zato sem se odločila za uporabo aplikacije. Torej poskušala sem združiti Knjižnično informacijska znanja z učenjem na prostem v obliki raziskovanja in odkrivanja. Zamislila sem si krožno učno pot, ki pelje dijake po Ljubljani mimo različnih tipov knjižnic (šolska, splošna, specialne, univerzitetne, narodna knjižnica), arhiva, tiskarne in podobne ustanove. Dodana vrednost aktivnosti je ta da so nekatere lokacije vsebinsko povezane tudi z urami, ki se izvajajo v šoli (tiskanje s premičnimi črkami, Cobiss). Cilj celotne dejavnosti je tudi ta, da se dijaki 1. letnika seznanijo z mestno okolico šole, saj veliko dijakov prihaja iz primestnih območij.

KLJUČNE BESEDE

Knjižnično informacijska znanja, informacijsko opismenjevanje, pouk na prostem, IKT

ABSTRACT

In primary and secondary schools, we also teach Library Information Skills. Gymnasiums have a certain number of hours that are held in this group, and librarians and IT teachers usually take care of the organization and implementation. These skills are also connected to digital literacy and are important to know how to get to the information and data we are looking for. Since the 2021/22 school year was still uncertain due to covid, we mainly thought about how to design activities in such a way that they can be carried out despite the restrictions. Naturally, the activities will be planned and carried out outdoors, so that they can also be carried out independently. That's why I decided to use the app. So I tried to combine library information skills with outdoor learning in the form of research and discovery. I imagined a circular learning path that takes students around Ljubljana past different types of libraries (school, general, special, university, national library), archives, printing houses and similar institutions. The added value of the activity is that some of the locations are also content-related to the lessons taught at school (printing with movable letters, Cobiss). The aim of the whole activity is also to familiarize the first-year students with the urban surroundings of the school, since many students come from suburban areas.

KEYWORDS

Library information skills, information literacy, ICT, outdoor learning

1 UVOD

Ure knjižnično informacijskih znanj (KIZ) so del gimnazijskega kurikula [2,3], ki jih izvede šolski knjižničar in učitelj informatike. Ponavadi se izvedejo v obliki predavanja v učilnici in vsebujejo iskanje informacij ter navajanja virov, uporabo Cobissa, predstavitve različnih tipov knjižnic, zgodovino knjižnic, seznanitev z UDK sistemom ipd.

Kot mnogi učitelji smo iskali način kako bi ure izvedli drugače brez videokonferenčnega okolja, tako, da bi bile za dijake zanimive in da bi pridobili vsaj del teh znanj. To smo izvedli z uporabo aplikacije CŠOD Misija [1], kamor lahko vnašamo različne raziskovalne učne poti. Uporabnik si naloži aplikacijo in izbere učno pot, pri čemer se mu odpre zemljevid točk, ki jih mora obiskati. Šele ko je posameznik na sami lokaciji točke, to aplikacija zazna in mu dovoli reševanje izziva. Z reševanjem izzivov uporabnik pridobiva znanja in pa točke, ki se seštevajo. Aplikacija je v dveh jeziki, angleškem in slovenskem jeziku, slednje se mi zdi za šolski prostor pomembno. Tudi oblikovno je aplikacija zelo lična, pregledna in preprosta za uporabo. Naj še omenim, da je prednost aplikacije, ki omogoča, da je zemljevid naložen tako, da se lahko uporablja na brezpovezavni način.

V nadaljevanju bom aplikacijo bolj podrobno predstavila skozi lasten konkreten primer, saj sem jo uporabila za izvedbo KIZ na način, da sem pripravila učno pot po mestnem središču. Priprava vsebinskega dela (ideje, besedilo, video in avdio gradivo) je vzelo veliko časa, zatem pa je prišlo še vnašanje v aplikacijo ter postavitev koordinat točk.

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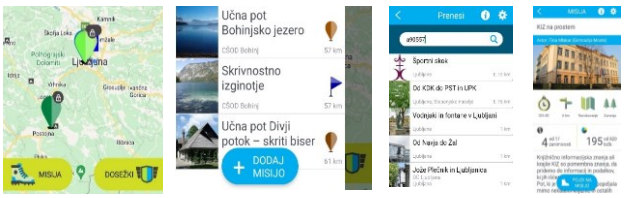
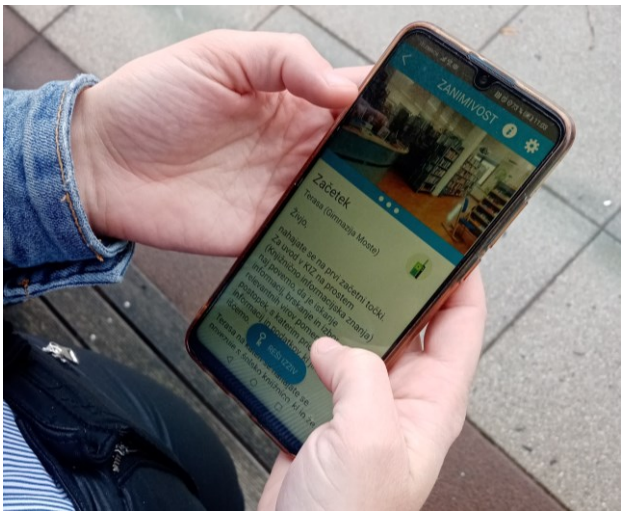
2 UČNA POT KIZ

Aplikacija, ki smo jo uporabili omogoča vnos učnih poti, tako imenovanih »misij«. Misije so lahko treh različnih tipov, uporabili smo tip raziskovanja, kar pomeni, da so vse točke na zemljevidu že vnaprej vidne. Postavila sem jo pod skrito kodo, katero so dijaki vtipkali v iskanje misije in so si jo naložili, kot prikazuje slika 1.



Slika 1: Prenos misije po korakih

Začetna točka je bila postavljan na terasi naše šole, prikaz na sliki 2. To je bila nekako uvajalna točka, da se dijaki sprva seznanijo z aplikacijo, saj je vsebovala razlago poti v besedi, slike, zvočni posnetek in vse tipe nalog izzivov, s katerimi se bodo srečali na učni poti.

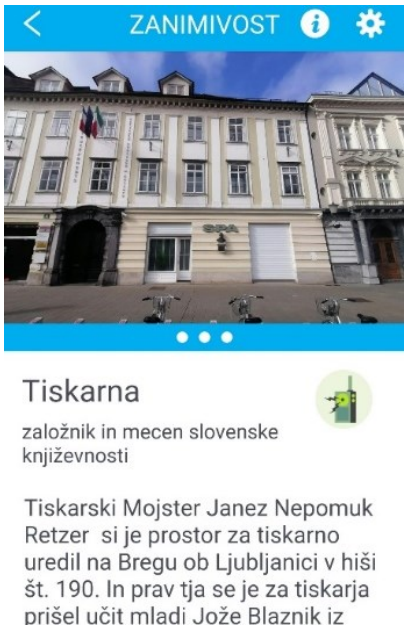


Slika 2: Prva točka nas seznani z aplikacijo

Vsega skupaj smo pripravili 17 točk, ki so jih dijaki obiskali in so sestavljale kar obsežen sprehod skozi mesto: Medicinska knjižnica, Semenišče, Trubarjeva Hiša literature in Tromostovje, Blaznikova tiskarna in Tiporenesansa, Arhiv Slovenije, NUK, Cankarjev spomenik in Centralna tehniška knjižnica, Trubarjev spomenik, Mestna knjižnica Ljubljana Otona Župančiča, Kinoteka z mediateko in Muzejska ploščad.

Z začetno točko sem jih seznanila z različnimi načini kjer lahko pridobijo namige za reševanje izzivov, seveda pa so nekateri izzivi zahtevali pridobivanje informacije iz okolja lokacije same. Takšen primer je bila točka Semeniške knjižnice, ki se nahaja v samem centru mesta na tržnici. Ob vhodu v Semenišče je obokan portal, ki vsebuje več okrasnih in kiparskih elementov. Iz tega so morali dijaki prepisati napis, ki je uokvirjen nad vrati v latinščini. Prav tako so morali poiskati detajl na kljuki, kjer je ikona škofa, ki v rokah drži predmet (knjigo).

Za reševanje izzivov dobijo različne namige, ki jih pregledujejo. Kot prikaže Slika 3 so to fotografije (ob kliku galerijo se odpre še več slik z opisom, kamor lahko tudi skrijemo odgovor), avdio (po želji dodamo zvočni posnetek, ki ga seveda sami posnamemo), besedilni opis. Tudi uporaba spleta je dovoljena pri iskanju odgovora, ni pa nujna.



Slika 3: Primer informacij, ki jih lahko vnesemo v aplikacijo

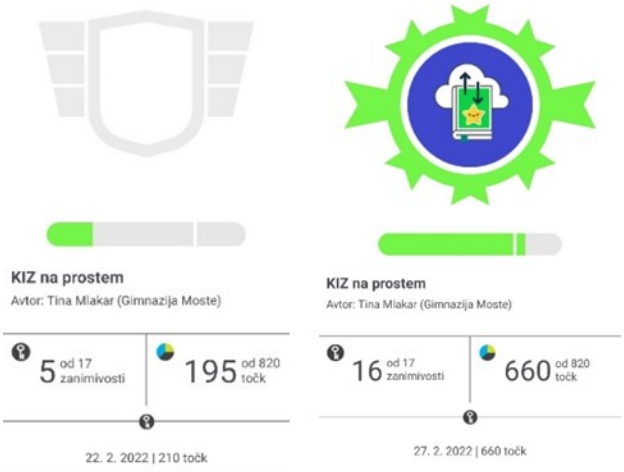
Centralna tehniška knjižnica in Cankarjev spomenik se nahajata na isti ploščadi. Pri obisku CTK sem bila previdna, zato sem naloge oblikovala tako, da ne zahtevajo vstopanja v prostore knjižnice, da nebi ogromno število dijakov motilo obiskovalce pri učenju. Prav tako je za takšne vstope dobro pridobiti soglasje vodstva in opozoriti zaposlene. Enake pomisleke sem imela pri točki MKL, vendar sem ocenila, da je splošna knjižnica bolj odprta in pretočna z obiskovalci, zato sem izzive postavila tudi znotraj knjižnice. Tukaj so se dijaki sprehodili med police, v čitalnico, ter v kletno nadstropje mediateke. V opisu točke sem predstavila UDK sistem in ga ponazorila s primeri, pri izzivu pa so sami poiskali polico na strokovnem oddelku in vpisali številko UDK-ja v odgovor. Za izziv v čitalnici sem na uporabila revijo, ki je tisti mesec ravno izšla, naloga pa je spraševala po naslovu revije, katere beseda je sopomenka izrazu edinstven, enkraten (gre za revijo Unikat). Sprehodili so se tudi pri leposlovju in poiskali avtorja, ki se začenja na črko M, primer izziva je ponazorjen na Sliki 4.

Za vsak slučaj sem vse namige do rešitev skrila tudi v galerijo (vkolikor kateri od dijakov nebi mogel vstopiti v knjižnico, zaradi morebitnega pogoja PCT). Pri MKL sem tudi uspela pridobiti tudi privolitev vodstva, ki so z obiskom dijakov seznanili zaposlene. Končna točka je bila na Muzejski ploščadi, kjer sta dijake pričakala profesorja, da sta vodila seznam prisotnosti.

Slika 4: Oddelek leposlovja, iščejo avtorja Murakami

3 ZNAČKA KIZ

Pri reševanju izzivov se točke seštevajo za pravilne odgovore in tudi odštevajo za nepravilno vnesene odgovore, kot lahko vidimo na sliki 5. Tako dijak nabira točke in ob določenem seštevku prejme značko. Izgled značke in opis uredimo sami, v našem primeru sem izbrala ikono knjige in oblak. Značka je tudi služila preverjanju opravljene poti.



Slika 4: Sprotno seštevanje levo in pridobljena značka desno

4 IZVEDBA KIZ NA PROSTEM

Dijaki so učno pot opravili na predviden dan v načrtovanem času in ne v svojem prostem času. Začeli so na šoli in so imeli 3 ure časa da so opravili celotno učno pot. Z začetne točke na poli smo jih pošiljali po skupinah. Na učni poti so jih na nekaterih lokacijah pričakali nadzorni učitelji, ki so preverili prisotnost in dijake usmerili v primeru težav.

Pomemben del izvedbe je podpora vodstva, ki mi je zagotovilo čas za pripravo, zbiranje gradiva na terenu, nadzorne učitelje na dan izvedbe, ter nenazadnje zaupanje za novo aktivnost. Pred izvedbo aktivnosti smo pripravili tudi navodila za dijake in za učitelje. Dijake in njihove starše sem že vnaprej obvestila o uporabi aplikacije za šolske namene, namreč nekaterim so morali starši odobriti nalaganje nove aplikacije, saj so imeli zaklenjen telefon.

Razporeditev učiteljev je bila premišljena glede na časovne okvire obiska točk. Predvidevala sem približen čas ko bodo dijaki prehajali preko lokacij in tako razporedila učitelje. To se ni vedno izšlo, saj niso vsi ubrali predvideno krožno pot. Dijaki so imeli za končanje učne poti na boljo pribl. 2 uri časa in še dodatne pol ure za vrnitev na šolo.

Želela bi si da bi s tega dne imeli več fotografij, vendar sem jih uspela dobiti le nekaj. Sama sem pri pošiljanju skupin s prve točke imela polne roke dela in zato nisem uspela obiskati točk na terenu ob samem poteku aktivnosti. V splošnem smo z izvedbo zadovoljni, so se pa ob tem pojavile nekatere posebnosti, ki so smiselne za upoštevanje pri načrtovanju takšne aktivnosti v prihodnje.

5 ZAKLJUČEK

Prva stvar, ki smo se jo naučili je, da vsak projekt in dejavnost, ki se jo lotimo, v pripravah vzame veliko več časa kot je načrtovano, saj vmes pridejo nepredvideni zapleti. Prav tako je težko planirati koliko časa bo posameznik potreboval za izvedbo učne poti, zato je najbolje, da zadevo rešujejo samostojno brez nadzornih učiteljev in brez omejenega časa. To nas pripelje do naslednjega razmisleka, in sicer preverjanje opravljene misije. Namreč v ozadju aplikacije ne vidimo kdo od dijakov se je registriral in opravil misijo, zato smo preverjali pridobljene značke na telefonih. Pri tem smo pazili, da niso prikazovali zaslonske slike sošolcev, ali da si niso izposodili telefon od nekoga, ki je misijo opravil in ga prinesli v vpogled. Pri slednjem nismo imeli vpliva, tako so zamudniki lahko »goljufali«. Zadrego sem tudi sporočila na oblikovalce aplikacije in zagotovili so mi, da bodo uredili v prihodnje pregled nad opravljanjem misije, kar nam bo močno olajšalo samostojno izvedbo z manj nadzornimi učitelji.

Na učno pot smo razporedili pet učiteljev. Na začetni in končni točki v mestu naj bi preverjali prisotnost dijakov. Sicer pa so nadzorni učitelji imeli nalogo, poleg vodenja seznamov dijakov na točkah imeli tudi vlogo pomoči in usmerjanja, če se jim je kje zataknilo ali če niso dobro poznali mesta. Nadzorni učitelj pri MKL je usmerjal in pomagal dijakom, saj so imeli tam kot predvideno največ vprašanj. Idealno bi bilo, da bi vsi nadzorni učitelji prej že opravili celotno pot in bi poznali aplikacijo ter potek, vendar tega vsi niso mogli zagotoviti, smo jih pa seveda podrobno informirali o točki na kateri so se nahajali in kakšne izzive skriva.

Nepredvideno se je zgodilo, da so se nekateri dijaki kljub navodilu h kateri točki naj se napotijo v mestu, odpravili v drugo smer krožne poti ali pa celo »cik-cak«, zato so se z nadzornimi učitelji zgrešili, saj se niso ujeli časovno, namreč učitelji so bili na točki le predvideni čas, ne cel dan dejavnosti. Tudi to težavo smo omenili snovalcem aplikacije in skupaj smo ugotovili, da bi to rešili s preprosto pretvorbo učne poti iz tipa »Raziskovanje« v učno pot »Ekspedicija«. Glavna razlika je ta, da so pri raziskovanju vse lokacije točk znane vnaprej, pri ekspediciji pa se točke odpirajo v povezavi s prejšnjo (ko jo rešiš se odpre

naslednja). Prav tako pri ekspediciji pridobijo značko šele na koncu opravljene poti, medtem ko pri raziskovanju značko prejmejo že ob visokem številu točk, kljub temu da vse točke niso obiskane.

Pri sestavljanju vsebinskega dela in pripravi fotografskega materiala je smiselno planirati več časa za testiranje končne verzije in vnašanje popravkov. Med fotografiranjem lokacij za pripravo gradiva nas je aktivnost popolnoma prevzela in sem zamišljeno hodila po mestu in zapisovala zaznamke, ideje, fotografirala. V tem delovnem zagonu svojega prihoda in fotografiranja nisem napovedala, tako, da so me na eni od lokacij opomnili naj preneham. Pojasnila sem jim, da bodo fotografije uporabljene le za šolski projekt in da ne vsebujejo obrazov ljudi, vendar niso bili zadovoljni. Tako sem se naučila, da sem v hitenju pozabila na komunikacijo z ustanovami, ki je seveda zaželjena in jo bom naslednjič bolje izpeljala. Še en razlog zakaj se hitenje ne izplača naj omenim na primeru napačno vnešenih koordinat, ki so točko postavile v drugo državo. Na srečo smo testno verzijo večkrat preverili in rešili tudi to zagato.

Dijaki so torej skozi učno pot pridobivali knjižnično informacijska znanja na prostem, namesto v učilnici in tako imeli drugačen potek učenja. Samostojno so iskali informacije, odgovore in se orientirali po mestu. Seveda si vnaprej želimo učno pot še dodelati, predvsem vsebinsko pri nalogah in izzivih. Ob upoštevanju časa, ki je bil na voljo za pripravo in dejstva, da smo zadevo prvič uporabili, pa moram poudariti, da smo z izvedbo zadovoljni, saj smo pridobili izkušnjo za prihodnjo priliko. Morda bi prihodnjič dodala še neke vrste anketo za povratno informacijo, npr. Mentimeter, za preverjanje odziva kako je bila dejavnost sprejeta med dijaki.

LITERATURA IN VIRI

[1] Aplikacija CŠOD Misija. Dostopno na naslovu http://misija.csod.si/si/ (29. 6. 2022)

[2] Fekonja. Romana, 2018. Povzetek stanja v šolskih knjižnicah. Naloge in delo šolskega knjižničarja. Dostopno na naslovu https://home.izum.si/cobiss/konference/konf_2018/presentations/2_03_RomanaFekonja.pdf (29. 6. 2022)

[3] Posodobitve pouka v gimnazijski praksi. Knjižnično informacijsko znanje, 2010. Zavod RS za šolstvo, Ljubljana. Dostopno na naslovu https://www.zrss.si/projektiess/gradiva/posgim/GRA_Knjiznicno_informacijsko_znanje.pdf (29. 6. 2022)

Uporaba Google Drive za usklajevanje med učitelji in delo z učenci

Use of Google Drive for Coordinating Between Teachers and Working With Pupils

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POVZETEK

Informacijsko Komunikacijske Tehnologije se po letu 2000, postopoma integrirajo v naš pedagoški proces. To je seveda nujno, saj moramo tudi pedagoški delavci slediti razvoju, ker s tem povečamo zanimanje učencev za šolo in hkrati nadgradimo naše poučevanje. Glede na vse večjo obremenjenost učiteljev s dokumentacijo, pa lahko uporaba informacijske komunikacijske tehnologije tudi nam močno izboljša preglednost našega dela, ga bolje sistematizira in splošno olajša. V članku na kratko povzamem dve metodi uporabe programa Google Drive za delo z učenci in dve za lažjo komunikacijo znotraj aktivov. Pri obeh uporabljamo skupne mape ustvarjene znotraj omenjene aplikacije, v katerih imamo shranjene dokumente, ki jih lahko urejajo učitelji ali učenci z dodeljenim statusom urednika. Opisane metode močno olajšajo komunikacijo učiteljev, ki poučujejo enake predmete ter z možnostjo vzajemnega popravljanja in dopolnjevanja nadgradijo njihove urne priprave. Učencem pa olajšajo delo na skupnih projektih ter dostop do preglednice datumov ustnih zagovorov, ki jih ob predhodno dorečenimi pravili dopolnijo sami. Vsi opisani postopki imajo seveda še mnoge druge možne uporabe, katerih se bodo bolj inovativni učitelji zagotovo poslužili.

KLJUČNE BESEDE

IKT, Google Drive, skupne mape, komunikacija v aktivu

ABSTRACT

Information and Communication Technology slowly started to integrate into our education system after the year 2000. This is essential for teachers, because we must follow the progress to enhance the interest of our pupils for learning and at the same time to upgrade our approach towards teaching. Use of Information and Communication Technology can also lessen the burden of paperwork for teachers, which nowadays increases annually, with better overview and better systematisation of documents. In this article I shortly summarize two uses of Google Drive for working with students and two for better communication between teaches. In both we use shared folders inside the application with different types of files, that can be managed by teachers or students with editor status. Described methods enhance coordination between teachers that teach same subjects and enable better preparation for specific topic, because teachers can correct and upgrade each other. For pupils, this means better and easier work on common projects and access to shared table of dates for oral examination, which they fulfil on their own with previously set rules. All described procedures have a lot more potential and can be used in different settings, which innovative teachers will most definitely figure out.

KEYWORDS

ICT, Google Drive, shared folders, coordination between teachers

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1 UVOD

Uporaba Informacijsko Komunicijskih Tehnologij (IKT), se je ob prehodu v 21. stoletje začela vse pogosteje in bolj intenzivno integrirati v poučevanje znotraj izobraževalnih ustanov. To je ob hitrosti razvoja IKT, potencialu, ki ga kaže za lažje učenje in pogostosti uporabe tovrstnih tehnologij, ne le za učenje ampak tudi komunikacijo z vrstniki [3], nujen korak, ki smo ga morali pedagoški delavci narediti in integrirati v svoj učni proces. Z uporabo IKT učencem približamo snov, jo seveda naredimo veliko bolj zanimivo in najbolj pomembno, ustvarjamo mlade odrasle, ki se bodo znali in imeli interes za vseživljenjsko učenje [1,2,4].

Pogosto pa pozabljamo, da v današnjem času, ko smo pedagoški delavci iz leta v leto bolj obremenjeni s papirologijo, lahko IKT uporabimo tudi na načine, ki nam bi močno olajšali delo, omogočili večjo usklajenost znotraj aktivov in s pomočjo katerih bi si delo bolj organizirali ter naredili bolj pregledno.

V tem članku bom na kratko predstavil nekaj načinov, s katerimi sem si v preteklih letih olajšal pedagoško delo, slednje naredil bolj pregledno in omogočil učencem večjo integracijo IKT v pedagoški proces, na kar so se v veliki meri odzvali zelo pozitivno.

2 PREGLED LITERATURE

Večina pedagoških delavcev je bilo tekom svoje kariere, že seznanjenih s kopico različnih programov, ki jim seveda olajšajo in obogatijo proces poučevanja. Težava pri veliki večini teh programov je, da so do neke mere kompleksni in navadno

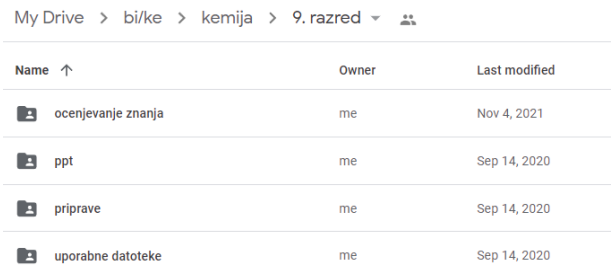
delujejo na povsem novi osnovi, kar za mnoge predstavlja prevelik izziv (posebno za starejše učitelje, ki imajo manj osnovnega IKT znanja) zaradi česar se slednjih ne poslužujejo. Zato sem se odločil, da pri uporabi IKT uberem enak pristop, kot pri poučevanju učencev, pri čemer že pridobljeno znanje nadgradimo z novim. Na ta način sem pridobil več pozornosti s strani učiteljev, ki v uporabi IKT niso tako vešči.

Odločil sem se nadgraditi uporabo aplikacije Google Drive, ki jo ima večino učiteljev, saj navadno uporabljajo google mail in imajo zato že ustvarjen gmail račun. Google Drive je ena od Googlovih aplikacij, ki omogoča shranjevanje dokumentov na spletu. Večina učiteljev ima ustvarjen brezplačni račun, pri katerem imajo na razpolago 15GB prostora, kar je več kot dovolj za shranjevanje vseh pomembnih dokumentov, slik in povezav do poučnih gradiv. Poleg tega se lahko Google Drive namesti direktno na namizje računalnika v obliki klasične mape v kateri imate shranjene vse dokumente. Prednosti te mape pa so, da se vsi naloženi dokumenti v njej avtomatsko shranjujejo na splet in prenašajo tudi na druge računalnike, kjer imate naloženo aplikacijo Google Drive. Poleg tega lahko ustvarjate tudi mape, ki jih uporablja in spreminja več uporabnikov, kar ima izjemno aplikativno vrednost pri komunikaciji učitelj-učitelj in učitelj-učenec. Znotraj aplikacije lahko ustvarjamo tudi različne oblike dokumentov, Google docs (podobno kot word dokumenti), Google sheets (podobno kot Excel dokument) in Google slides (podobno kot Power point dokument). Prednost teh dokumentov je da jih lahko urejamo tudi na spletu, tako da lahko učenci ali učitelji, ki nimajo nameščene namizne aplikacije Google Drive, prav tako sodelujejo pri preoblikovanju ali ustvarjanju skupnega dokumenta [5].

3 REZULTATI

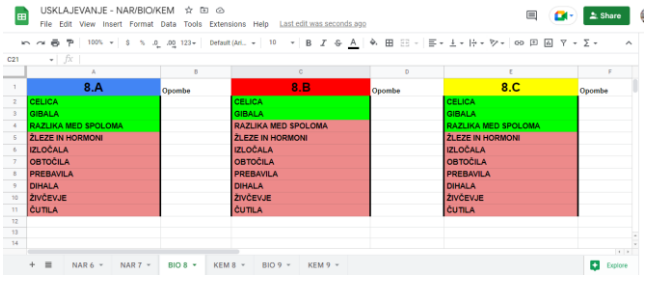
Usklajevanje znotraj naravoslovnega aktiva

Ker na naši šoli (sklepam da je na drugih večjih šolah prav tako), učiva biologijo, kemijo in naravoslovje dva učitelja, je zelo pomembno, da sva pri podajanju snovi karseda usklajena, ker obstaja verjetnost, da bo en od naju naslednje leto poučeval razred od drugega učitelja, pri čemer mora biti natančno seznanjen s snovjo, ki so jo že predelali oz. jo še niso natančno prediskutirali. Poleg tega se učenci in seveda tudi starši med seboj pogovarjajo in hitro opazijo že manjša odstopanja pri poučevanju snovi, kaj šele da en učitelj uči v popolnoma drugačnem vrstnem redu ali pa kaj celo spusti, drugi pa ne. S tem namenom sem ustvaril skupno datoteko v Google Drive, v kateri imava mape za vsak predmet in razred ločene. Znotraj vsakega predmeta (npr. 9. razred kemija) pa najdete aktualen LDN, posamične urne priprave, PPT datoteke in uporabne dokumente (slike, videe, itd.), ki olajšajo razlago določene snovi (Slika 1). Na ta način lahko skupaj urejava LDN, piševa priprave, se dopolnjujeva, popravljava napake in najbolj pomembno ostajava dosledna pri podajanju snovi, saj se konstantno primerjava s pripravami od lanskega leta. Tako nadgradiva najino fizično komunikacijo še v elektronski obliki in nisva odvisna le od skupnih aktivov (ki so seveda za dobro delo v aktivu še vedno izjemno pomembni). Olajša se tudi delo pri poučevanju v različnih učilnicah, saj ne potrebuješ IKT gradiv prenašati z usb ključem ampak so vsa gradiva dostopna na spletni aplikaciji Google Drive.



Slika 1 Skupna mapa za kemijo na Google Drive

Ko učitelji poučujemo enake predmete se trudimo, da ostajamo karseda usklajeni pri hitrosti poučevanja in zaporedju predvidenih snovi pri dotičnem predmetu. Zato sem naredil skupno Excelovo datoteko (ki sem jo v Google Drive pretvori na Sheet file) v kateri sem za posamičen oddelek enega razreda naredil razdelke za vsak oddelek in v vsakega vpisal glavna poglavja, ki jih bomo tekom leta obravnavali. Ko učitelj zaključi poglavje ga iz rdeče barve obarva v zeleno (Slika 2). Če vzamemo primer biologije osmih razredov, kjer imamo tri oddelke in jaz poučujem dva, druga učiteljica pa enega, bo lahko na ta način učiteljica točno videla katera poglavja sem jaz že obdelal ter katera še nisem, enako velja zame. Sicer se hitro vprašamo, zakaj se o tem ne pogovorimo na aktivu in določimo naslednjo snov? Kar vsekakor se in vse skupaj tudi prediskutiramo na aktivih, vendar če skupaj poučujeta dva učitelja biologijo in kemijo v osmem in devetem razredu ter naravoslovje v šestem in sedmem razredu, vse skupaj nanese šest različnih oddelkov, kjer se hitro kaj pozabi ali zameša. Zato nam tovrstna preglednica olajša pregled snovi in načrtovanje dela saj natanko vemo, kaj še nismo obravnavali in koliko časa nam vzame vsaka snov. Poleg tega lahko kadarkoli preverimo dogovore iz aktiva, da ne pride do zmešnjave.



Slika 2 Skupen Google sheet za usklajevanje poučevanja

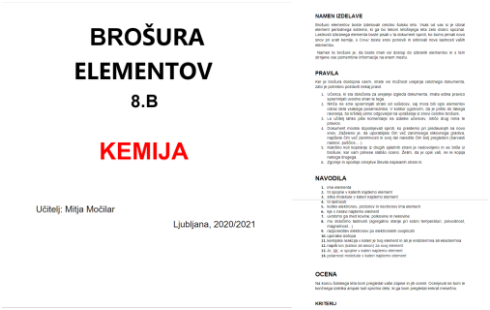
Primeri prakse dela z učenci v Google Drive.

Uporaba skupnih dokumentov v Google Drive nam in učencem lahko močno olajša delo. Pri tem bom opisal dve najpogosteje uporabljeni metodi dela.

Ker se sam poslužujem napovedanega ustnega ocenjevanja, mi je skupni dokument, kjer imamo tabelo datumov in imen učencev določenih za nek termin, bil zelo priročen. O tabeli jih obvestim na začetku leta, pri čemer imajo učenci 14 dni časa, da se sami vpišejo v njo in si določijo termin spraševanja. V kolikor to ne storijo sami, jim ga določim jaz. Pri tem jim omejim obdobje spraševanja in število vprašanih v eni uri. Vsak od

učencev si določi tudi rezervni termin. V kolikor je odsoten pri obeh izbranih terminih, ga vprašam prvo uro ko pride. S tem so vsi seznanjeni na začetku leta, s čimer se izognem raznim izgovorom med letom. Nad seznamom so zadovoljni vsi učenci, saj sami določijo termin in imajo avtomatsko zabeleženega na Google Drive, kar pomeni, da jim je slednji vedno pri roki hkrati pa ne morejo trditi, da so pozabili ali ga spregledali. Ta seznam seveda tudi nam olajša zadeve, saj nam je vedno dostopen. Take sezname uporabljam tudi v primeru govornih nastopov in pisnih preverjanj znanja (pri slednjih seveda sam določim termin).

Uporabe skupnih dokumentov se poslužujem tudi pri kemiji v osmem razredu, kjer učenci tekom leta izdelujejo brošuro kemijskih elementov. Na začetku dokumenta so napisana pravila pisanja v brošuro, pod njimi pa so razvrščeni kemijski elementi po vrsti od vodika pa vse do elementa katerega vrstno število je enako številu učencev v razredu (Slika 3). Učenci si nato sami izberejo kemijski element in ga skozi celotno leto dopolnjujejo, glede na trenutno obravnavano snov pri pouku. Na ta način učenci pridobijo dodatni učni pripomoček, ki so si ga izdelali sami in na koncu leta opise za prvih x elementov periodnega sistema, ki jim bodo seveda zelo prav prišli v devetem razredu.



Slika 3 Brošura kemijskih elementov (skupen dokument)

4 ZAKLJUČEK

S tem člankom sem želel olajšati delo učiteljem ter jim na enostaven način omogočiti boljšo preglednost njihovega dela in s tem optimizacijo celotnega učnega procesa. Prav tako opisani pristopi omogočajo integracijo IKT v pedagoški proces, olajšajo skupinsko delo učencev in dostopnost pomembnih podatkov. Opisane metode dela imajo seveda še mnoge druge možnosti za aplikacijo pri pouku, ki jih bodo učitelji, s pridobljenim znanjem in malo inovativnosti razvili.

LITERATURA IN VIRI

[1] Mann D., Shakeshaft C., Becker J. and Kottkamp R.,1999 West Virginia's Basic Skills/Computer Education Program: An Analysis of Student Achievement Milken Family Foundation, Santa Monica CA.

[2] Sivin-Kachala J (1998) Report on the Effectiveness of Technology in Schools 1990–1997 Software Publisher's Association, Washington DC.

[3] Sutherland R., Lindstro M.B., Lahn, L.C., 2009, Sociocultural perspectives: technology enhanced learning and knowing. In: de Jong, T., Balacheff, N., Ludvigsen, S., Barnes, S., Lazonder, A. (Eds.), Technology-enhanced Learning: Principles and Products. Springer-Verlag: 39–53.

[4] Wenglinsky H., 1998, Does it Compute? The Relationship between Educational Technology and Student Achievement in Mathematics Educational Testing Service Policy Information Center, Princeton NJ.

[5] Wikipedia 2022, Google Drive, Wikipedia The Free Enciklopedia, Dostopno na: https://en.wikipedia.org/wiki/Google_Drive (10.8.2022)

Spletni vodnik Plečnik v Kamniku v obliki sobe pobega

Online Guide Plečnik in Kamnik in the Form of an Escape Room

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POVZETEK

Na Osnovni šoli Komenda Moste so v šolskem letu 2021/2022 obeležili Plečnikovo leto z raziskovanjem in spoznavanjem mojstrovih umetnin v Ljubljani, Kamniku in Komendi. Delo na terenu se je šolska knjižničarka odločila učencem približati in jih dodatno motivirati s pomočjo informacijsko-komunikacijske tehnologije. Pri organizaciji dejavnosti na terenu je zasledila spletne vodnike Nexto in jih vključila v raziskovanje učencev. Ker za Kamnik tak spletni vodnik ni obstajal, se ga je odločila izdelati sama. Po zanesljivih spletnih referenčnih virih in predhodnem ogledu trase je pripravila opise posameznih točk ogleda, dodala lastni slikovni material in vprašanja za preverjanje znanja. Pripravljeno je prenesla v brezplačne Google obrazce v obliki sobe pobega, kjer pravilna rešitev odpre naslednji izziv. Tako je nastal spletni vodnik Plečnik v Kamniku, ki je predstavljen v prispevku. Učenci so z lastnimi pametnimi telefoni v manjših skupinah po predhodnih navodilih učiteljice samostojno sledili napotkom v spletnem vodniku, raziskovali Plečnikova dela v Kamniku in reševali naloge na koncu vsakega sklopa. Razen prevoza so vse dejavnosti na terenu potekale brezplačno, vendar niso minile brez zagat. Učencem so iz njih pomagali spremljajoči učitelji. Učiteljico izbirnega predmeta so po končanih dejavnostih na elektronski pošti že čakali vsi oddani odgovori učencev. Priprava evalvacije opravljene dejavnosti je bila zato hitra in enostavna.

KLJUČNE BESEDE

Virtualni vodič, soba pobega, lokalna kulturna dediščina

ABSTRACT

Primary School Komenda Moste celebrated Plečnik's year in the school year 2021/22 by researching and getting to know the master's works of art in Ljubljana, Kamnik and Komenda. The school librarian decided to bring the work in the field closer to the students with the help of information and communication technology. When organizing activities in the field, she found the Nexto online guides and included them in the students' research. Since there is no such virtual guide for Kamnik, she decided to make it herself. She prepared descriptions of individual points of view, pictorial material and questions for knowledge testing and transferred everything to free Google forms. Thus an online guide named Plečnik in Kamnik was created in the form of an escape room, where the correct solution opens the next challenge. The students used their smartphones and followed the instructions in small groups in the online guide independently. They researched Plečnik's works in Kamnik and solved the tasks at the end of each section. The research was for free, but it didn't go without problems. Students read the instructions too quickly and too superficially. Since they did not observe the appropriate way of recording the correct answers, the system did not consider them as correct, so they could not continue their research. The accompanying teachers had to explain the instructions to them additionally if necessary, and helped them to enter the answer appropriately.

KEYWORDS

Virtual guide, escape room, local cultural heritage

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1. ORGANIZACIJA DELA IN SPLETNI VIRI

Aplikacija Nexto je bila na začetku leta 2015 zamišljena, da uporabniku preko mobilne naprave daje osnovne informacije o njegovi bližnji okolici. Mobilna naprava informacije sprejema prek posebnih oddajnikov Bluetooth, ki z njo začnejo komunicirati, ko se jim uporabnik dovolj približa. Nexto je bila načrtovana za uporabo med obiski muzejev in naravnih znamenitosti ali pa raziskovanjem novih krajev [1].

Danes aplikacijo Nexto lahko brezplačno uporabljamo kot pametni mobilni vodnik po več kot tridesetih destinacijah slovenske kulturne in naravne dediščine.

Aplikacija Nexto Ljubljana uporabniku s pomočjo obogatene resničnosti razkrije štiri velika neuresničena Plečnikova dela za Ljubljano: Mesarski most, Novi Magistrat, Magistratni vstop na grad in Katedralo svobode. Pot ga vodi tudi mimo uresničenih Plečnikovih del: čez Tromostovje mimo Prešernovega trga na Krekov trg, do Čevljarskega mostu in Novega trga, Križank, Vegove ulice in NUK ter parka Tivoli. Vsaka točka se začne z uganko oziroma nalogo, ki jo mora uporabnik razvozlati, da odklene informacije o projektu, o katerem mu pripoveduje Plečnik kot avdiogovorec. Ob koncu vsake točke mora uporabnik rešiti uganko, da razkrije lokacijo naslednje točke, ki mu ni znana vnaprej [2].

Zaradi dobrega odziva na tovrstno spoznavanje Ljubljane je knjižničarka začela razmišljati o raziskovanju Plečnikovih del v bližnji okolici, v Kamniku. Ker še ni obstajal noben spletni vodnik, ki bi ji bil v pomoč pri organizaciji dela na terenu, se je odločila, da ga naredi sama. Iskala je brezplačne alternative, ki

bodo dostopne preko poslane povezave. Odločila se je za uporabo Googlovih obrazcev, v katere je prenesla predhodno pripravljeno vodenje in naloge, povezane z raziskovanimi točkami v Kamniku. Po zgledu aplikacije Nexto Ljubljana je vodenje in vprašanja uredila v obliko sobe pobega, torej v obliko, kjer je za napredovanje k naslednji točki/nalogi, nujen en in edini pravilni odgovor. Pri sestavi vodenja in nalog je izhajala iz zanesljivih spletnih virov, npr. Kamra, dLib, Kamniško-Komendski bibliografski leksikon …

2. IZDELAVA SPLETNEGA VODNIKA

Pri izdelavi dotičnega spletnega vodnika je avtorica izbrala obliko t. i. sobe pobega v Google obrazcih, ki jih je spoznala že v času karantene med iskanjem novih spletnih načinov dela z učenci. Za naloge v obliki sobe pobega je slišala v strokovnih krogih [3]. Poleg splošnih informacij o Google obrazcih so bile zelo uporabne informacije, predstavljene v spletnem predavanju predavateljice Courtney Drysdale, zaposlene na Univerzi Regis [4, 5]. O sobah pobega za potrebe pouka se je v času karanten in kasneje veliko govorilo in pisalo [6], saj so se izkazale za motivacijsko močno in zanimivo orodje za delo z učenci, v obliki spletnih vodnikov pa jih avtorica prispevka še ni zasledila.

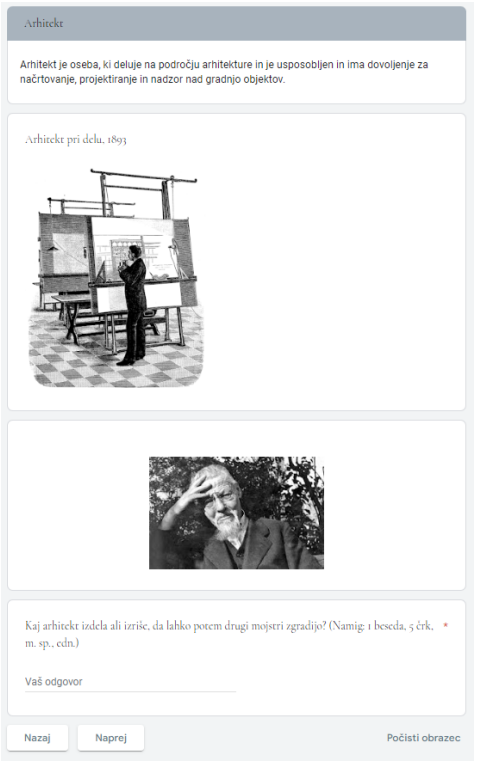
Kot pri pravi sobi pobega so učenci ujeti v eno nalogo, iz katere lahko napredujejo le s pravilnim odgovorom, ki je ključ za vstop v naslednjo nalogo. Tovrstna oblika je učencem zelo všečna in jih motivira veliko bolj kot druge oblike nalog. Pravilni odgovor je potrebno vpisati v pričakovani obliki, da ga sistem, torej Google obrazci prepoznajo kot pravilnega.

Pri vsaki postaji se je avtorica odločila za kratko besedno predstavitev, ki ji je sledila še slikovna ponazoritev (Slika 1).

Slika 1: Opis in slikovna predstavitev

Informacije je povzela po pisnih virih [7], zanesljivih spletnih virih [8] in po predhodnem ogledu načrtovane trase, kjer je s fotografiranjem poskrbela za zadostno in ustrezno lastno slikovno gradivo.

Na koncu sklopa informacij o določeni točki ogleda je vedno zastavljeno vprašanje, povezano s predhodnimi informacijami. Z odgovorom so učenci preverili in utrdili pridobljeno znanje, bodisi samo iz besednega opisa in logičnega razmišljanja ali dejstev, ki so jih morali povezati z napisanim ali prepoznati v videnem na terenu (Slika 2).

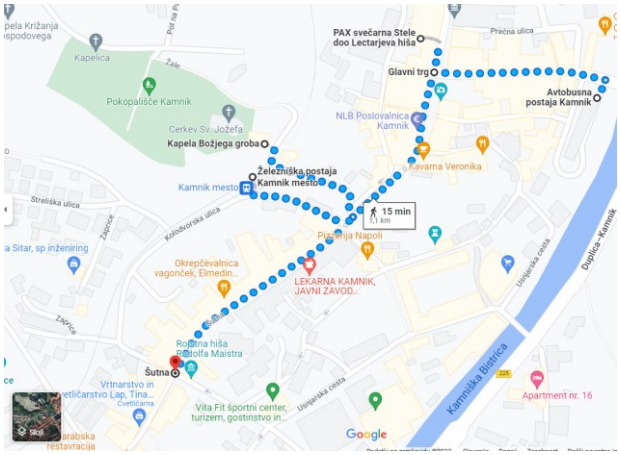


Slika 2: Vprašanje

Največjo težavo je učencem predstavljalo natančno branje. V osnovnih navodilih je namreč pisalo, da morajo vse odgovore zapisati z velikimi tiskanimi črkami in pravopisno pravilno, ker drugače ne bodo prepoznani kot ustrezni in zato ne bodo napredovali k naslednji točki/nalogi (Slika 3).

Slika 3: Navodila za vpisovanje odgovorov

Učenci so lahko kadarkoli preverili zemljevid načrtovane poti in svojo trenutno lokacijo (Slika 4). Pri prehajanju na naslednje postaje ogleda se je to izkazalo za uporabno pomoč.



Slika 4: Zemljevid vodene poti

3. VSEBINA SPLETNEGA VODNIKA

Namen izdelanega spletnega vodnika [9] je spoznati življenje in delo arhitekta Jožeta Plečnika preko umetnin, ki jih je ustvaril v Kamniku.

V 1. slopu so predstavljene informacije o arhitektovem življenju, ki so podprte s slikovnim gradivom, dostopnim na portalu Kamra in dLib. Zaključi ga vprašanje *Kaj arhitekt izdela ali izriše, da lahko potem drugi mojstri zgradijo? (Namig: 1 beseda, 5 črk, m. sp., edn.)*, s katerim učence usmerimo na rezultat arhitektovega dela.

V 2. sklopu spletni vodnik preveri pridobljeno znanje po ogledu svečarskega muzeja v Lectarjevi hiši, kjer so se učenci udeležili tudi delavnice poslikave Plečnikovih sveč [10].

Naslednji sklop podatkov je vezan na Glavni trg v Kamniku, kjer učenci pred znamenito fasado na Maistrovi 2 odkrijejo razliko med fasado in fresko. Spoznajo tudi tehniko, ki jo pogosto vključeval v svoje načrte in je sestavni del preučevane fasade.

Spletni vodnik nato napoti obiskovalca v Kapelo Božjega groba v frančiškanskem samostanu, kjer spoznajo Plečnikovo vsestranskost, praktičnost in simboliko. Z natančnim opazovanjem in povezovanjem videnega s časom Plečnikovega ustvarjanja učenci izberejo pravi odgovor in dobijo navodila za nov izziv.

Po Ljubljanski cesti se sprehodijo do Cerkve Marijinega brezmadežnega spočetja, poiščejo in raziščejo naslednjo mojstrovo umetnino, čeprav slavna kropilnica žal ni več dostopna javnosti.

Na vračanju proti avtobusni postaji se spotoma ustavijo še na železniški postaji Kamnik mesto, ki je dolgo časa veljala za Plečnikovo. Preverijo svoje pridobljeno znanje s prepoznavo posameznih arhitekturnih detajlov.

Raziskovanje zaključijo na mostu čez Nevljico, kjer razmislijo o vzrokih za uporabo različnih materialov, ki jih je arhitekt predvidel v svojem načrtu.

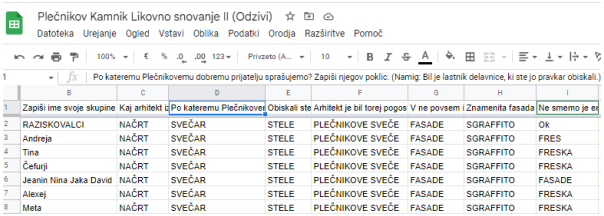
Na avtobusu imajo možnost dokončati svoje reševanje in dokončno oddati svoje odgovore.

Spletni vodnik jih sproti pohvali za vsak opravljen izziv. Na koncu jih napoti k dodatnem raziskovanju o mojstru Jožetu Plečniku in njegovih delih na portalu Kamra. Predlaga jim tudi nadaljevanje raziskovanja Plečnikovih sanj z aplikacijo Nexto Ljubljana v slovenski prestolnici.

4. REZULTATI

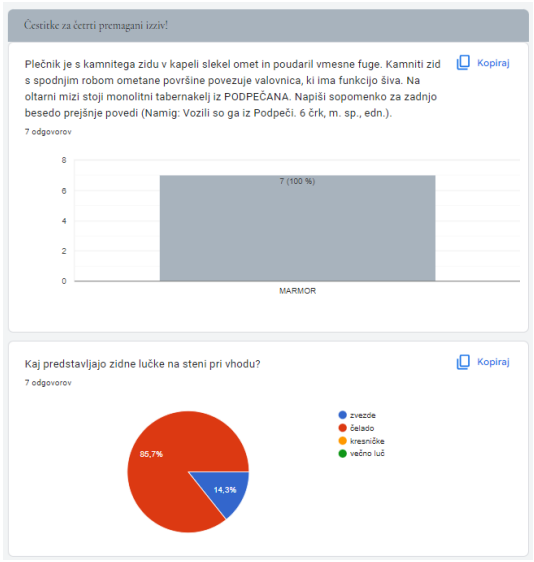
Google obrazci omogočajo hiter in različen pregled poslanih odgovorov in evalvacijo le-teh. Odgovore lahko pogledamo v obliki tabele (Tabela 1) ali grafov (Slika 5).

Tabela 1: Oddani odgovori



Zapiši ime svoje skupine	Kaj arhitekt iz	Po kateremu Plečnikovem	Obiskali ste Arhitekt je bil torej pogos	V ne povsem i	Znamenita fasada	Ne smemo je ei
RAZISKOVALCI	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	Ok
Andreja	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FRES
Tina	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FRESKA
Čefurji	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FRESKA
Jeanin Nina Jaka David	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FASADE
Alexej	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FRESKA
Meta	NAČRT	SVEČAR	STELE	PLEČNIKOVE SVEČE	FASADE	SGRAFFITO	FRESKA

S klikom na določeno polje v tabeli se odpre celotno besedilo vprašanja, kar olajša pregled odgovorov in evalvacijo le-teh.

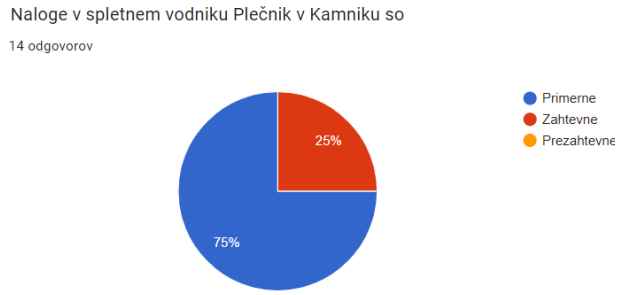


Slika 5: Rezultati v grafih

Učitelji preko poslanih odgovorov doma ali v učilnici hitro in učinkovito evalvirajo pridobljeno in osvojeno znanje dela na terenu.

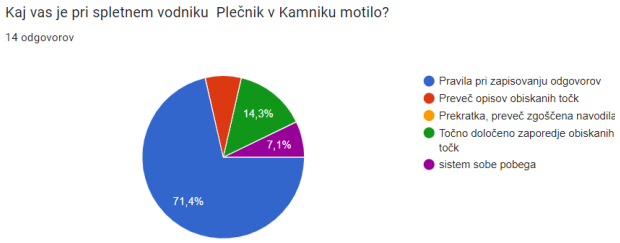
Učenci so bili nad novo obliko dela na terenu navdušeni. Delo na terenu so označili kot najboljšo dejavnost v celem šolskem letu. Všeč jim je bila samostojnost pri raziskovanju, spremljajočih učiteljev zaradi primerne razdalje sploh niso opazili. Zapletlo se je le pri neustreznem vnašanju pravilnih odgovorov (neustrezne črke, sklon, število …), ker niso mogli dostopati do naslednjega sklopa informacij za raziskovanje. Šele takrat so potrebovali in poiskali pomoč učitelja.

Po opravljenem terenskem delu in prvi preizkušnji spletnega vodnika v praksi je avtorica za sodelujoče učence izbirnega predmeta Likovno snovanje II pripravila kratko anketo, da bi pridobila iskrene in realne povratne informacije. Rezultati opravljene evalvacije so opozorili na najmočnejše in najšibkejše točke spletnega vodnika (Sliki 7,8).



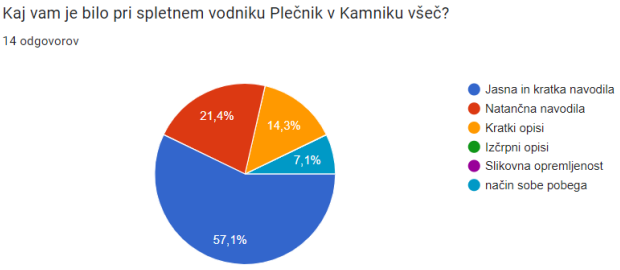
Slika 6: Zahtevnost nalog

Četrtina učencev meni, da so naloge v spletnem vodniku prezahtevne, kar je verjetno posledica natančno določenega vpisovanja odgovorov. Velik del, tj. 71,4 % oz. 10, sodelujočih učencev namreč meni, da je najbolj moteča lastnost vodnika prav predpisana oblika (velike tiskane črke in za vsak odgovor točno določena sklonska oblika rešitve) vpisa pravilnega odgovora (Slika 7). Za naloge v obliki »sobe pobega« pa je ravno upoštevanje tovrstnih navodil ključno za napredovanje.



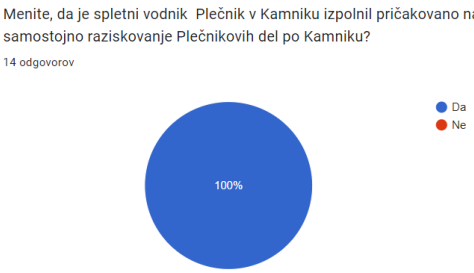
Slika 7: Moteče lastnosti spletnega vodnika

Kot najbolj všečno lastnost vodnika so učenci izbrali več možnosti. Večini, 57,1 % oz. 8 učencem, so bila všeč jasna in kratka navodila, 21 % oz. 3 učencem so bila všeč kratka navodila, 14,3 % oz. 2 učencema kratki opisi posameznih točk, 7,1 % oz. en učenec pa je pod drugo napisal način vodnika, torej način sobe pobega (Slika 8).



Slika 8: Pohvaljene lastnosti spletnega vodnika

Ugotovili smo, da so vsi udeleženi učenci spletni vodnik prepoznali kot učinkovito orodje za samostojno raziskovanje Plečnikovega Kamnika (Slika 9).



Slika 9: Izpolnjen namen spletnega vodnika

V zadnjem vprašanju ankete so štirje učenci (28,6 %) predlagali, da omogoči poljubno izbiranje raziskanih postaj, pet (35,7 %) pa jih je zapisalo, da je potrebno olajšati vpisovanje odgovorov.

Na podlagi opravljene evalvacije lahko sklenemo, da je spletni vodnik Plečnik v Kamniku učencem za samostojno raziskovanje všeč, saj so z njim učinkovito in uspešno spoznali Plečnikova dela v Kamniku. Želijo pa si možnost samostojne izbire poti raziskovanja in čim lažji način odgovarjanja, tj. prepoznavo in izbiro ustreznega odgovora med večimi možnimi.

5. ZAHVALA

Hvaležna sem sodelavki, učiteljici likovne umetnosti in izbirnega predmeta likovno snovanje, gospe Tini Kosi, ki je pogumno sprejela izziv predlaganega terenskega dela v povezavi z IKT storitvami in ga z medpredmetnim sodelovanjem obogatila ter preizkusila ustvarjeno aplikacijo. Zaradi njenih konstruktivnih predlogov je le-ta dočakala nadgradnjo in bo uporabljana tudi v naslednjem šolskem letu.

LITERATURA IN VIRI

[1] Matic Tomšič. 2015. Nexto: slovenska aplikacija, ki lahko zamenja turističnega vodnika. Dostopno na naslovu https://siol.net/digisvet/novice/nexto-slovenska-aplikacija-ki-lahko-zamenja-turisticnega-vodnika-62593 (1. 8. 2022)

[2] Legendarne Plečnikove vizije. Dostopno na naslovu https://www.ljubljana.si/sl/aktualno/legendarne-plecnikove-neuresnicene-vizije/ (1. 8. 2022)

[3] Gregor Škrlj: Knjižnica in spletna soba pobega. 2021. Dostopna na naslovu https://knjiznicarske-novice.si/novica/1274/pokazi [2. 8. 2022]

[4] Courtney Drysdale: Creating Online Escape Games with Google Forms. 2021. Dostopno na naslovu https://enetlearning.adobeconnect.com/p8gxxra41eno/ (3. 8. 2022)

[5] Hitro pridobite vpoglede z aplikacijo Google Forms. Dostopno na https://www.google.com/intl/sl_SI/forms/about/ (3. 8. 2022)

[6] Tjaša Kampos: sobe pobega in drugi miselni izzivi pri pouku. 2021. Dostopno na naslovu https://www.zrss.si/wp-content/uploads/Konference/2021/NAK2021/1dan/SEKCIJA%206/Sobe%20pobega%20in%20drugi%20miselni%20izzivi%20pri%20pouku%20T.Kampos.pdf (3. 8. 2022)

[7] Maja Avguštin in Saša Lavrinc. 2010. Plečnik na Domžalskem in Kamniškem. Ljubljana : Zavod za varstvo kulturne dediščine Slovenije, 2010 (Ljubljana : Littera picta)

[8] Plečnikova dela v Kamniku in okolici. Dostopno na naslovu https://www.kamra.si/digitalne-zbirke/plecnikova-dela-v-kamniku-in-okolici/ (3. 8. 2022)

[9] Andreja Nagode Burger: Plečnik v Kamniku. Dostopno na naslovu https://forms.gle/yj7MDtSdJ2M5PfUk6 (1. 8. 2022)

[10] Lectarjeva hiša. Zibelka 300 letne tradicije oblikovanja in izdelave sveč za vse priložnosti. Dostopno na naslovu https://www.pax.si/lectarjeva-hisa/ (3. 8. 2022)

Razvoj digitalnih kompetenc pri delu z učenci z učnimi težavami

Development of Digital Competencies Working With Students With Learning Disabilities

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POVZETEK

Uporaba mobilnih naprav, računalnikov in svetovnega spleta se je v zadnjem obdobju močno povečala, saj je prisotna na vseh ravneh družbenega življenja. S tem je povezana tudi potreba po izobraževanju in pravilni uporabi omenjenih naprav, obdelave in uporabe informacij. Digitalne kompetence zajemajo različne procese in oblike obdelave in uporabe podatkov v informacijsko-komunikacijski tehnologiji. Razvoj digitalnih kompetenc je pri mladih povezan z njeno uporabo, saj se dnevno soočajo s tem in jo uporabljajo. Slednji pogosto s premalo znanja in veščinami (ne)kritično uporabljajo spletna orodja, komunikacijo preko družabnih omrežij, izmenjujejo in objavljajo podatke. Z ustreznimi izobraževanji se jih v šolah uči pravilne uporabe. Pri učencih z učnimi težavami poteka v primerjavi z njihovimi vrstniki težje, počasneje in parcialno. Svojimi primanjkljaji ne zmorejo uvideti vseh pasti in nevarnosti pri uporabi svetovnega spleta in mobilnih naprav. Pri tem jih je potrebno izobraževati in opolnomočiti, da bodo lahko kljub svojim težavam osvojili osnovne veščine znotraj digitalnih kompetenc ter jih pravilno uporabljali. S tem bodo znali varno in pravilno uporabljati digitalne oblike in naprave v vsakdanjem in profesionalnem življenju.

KLJUČNE BESEDE

Digitalne kompetence, učenci z učnimi težavami, usposabljanje

ABSTRACT

The use of mobile devices, computers and the internet has recently increased significantly increased, because it is present at all levels of social life. Related to this is the need for education and the correct use of the mentioned devices, processing and use of information. Digital competence includes different processes and forms of data processing and use in information and communication technology. The development of digital competence among young people is related to its use, as they are facing and using it on a daily basis. The latter, possessing insufficient knowledge and skills, often (un)critically use online tools, communicate via social networks, exchange and publish data. Given appropriate education in schools we teach them proper use. Among students with learning dissabilities the process is more difficult, slower and partial. With their deficits they cannot see all the pitfalls and dangers of using the internet and mobile devices. In doing so it is necessary to educate and empower them to aquire the basic skills within the digital competence and use them properly despite their difficulties. With this they will know how to safely and correctly use digital forms and devices in their everyday and professional life.

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KEYWORDS

Digital competence, students with learning difficulties, training

1 UVOD

Uporaba računalnikov, pametnih mobilnih telefonov in ostalih digitalnih pripomočkov se je v zadnjih letnih močno povečala ter razširila v vse družbene sisteme. Zaradi hitrega razvoja in napredka se je način življenja povezal preko svetovnega spleta ter družabnih omrežij. IKT je po opredelitvi OECD [1] kombinacija proizvodne in storitvene industrije, ki prenaša ter prikazuje podatke s pomočjo elektronske oblike. Znotraj IKT se pojavljajo različne možnosti računalniških, komunikacijskih in informacijskih naprav, aplikacij in drugih storitev. Vse te možnosti pa se tudi nadgrajujejo, širijo in povezujejo tako na profesionalnem kot privatnem življenju posameznika [2,3].

Vsaka naprava, ki se jo porablja znotraj IKT, zahteva določeno stopnjo znanja za njeno varno uporabo. Mnoga podjetja najdejo tržno nišo ravno med mladimi, ki pogosto spremljajo nove tehnične izdelke in jih nato kupujejo. Množičen porast pametnih mobilnih naprav je prispeval tudi k množični uporabi spleta, pri tem se porajajo različni vidiki pravilne in varne uporabe. Mladi običajno dokaj hitro usvajajo nove aplikacije in spletne novosti. Učenci z učnimi težavami so dokaj posebna skupina, saj imajo nekateri premalo znanja o celovitem delovanju in pri uporabi spleta ter pametnih mobilnih naprav. Vso to znanje o digitalnih informacijah in napravah se je v zadnjih letih oblikovalo v t. i. digitalnih kompetencah.

2 IKT V VZGOJI IN IZOBRAŽEVANJU

Mladi preživljajo veliko časa s pametnimi telefoni, računalniki in igralnimi konzolami. Vzporedno z zabavo in igranjem videoiger, komuniciranjem preko družabnih omrežij pridobivajo osnovna znanja za njihovo uporabo. Vse te naprave so se pred

nekaj leti začele uporabljati tudi v sistemu vzgoje in izobraževanja, saj so v omenjenem sistemu zelo pomembne z vidika omogočanja kvalitetne in učinkovite podpore pri pouku. IKT je postala dostopna za njeno vpeljavo v izobraževalne vsebine in učne načrte kot del načrtov v šolah [4]. Z omenjeno tehnologijo učenci, pedagoški delavci in ostali strokovnjaki uporabljajo gradivo na spletu, ga urejajo, objavljajo in delijo s širšo družbo. Množičnost podatkov je potrebno selekcionirati in se jih naučiti ločevati, ovrednotiti in jim zaupati. Pri tem je potrebno pokazati dovolj znanja in veščin, da se posameznik nauči postati informacijsko opismenjen, saj lahko v nasprotnem primeru pride do informacij, ki so nezanesljive, napačne ali težko preverljive [5]. Skozi vseživljenjsko izobraževanje se morajo pri svojem delu pedagoški in drugi strokovni delavci do neke mere naučiti uporabljati IKT vsaj na osnovni ravni [6]. S tem bodo deležniki v vzgoji in izobraževanju pri poučevanju ter učenju dodatno motivirali otroke ter pridobivali digitalno funkcionalnost digitalnih kompetenc. Pri pouku je tovrsten način še posebej pomemben, saj morajo mladi v procesu pridobivanja znanja pridobiti veščine za pravilno uporabo informacijske tehnologije. Z dopolnjevanjem učnih vsebin s pomočjo gradiv z interaktivnimi viri mladi pridobivajo večjo motivacijo in izkušnje pri učenju. Svetovni splet, interaktivni viri in aplikacije z izobraževalnimi gradivi omogočajo učiteljem, da ponudijo možnosti za učinkovito učenje in večje vključevanje samih učencev v izobraževalni proces v svetu digitalizacije. Učitelji spodbujajo rabo tehnologije pri učencih ter jih tako učijo pravilnih pristopov pri iskanju informacij, analiz, oblikovanju rešitev ter učinkoviti komunikaciji. Samo učenje s pomočjo pametnih mobilnih naprav in spleta se nanaša na načine, ko se uporablja omenjena tehnologija hkrati s spodbujanjem učenja [7]. Rezultati raziskav so pokazali, da uporaba informacijsko-komunikacijske tehnologije v podporo učnemu okolju pozitivno vpliva na učenje [4]. Med mladimi je prvi vir informacij ter najpogosteje uporabljena tehnologija v učne namene računalniška in informacijska tehnologija [8].

Učenci, ki vsakodnevno uporabljajo računalnik v prostem času, dosegajo nižje učne dosežke, podobno kot imajo slabše učne dosežke učenci, ki računalnika nikoli ne uporabljajo [3]. Po podatkih iz PISE (2009) so ugotovili, da učenci v domačem okolju uporabljajo računalniško opremo v večji meri za zabavo, igranje iger, manj pa za šolsko delo [9].

Uporaba elektronskih gradiv je za učenje smiselna, ko z njeno uporabo dosežemo časovno racionalizacijo, boljše rezultate pri učenju in preverjanju doseženega znanja. Tovrstni način se razlikuje od pouka v živo, zato je bilo potrebno predhodno določiti cilje in načine podajanja učne snovi, načrtovati izvedbo, pripraviti ustrezna e-orodja v učnem okolju ter samovrednotiti dosežke in pridobljeno znanje [10]. Učenci, ki imajo nižje sposobnosti, potrebujejo smiselno sestavljene naloge, prilagojene težavnostnim stopnjam, da vsebujejo dovolj podpornega konkretnega slikovnega gradiva ter animacij (še posebej so poučne pri možnostih ponovitve in korigiranju hitrosti). Spletne strani z učno vsebino, ki omogočajo spletne povezave z navezovanjem na sorodne vsebine, učencem spodbudijo željo po spoznavanju novih informacij, hkrati pa jih učijo pravilne uporabe osnov digitalnih kompetenc [10].

3 DIGITALNE KOMPETENCE V VZGOJI IN IZOBRAŽEVANJU

Digitalne kompetence sta OECD (2010) in Digitalna agenda Evrope (2013) uvrstili med temeljne kompetence državljana v sodobni družbi ter izobraževalnemu sistemu pri pridobivanju in razvijanju teh kompetenc. Pri opredelitvi digitalnih kompetenc so to veščine pri uporabi sodobnih tehnologij, sposobnost uporabe znanja in veščin v konkretnih situacijah. Avtorji različno opredeljujejo pojme digitalne kompetence, največkrat so v uporabi v zvezi z veščinami, povezanimi s IKT, računalniško informatiko in svetovnim spletom, pogosto pa so pod digitalno kompetentnost uvrščali tudi medijsko pismenost [11]. V povezavi z omenjenimi kompetencami se ta področja dotikajo profesionalnega, zasebnega, družbenega življenja in preživljanja prostega časa

Digitalne kompetence zahtevajo določeno mero informacijsko-komunikacijske pismenosti in druge oblike komuniciranja. Osnovna raba IKT ter dostopnost do svetovnega spleta potrebujejo pri digitalnih kompetencah ustrezno poznavanje IKT, ravnanje z njimi in ustrezen odnos do njih [12]. S pomočjo digitalnih kompetenc usvojimo sposobnost ocenjevanja in upravljanja velikih količin informacij ter znanja.

Evropski okvir digitalnih kompetenc za državljane [12] je na petih področjih poudaril sposobnosti pri razvoju digitalnih kompetenc: obdelavo podatkov, komunikacijo, ustvarjanje vsebin, varnost in reševanje problemov. Te spretnosti se nanašajo na tehnično uporabo IKT, kompetence IKT pa so mišljene kot integrirana in funkcionalna uporaba digitalnega znanja, spretnosti in odnosov [3].

Digitalne kompetence so med drugim razvrščene v pet sklopov:

- obdelava informacij (iskanje informacij, uporaba različnih iskalnikov, uporaba filtrov, razvrščanje in preverjanje informacij …);
- ustvarjanje vsebin (ustvariti zahtevnejše digitalne vsebine v različnih formatih, npr. besedila, preglednice, slike, avdio vsebine), uporaba orodja in urejevalnikov za ustvarjanje spletnih strani, urejanje vsebin …);
- komunikacija (uporaba naprednejših funkcij za spletno komuniciranje, spletna orodja in nalaganje datotek, uporaba spletnih storitev, družbenih omrežij, spletne skupnosti …);
- reševanje problemov (uporaba digitalne tehnologije, reševanje nastalih težav, specialnih podatkovnih baz in programov …);
- varnost (zaščititi z varnostnimi programi, pravilna uporaba gesel, prepoznati neželeno elektronsko pošto, tvegane spletne strani ...).

Učenci so v srednješolskem izobraževanju v Sloveniji nad povprečjem EU pri zaupanju v digitalne kompetence:

- varnost SLO (2,94), EU (2,85);
- komunikacija SLO (3,36), EU (3,26);
- informacijska pismenost SLO (3,05), EU (3,04);
- reševanje problemov SLO (2,86), EU (2,65);
- ustvarjanje vsebin SLO (2,84), EU (2,74).

Pri pedagoških delavcih so rezultati pokazali slabše znanje glede na povprečje EU:

- varnost SLO (2,59), EU (3);
- komunikacija SLO (2,32), EU (3,05);
- informacijska pismenost SLO (2,68), EU (3,17);

- reševanje problemov SLO (2,49), EU (2,8);
- ustvarjanje vsebin SLO (2,32), EU (2,67).

Starši so izkazali visoko zaupanje v Sloveniji do poučevanja otrok za varno in odgovorno uporabo interneta (68 %), kar je višje kot v EU (52 %) [11].

4 UČENCI Z UČNIMI TEŽAVAMI IN IKT

V vzgoji in izobraževanju so z dodatnimi veščinami in specialnimi znanji učence, ki imajo učne težave, ustrezno opredelili ter strokovno določiti njihove primanjkljaje za lažje premagovanje učnih težav. Ti imajo različne vrste primanjkljajev in so posledično učno manj uspešni glede na svoje vrstnike, saj počasneje usvajajo znanja ter spretnosti pri učnih predmetih. Učne težave se pri učencih kažejo kot posledica prepleta dejavnikov, ki vplivajo na učenčevo šolsko delo: podpovprečne in mejne intelektualne sposobnosti, slabše razvite samoregulacijske sposobnosti, težave v socialno-emocionalni akomodaciji, primarni socialno-kulturno-jezikovni drugačnosti, socialni in kulturni deprivaciji oz. izoliranosti, pomanjkanju motiviranosti za delo. Učne težave vplivajo na nekatere ali mnoge vidike posameznikovega življenja (izobraževanje, delo, interakcije v družini, v socialnem okolju) ter se kažejo v različnih pogledih. Primanjkljaji se med seboj prepletajo ali so ločeni ter vplivajo na učno delo in na samo življenje [13].

Nekateri med njimi z različnimi oblikami pomoči (dopolnilni pouk, individualna in skupinska pomoč, dodatna strokovna pomoč) pridobijo možnost za premostitev svojih primanjkljajev. Z uporabo pametnih mobilnih naprav in računalnikov so otroci s posebnimi potrebami bolje motivirani za učenje, usvajanje ter pomnjenje znanja. Spletne vsebine, orodja in spletne aplikacije pri učenju digitalnih kompetenc omogočajo dinamično, nazorno, dostopnejše, multisenzorno podajanje informacij, ki so za učence zanimive in privlačne. S tem bolje procesirajo, obdelajo vsebino in njihovo pomnjenje [13].

Učitelji učencem z učnimi težavami in premajhno vključenostjo v razred nudijo oporo pri vključevanju v razredno okolje, aktivnosti, pouk ter upoštevajo njihove primanjkljaje. Med šolami prihaja do različnih spodbujanj motiviranosti učiteljev za poučevanje in motiviranosti otrok za učenje [13].

5 RAZVOJ IN UPORABA DIGITALNIH KOMPETENC PRI UČENCIH Z UČNIMI TEŽAVAMI

Digitalne kompetence se med učenci razvijajo tako v šolskem kot izvenšolskem okolju pri uporabi IKT. Še posebej so bile v zadnjih dveh letih v času dela na daljavo prisotne velike dileme in težave glede izpeljave učno-vzgojnega procesa. Komunikacija je potekala v virtualnem svetu, s tem pa so morali vsi deležniki hkrati razvijati digitalne kompetence in spretnosti. Vsakodnevno so se morali soočati z novimi izzivi glede zagotavljanja kvalitetne izvedbe pouka in ostalih učnih vsebin. Po zaprtju šol so se vzgojno-izobraževalne ustanove različno spoprijele z izvajanjem pouka na daljavo. Uporabljale so različna spletna orodja – ZOOM, Microsoft Teams, Cisco Webex, Jitsi, Skype, Vox Arnes, Youtube. Pri svojem delu so uporabljali spletno pošto, spletne učilnice ter interaktivne spletne strani. Po odprtju vzgojno-izobraževalnih ustanov se je marsikje tovrsten način dela delno ohranil kot dodatna možnost. S tem se je pridobila časovna in prostorska neomejenost dostopa do izmenjevanja informacij, boljša komunikacija, omogočil se je dostop do informacij, delitve znanja in dela z multimedijskimi orodji. S pomočjo IKT se je nudila učencu z učnimi težavami možnost prilagoditve, nazornost, postopnost, konkretizacija, utrjevanje in ponavljanje učne snovi.

Pri razvoju digitalnih kompetenc so učenci z učnimi težavami slabše opremljeni z lastnim znanjem, saj je več težav pri sledenju, razvijanju in uporabi IKT pri šolskem delu. Interaktivne vsebine morajo biti dovolj prilagojene, pravilno in smiselno sestavljene, prilagojene težavnostnim stopnjam, vsebovati morajo dovolj slikovnega gradiva ter animacij (še posebej so poučne pri možnostih ponovitve in korigiranja hitrosti) [10].

Pri delu z učenci z učnimi težavami je bilo s posameznimi spletnimi orodji, ki so vključevala animacije z učno vsebino, videoposnetke, virtualne osebe, zaznati boljše in hitrejše usvajanje znanja. Gradivo jih je bolj pritegnilo, informacije so bolje sprejeli preko različnih čutil. Didaktične spletne strani omogočajo poučevanje, utrjevanje in ponavljanje snovi učno šibkejšim učencem, da bodo snov bolje memorirali ter usvojili. S temi orodji pridobijo znanje na zanimiv in razgiban način, ki omogoča pot k samostojnemu pridobivanju iskanja informacij ter nadgraditve obstoječega znanja. Z uporabo spletnih orodij so bolje motivirani, aktivni, dinamično in zavzeto rešujejo naloge, abstraktne vsebine bolje konkretizirajo ter si jih zapomnijo. S tem je proces memoriranja podatkov, ki učencem povzroča težave in nemotiviranost, učinkovitejši ter trajnejši. Nekateri učenci so zaradi slabših tehničnih možnosti imeli omejen ali onemogočen dostop do teh vsebin in se posledično niso mogli učiti tako kot njihovi vrstniki.

Iz prakse je razvidno, da učenci med brskanjem, iskanjem in izbiranjem podatkov pogosto nekritično uporabljajo informacije, saj se ne zavedajo vseh nevarnosti. Njihovo splošno razumevanje in dojemanje je premalo zaznavno. Ne zavedajo se negativnih posledic, saj imajo poenostavljene poglede na tovrstno problematiko, slabše obdelajo ter vrednotijo podatke. S pridobljenimi informacijami slabše in površno upravljajo, ne poznajo varnostnih protokolov ter ukrepov za zaščito svojih vsebin. Pri tem so tudi žrtve izsiljevanj in spletnih prevar, saj nehote pošiljajo podatke nepreverjenim spletnim stranem ali sogovornikom na družabnih omrežjih. Pri komunikaciji na spletu in družabnih omrežjih je zaznati pomanjkljivo in neprimerno komuniciranje med učenci, kar privede do različnih oblik nasilja med deležniki. Pri pošiljanju, izmenjavi datotek in informacij se učenci premalokrat zavedajo, da so vse aktivnosti na spletu hranljive in jih je ob neprimerni vsebini težje omejiti ter zaustaviti. Zato jih je potrebno učiti, da se preko učenja digitalnih kompetenc ustvarja digitalna identiteta na spletu, ki omogoča drugim vpogled v delovanje na spletu. Učence o tem redno izobražujemo učitelji dodatne strokovne pomoči skupaj z učiteljem računalništva.

Pri pouku so učenci z učnimi težavami pri izvajanju dodatne strokovne pomoči spoznavali omenjene nevarnosti. Tako so se morali pri pouku na daljavo soočiti z spremembo okolja, drugačnim bioritmom, organizacijo dela, načinom učenja ter opravljanjem nalog s pomočjo IKT. Med urami dodatne strokovne pomoči so se učenci naučili iskati osnovne informacije v spletnih učilnicah, preko elektronske pošte in videokonferenc.

Učence smo učitelji DSP seznanili o uporabi spletnih brskalnikov, iskanju ključnih informacij, preverjanju le-teh. Pri tem smo večkrat ugotovili, da sta njihovo šibko splošno znanje in primanjkljaji težava za učinkovito in uspešno obdelovanje informacij. Zraven tega je tudi prešibko poznavanje strokovnih terminov, slabše dojemanje postopkov iskanja informacij …

Učenci z učnimi težavami so pri ustvarjanju predstavitev za govorne nastope potrebovali pomoč pri urejanju in obdelavi besedil in slikovnega gradiva (powerpoint, word, slikar, …), saj so bili postopki za dosego želenih rezultatov prezahtevni zanje. Pri nekaterih učencih je bila tudi težava pomanjkanje ustrezne računalniške in druge opreme zaradi šibkega socialnega statusa njihovih družin, nezmožnosti nudenja pomoči ostalih družinskih članov.

Prav tako se je pokazal nov izziv pri strukturiranem učenju postopkov od ustvarjanja, obdelave učnih gradiv do objavljanja končnih izdelkov v spletne učilnice, saj je bilo potrebno učencem večkrat pokazati s slikovnim materialom poti do spletnih učilnic, prijave vanje in pravilnega nalaganja datotek. Za utrjevanje uporabe in nalaganja gradiv v spletne učilnice je bilo potrebno večkrat ponoviti posamezne korake, tako da so učenci kasneje samostojno uporabljali dane pripomočke ter programe. Uporabe kompleksnejših baz podatkov omenjeni učenci samostojno niso zmogli uporabljati, saj je kompleksnost postopkov zanje prezahtevna.

Varna uporaba spleta, socialnih omrežij in aplikacij je pomembna za zdrav psihosocialni razvoj mladih. Pri uporabi varnih gesel za elektronsko pošto, pri prijavi v aplikacije, jih je bilo potrebno naučiti uporabe pametnih in varnih gesel. S tem so imeli učenci z učnimi težavami nekaj težav, kako se tega lotiti, saj je šlo za kombinacijo različnih, na videz nesmiselnih znakov. S pomočjo in nekajkratnimi ponovitvami so to osvojili.

Učenje digitalnih kompetenc je zavzemalo tudi prepoznavo nezaželene e-pošte, tveganih spletnih strani, saj so bili nekateri učenci že žrtve tovrstnih spletnih prevar. Osnovne elemente prepoznave tveganih spletnih strani so prepoznali, za bolj dovršene sumljive spletne strani pa je bilo potrebno kar nekaj ponovitev in opozoril nanje. Nekaterim so zaklenili uporabniške profile na spletnih igrah, socialnih omrežjih v zameno za plačljivo odškodnino. V veliko pomoč pri teh vsebinah je tudi spletna stran safe.si, kjer s primernimi vsebinami in informacijami omogočajo mladim prepoznavati nevarne in škodljive elemente pri uporabi spleta ter družabnih omrežij. Primerjalno gledano so bili učenci z učnimi težavami v zaostanku glede spretnosti, uporabljanja in razumevanja teh elementov digitalnih kompetenc. Kot učitelj sem namenil kar nekaj časa za usposabljanje učencev, da so dojeli osnovne principe delovanja IKT in digitalnih kompetenc. Učenci z učnimi težavami so sami spoznavali elemente digitalnih kompetenc, ampak so se pogosto ustavili pri osnovnih korakih, saj niso imeli potrebnega predhodnega znanja. S pomočjo učitelja DSP in učne pomoči so po korakih nato sistematično in s ponovitvami pridobili potrebna znanja.

Pri svojem delu je bilo opaziti, da približno petina učencev potrebuje pomoč pri osnovnem iskanju pravilnih informacij, shranjevanju le-teh, obdelave in predstavitve. Polovica učencev z učnimi težavami se je v zadnjem letu veliko naučila in dokaj samostojno obvladala pridobivanje, obdelavo ter prikaz informacij. Ostali učenci pa potrebujejo še pomoč pri naštetih elementih digitalnih kompetenc. Varna raba in zaščita gesel, digitalne identitete je na slabše osveščeno, saj učenci neredno menjavajo gesla, še vedno preveč podatkov posredujejo na sumljivih spletnih straneh ali na socialnih omrežjih. Pri tem jih spodbujamo za večjo skrb in ozaveščenost za boljšo varnost.

6 ZAKLJUČEK

Informacijsko-komunikacijska tehnologija je spremenila način dela v službah in prostem času. Tako je posegla tudi v vzgojno-izobraževalni sistem, kjer je omogočila drugačen in sodoben način učenja za učence v učnem procesu. Učenci so pridobivali nove učne vsebine, ki so jim omogočile nova spoznanja in veščine v svetu digitalnih kompetenc. Slednje bodo kasneje v življenju potrebovali in uporabljali. Učenci z učnimi težavami so v tem oziru pogosto v zaostanku v primerjavi s svojimi vrstniki, saj potrebujejo več časa za usvajanje in uporabo digitalnih kompetenc. Nemalokrat se ne zavedajo pasti in negativnih posledic pri uporabi spleta, mobilnih naprav, podajanja in sprejemanja informacij. Njihovo znanje je šibko in premalo vedo o komuniciranju, varnosti, iskanju, objavljanju informacij na spletu, o varni uporabi teh naprav. Pedagoški delavci skušamo pomagati z usmerjanjem, izobraževanjem in ustrezno komunikacijo pri učenju in uporabi omenjenih resursov. S tem se bo učencem z učnimi težavami na njim razumljiv način predstavilo abstraktne vsebine, prilagodilo spoznavanje novih vsebin z omenjenega področja ter jih opolnomočilo pri njihovi uporabi. Tako bodo tudi spoznavali varno rabo naprav in spleta, ki je pomembna pri ohranjanju zdravega načina življenja.

7 VIRI IN LITERATURA

[1] OECD. (2002). Measuring the information economy. Dostopno na naslovu http://www.oecd.org/sti/ieconomy/2771153.pdf. (26. 7. 2022).

[2] Stare, M. in Bučar. M. (2005). Učinki informacijsko-komunikacijskih tehnologij. Ljubljana: Fakulteta za družbene vede.

[3] Tondeur, J., Aesaert, K., Pynoo, B., van Braak, J., Fraeyman, N. in Erstad, O. (2016). Developing a validated instrument to measure preservice teachers' ICT competencies: Meeting the demands od the 21st century. British Journal of Educational Technology, 48(2), 462–472. Dostopno na naslovu http://onlinelibrary.wiley.com/doi/10.1111/bjet.12380/abstract (26. 7. 2022).

[4] Brečko, B. N.,Vehovar, V. (2008). Informacijsko-komunikacijska tehnologija pri poučevanju in učenju v slovenskih šolah. Ljubljana: Pedagoški inštitut.

[5] Wechtersbach, R. (2006). Digitalna kompetenca in njeno izgrajevanje. Organizacija, 41(1). Dostopno na naslovu: https://www.dlib.si/stream/URN:NBN:SI:DOC-QK8BF35D/64619a2b-798b-4117-969c-6abe861637b7/PDF (26. 7. 2022).

[6] Hanzalova, P. in Chroustova, K. (2013). Instructional software with focus on instructional games in Mathematics and Chemistry education. New challenger in education: Retrospection of history of education to the future in the interdisciplinary dialogue among didactics of various school subjects. Ružomberk: VERBUM.

[7] Lowyck, J. (2008). Foreword. V J. M. Spector idr. (ur). Handbook of Research on Educational Communications and Technology (3. izdaja). New York. v Mayer, R. (b l.). Učenje s tehnologijo. Santa Barbara v Dumont, H., Istance, D., Benavides, F. (2013). O naravi učenja: uporaba raziskav za navdih prakse. Ljubljana: Zavod za RS za šolstvo. (Elektronski vir) Dsoptono na naslovu http://www.zrss.si/pdf/o-naravi-ucenja.pdf (26. 7. 2022).

[8] O'Neil, H. F. (ur.) (2005). What Works in Distance Education: Guidelines, Information Age Publishing. Greenwich: CT. v Mayer, R. (b l.). Učenje s tehnologijo. Santa Barbara v Dumont, H., Istance, D., Benavides, F. (2013). O naravi učenja: uporaba raziskav za navdih prakse. Ljubljana: Zavod za RS za šolstvo. (Elektronski vir) Dostopno na naslovu http://www.zrss.si/pdf/o-naravi-ucenja.pdf (26. 7. 2022).

[9] Eurydice (2012). Pomembni podatki o učenju in inovacijah z IKT po šolah v Evropi 2011. Ljubljana: MIZŠ.

[10] Rugelj, J., (2007): Nove strategije pri uvajanju IKT v izobraževanje. Dostopno na naslovu https://skupnost.sio.si/sio_arhiv/sirikt/www.sirikt.si/fileadmin/sirikt/predstavitve/2007/SIRIKT_2007_JRugelj.pdf (26. 7. 2022).

[11] Zakrajšek. S. (2022). Model za oceno scenarijev za povečanjedigitalnih kompetenc dijakov v splošni gimnaziji v republiki Sloveniji. Maribor: Fakulteta za organizacijske vede.

[12] Ferrari, A. (2013). DIGCOMP: A framework for developing and understanding digital competence in Europe. European Commission: Joint Research Centre. Dostopno na naslovu http://publications.jrc.ec.europa.eu/repository/bitstream/JRC83167/lb-na26035-enn.pdf. (26. 7. 2022)
[13] Nagode, A. (ur.) (2008). Navodila za prilagojeno izvajanje programa osnovne šole z dodatno strokovno pomočjo. Primanjkljaji na posameznih področjih učenja. Ljubljana: Zavod Republike Slovenije za šolstvo.

Digitalna pismenost kot sestavni del razrednih ur v osnovni šoli

Digital Literacy as an Integral Part of Classroom Lessons in Primary School

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POVZETEK

V prispevku so predstavljeni primeri razrednih ur, pri katerih so se uporabljale digitalne tehnologije z namenom razvijanja digitalne pismenosti pri učencih osnovne šole. Po pregledu strokovne literature in priporočil na področju šolstva ostaja digitalna pismenost integrirana v celoten vzgojno-izobraževalni sistem, kar omogoča elemente digitalnega opismenjevanja integrirati v vse šolske predmete. Razredne ure ponujajo širok nabor življenjskih tem, ki prve korake v digitalno pismenost umeščajo v kontekst. S tega vidika so razredne ure lahko izhodišče za razvijanje digitalne pismenosti, saj se spletna orodja kažejo kot uporaben element pri razvijanju vseživljenjskih tem. Prav s tem namenom smo predstavili nabor sedmih tematskih sklopov razrednih ur, ki so potekale na dveh osnovnih šolah.

KLJUČNE BESEDE

Digitalna pismenost, razredne ure, spletna orodja, cilji trajnostnega razvoja

ABSTRACT

The article presents examples of classroom lessons in which digital technologies were used with the aim of developing digital literacy among primary students. After a review of the professional literature and recommendations in the field of education, digital literacy remains integrated into the entire educational system, which enables elements of digital literacy to be integrated into all school subjects. Classroom lessons offer a wide range of life topics that put the first steps in digital literacy into context. From this point of view, classroom lessons can be a starting point for developing digital literacy, as online tools prove to be a useful element in developing lifelong topics. It was for this purpose that we presented a set of seven thematic sets of classroom lessons, which took place at two elementary schools.

KEYWORDS

Digitalliteracy, class hours, online tools, sustainable development goals

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1 UVOD

Spremembe v šolskem prostoru so pogojene s stanjem v družbi. Kljub dolgoletnim prizadevanjem šol, ki so se glede na svoje finančne in intelektualne vire soočale z vzpostavitvijo digitalnega opismenjevanja, še vedno ostaja sistematično razvijanje digitalnih kompetenc prepuščeno avtonomiji vzgojno-izobraževalnih zavodov. V zadnjih dveh letih je učenje na daljavo pokazalo nove izzive in možnosti za izboljšave. Pandemija koronavirusa je digitalni prehod in preobrazbo samo še močno pospešila [1]. S šolskim letom 2021/22 vse več šol sistematično pristopa k načrtu digitalne pismenosti ob pomoči smernic in dokumentov, ki so na voljo. Izziv vsake šole je delujoča in uporabna računalniška oprema, digitalno pismen strokovni delavec in spletno učno okolje, do katerega ima vsak učenec dostop.

Digitalno opismenjevanje bi zaradi digitalnega napredka družbe sicer moralo biti kot del obveznega programa osnovne šole sistemsko urejeno, vendar v praksi kljub temu ni tako. Kljub desetletnim opozarjanjem strokovni delavci na lastno pobudo iščejo načine, kako integrirati digitalno pismenost v natrpan redni učni program. Šolska zakonodaja ne predpisuje obveznega predmeta, ki bi zajela vse učence, da bi lahko vsak šoloobvezni otrok načrtno razvijal digitalne zmožnosti, zato učitelji iščejo načine, s katerimi bi digitalno pismenost integrirali v redni del pouka. Ker pa so razredne ure ena od možnosti, v katere se da integrirati elemente digitalnega opismenjevanja in razvijanje digitalnih kompetenc, smo se na Osnovni šoli Vide Pregarc v Ljubljani in Osnovni šoli Antona Martina Slomška Vrhnika odločili izvesti razredne ure, ki bi učencem ponudile spoznavanje in uporabo digitalne opreme in spletnih orodij vzporedno z razvijanjem kritičnega mišljenja, socialno-emocionalnih veščin ter z ozaveščanjem o varni rabi spleta.

2 DIGITALNA PISMENOST V OSNOVNI ŠOLI

V dokumentih in strokovni literaturi s področja izobraževanja se največkrat pojavi besedna zveza digitalna kompetenca, ki izvira iz angleščine, vendar pa se v slovenskih učnih načrtih vse bolj

uveljavlja termin digitalna zmožnost [2]. Je zgolj ena od osmih temeljnih zmožnosti, ki zagotavljajo odraslim dovolj orodij za učinkovito spopadanje z novimi izzivi, omogočajo praktično in čustveno oporo, so pomembne za posameznika in skupnost [3], vendar digitalna zmožnost vstopa v vse ostale zmožnosti in se z njimi prepleta.

Z revidirano konceptualizacijo ključnih kompetenc leta 2018 so se področja kompetenc preimenovala in preoblikovala, tako da smo v strokovni literaturi po letu 2018 prepoznali digitalno kompetenco kot sestavni del digitalne pismenosti [3]. Ta obsega nabor znanj, spretnosti in vedenj, kar omogoča posamezniku, da uporablja in deluje v digitalnem svetu, obenem pa digitalna pismenost omogoča varno in kritično uporabo tehnologij informacijske družbe na različnih področjih [3].

Digitalno pismen učenec naj bi v prvi vrsti poznal digitalne aparate in pripomočke in jih tudi uporabljal, tekom šolanja naj bi spoznal spletna orodja in pridobil znanja in spretnosti, s katerimi bi lahko brez težav opravljal svoje vsakodnevne potrebe. Z uporabo digitalne tehnologije bi tako učenec poiskal in upravljal različne informacije ter razvil strategije za doseganje ciljev. Tem splošnim smernicam pa se priključuje še kritično razmišljanje, zakonitosti digitalno-socialnega okolja ter varna raba interneta. Digitalna pismenost tako zajema zelo raznolik nabor vsebin in veščin, ki bi jih učenec ob zaključku osnovne šole moral poznati oz. obvladati. Pri tem je potrebno poudariti, da je tako kot pri vseh didaktikah posameznih predmetov, tudi pri digitalnem opismenjevanju smiselno izhajati iz razvojne stopnje otrok ter utrjevati in nadgrajevati digitalna znanja in spretnosti. Program osnovne šole sicer ponuja računalništvo kot neobvezni in obvezni izbirni predmet, vendar kot tak omogoča razvoj digitalne pismenosti le skupini učencev, ki si je ta predmet izbrala. Ker je od avtonomije učitelja odvisno, koliko in kaj bo v svoj redni pouk vnašal s področja digitalnega opismenjevanja, so razlike med šolami lahko zelo velike.

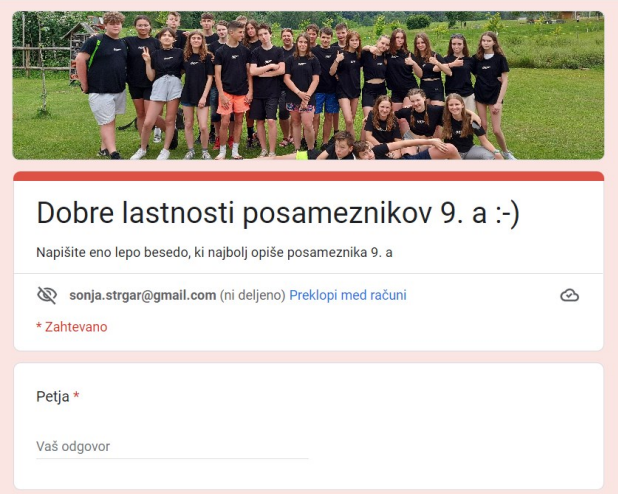
Razredne ure se v osnovni šoli izvajajo od četrtega do devetega razreda enkrat tedensko, včasih pa tudi po potrebi. Za učence prvega vzgojno-izobraževalnega obdobja so razredne ure sestavni del pouka, saj so vsebine integrirane v več predmetov, najbolj pa sovpadajo s spoznavanjem okolja. Ker se vsebine razrednih ur za učence od četrtega do devetega razreda dotikajo razredne klime, odnosov v razredu in pravil življenja v skupnosti, so s svojim širokim naborom priložnost za povezovanje z digitalnim opismenjevanjem, saj spletna orodja, komunikacijske spretnosti in digitalna tehnologija dobijo vseživljenjski okvir.

3 TEMATSKE RAZREDNE URE IN DIGITALNA PISMENOST V PRAKSI

3.1 Uporabnost spletnih anket

Razrednik velikokrat učence vpraša za mnenje, saj s tem ustvarja boljšo razredno klimo. Eden od načinov za pridobitev mnenja učencev so spletne ankete. V prikazanih primerih je spletne ankete izdelal razrednik, učenci so ankete le izpolnjevali. Prijave niso bile potrebne, saj so bile ankete anonimne ali pa so vpisali ime in priimek v anketo. Primeri spletnih anket med razrednimi urami:

- Spihalnik- Anketa je anonimna in ima eno samo trditev: »Kok je to bedno …«. Učenci zapišejo, kar jih v šoli moti ali pa kakšen problem, o katerem se nato pogovorimo na razredni uri.
- Dobre lastnosti posameznikov v razredu - Anketa je anonimna, učenci za vsakega sošolca zapišejo eno dobro lastnost (slika1). Anketo lahko razrednik uporabi za izdelavo srčkov v WordArt-u, ki jih podari učencem (slika 2) ob zaključku šolskega leta ali pa jih natisne in obesi v učilnico na vidno mesto, kar pripomore k vzdrževanju dobrih odnosov in povezanosti v oddelku.



Slika 1: Primer spletne ankete

Slika 2: Primer srčka v WordArt-u

- Ena od tem razrednih ur v tretjem vzgojno-izobraževalnem obdobju je obravnavanje spletnega nasilja. Razrednik učencem pripravi spletno anketo, kjer učenci najprej zapišejo ime in priimek, nato pa odgovorijo na vprašanja, ali vedo kaj je spletno nasilje, če so ga že doživeli ali pa izvajali nad drugimi. Na podlagi ankete se potem v razredu naredi razprava, kjer poiščemo rešitve in nasvete za preprečevanje spletnega

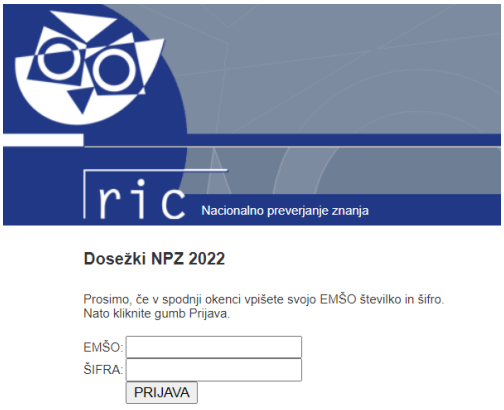
nasilja. Pomembno je, da učenci spregovorijo o svojih izkušnjah in poiščejo pomoč.

- Pri razredni uri smo ankete uporabili tudi pri debati o mobilnih napravah in zasvojenosti z njimi. Anketa je bila anonimna, zanimalo nas je, katere pametne naprave uporabljajo in za kakšen namen (šola ali za zabavo) ter katere pametne naprave bi lahko prinesli v šolo za potrebe pouka. Na podlagi analize ankete smo nato na razredni uri razvili debato o zasvojenosti z digitalnimi napravami in s socialnimi omrežji, ki smo si jih ogledali še v praksi in se pogovorili o nastavitvah profila ter o objavah video in slikovnih materialov.
- Primer spletne ankete, ki se zelo dobro odnese v praksi je tudi anonimna anketa z enim nedokončanim stavkom »Želim, da bi učiteljica vedela …«. Odgovor na vprašanje je lahko poljubno dolg, navadno pa učenci ali kaj pohvalijo ali pa napišejo težave, ki jih pestijo ali pa teme, ki jih zanimajo. Pri razredni uri se nato naredi analiza in odgovorimo na vsa vprašanja, ki so bila v anketi. Analiza anonimnih odgovorov daje razredniku možnost za vpogled v razredno klimo, odnose med učenci ter morebitne stiske in izzive, s katerimi se soočajo.

Spletne ankete se navadno rešujejo pri razredni uri. Razrednik rezervira računalniško učilnico, kjer učenci delajo na računalnikih, ali pa se dogovori z učenci, da razrednik učencem posreduje naslov spletne ankete in jo učenci rešijo doma, kar navadno rešujejo na pametnih telefonih ali tablicah. Spletne ankete ponujajo širok nabor vsebin, ki omogočajo anonimnost in so lahko zelo dobro izhodišče za obravnavo tem, ki učence zanimajo.

3.2 Vpogled v rezultate NPZ

Digitalno znanje razvijamo tudi pri vpogledih v rezultate nacionalnega preverjanja znanja za učence šestega in devetega razreda. Razrednik je prisoten pri predmetu, ki ga poučuje. Z učenci najprej odpre spletno stran https://npz.ric.si/ (slika 3), nato pomaga pri prijavi učencev, kjer se vpiše šifro in emšo. Sledi vpogled v rezultate posameznikov, nato pa razlaga točk pri posameznih nalogah. V kolikor je potrebno, se zapiše tudi ugovor na število točk.



Slika 3: Vpogled v NPZ

Učenci se zavedajo, da vse več administrativnih del poteka preko spleta. Postopki vpisa in prijav na različnih spletnih straneh potekajo na podoben način, zato se na razrednih urah od četrtega razreda dalje učenci preizkušajo v ustvarjanju računov in prijavah v razne spletne strani založb ali pa v Discord in Zoom, ki ga uporabljajo za potrebe učenja na daljavo.

3.3 Svetovni dan otrok

Razrednik lahko svoj oddelek vključi v projekt Svetovni dan otrok, ki ga izvaja Unicef. Svetovni dan otroka, 20. novembra, je dan, ko države podpisnice Konvencije o otrokovih pravicah obnovijo zavezo za uresničevanje otrokovih pravic. Opisani primer je bil izveden na daljavo, kjer smo preko Microsoft Teams-ov sodelovali v omenjenem projektu. Z učenci osmega razreda smo se naučili uporabljati omenjeno okolje ter se aktivno vključili v debato. Po dogodku so učenci napisali prispevek za šolsko spletno stran. Učenci so zapisali besedilo in priložili slike, ki so jih sami posneli (slikanje zaslona). Nato je razrednik prispevek objavil na šolski spletni strani (slika 4).

Ker smo letos v nekoliko drugačnih razmerah, smo se 20. novembra na Svetovni dan otrok udeležili dogodka preko aplikacije Microsoft Teams. V dogodku smo sodelovali otroci, podjetja in mediji, vse prisotne pa je nagovoril predsednik RS, g. Borut Pahor. Slogan letošnjega svetovnega dneva je **Vključite me, sem ključ do rešitve**. Na dogodku smo skupaj usmerili pozornost na otroke. Ker je dan otroka potekal v znamenju modre, smo vsi imeli modra ozadja in bili smo oblečeni v modra oblačila. Zakaj? Ker je modro, da podpiramo otroke. Ker je modro, da otroke postavljamo v središče naših sprememb. Ker je modro, da sledimo dobrim zgledom. Ker je modro, da razmišljamo o prihodnosti. Ker naš moder planet potrebuje, da postopamo modro.

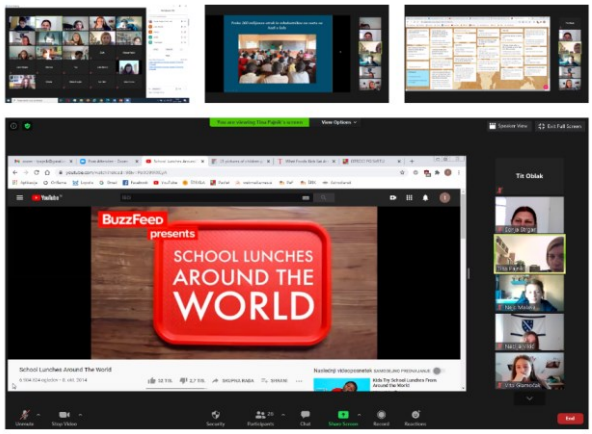
Zapisala Petja Bricelj, 8. a

Slika 4: Primer objave na šolski spletni strani

Sooblikovanje šolske spletne strani je ena od digitalnih zmožnosti, ki zahteva ne samo poznavanje in uporabo spletnih orodij, ampak tudi tvorbo besedila v določenem formatu, njegovo oblikovanje in vstavljanje slikovnega materiala v besedilo. Obenem avtor prispevka nosi odgovornost za soustvarjanje šolske podobe v spletnem prostoru, kar je tudi ena od vzgojnih komponent, ki jih želimo privzgojiti.

3.4 Otroci po svetu in izzivi mladostništva

V osmem razredu smo izvedli tematsko razredno uro z naslovom Otroci po svetu. S pomočjo orodja Zoom smo izvedli videokonferenčno razredno uro, saj so bili učenci OŠ Antona Martina Slomška Vrhnika napoteni v karanteno in so delali od doma. Predavala je učiteljica Tina Pajnik z OŠ Vide Pregarc. Pogovarjali smo se o vrednotah hrane, vode in doma, ter o različni šolski prehrani po svetu. Učiteljica je pokazala tudi, kakšne igre imajo v različnih celinah oz. državah, kako se razlikujejo in npr. v Indiji si otroci iz odpadnih stvari naredijo vozičke in se potem spuščajo ali pa se poganjajo. Pogovarjali smo se tudi, kaj nam pomeni dom in, da to ni samo dom, ampak tudi družina. Učenci so debatirali o tem, kaj je pomembno, ko se preseliš v drugo državo. Rešili so anketo v Padlet-u na temo, kaj pomeni dom in kaj je pomembno pri vključevanju v novo okolje (slika 5).



Slika 5: Primer videokonferenčne razredne ure

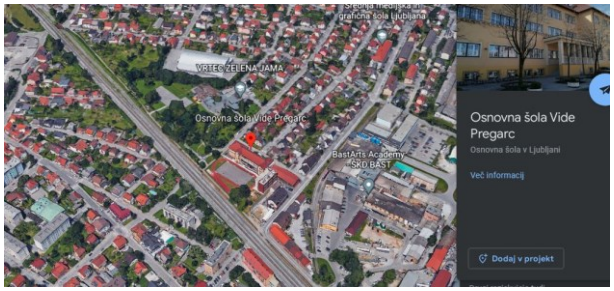
Padlet so učenci sedmih in osmih razredov uporabili tudi na razredni uri, ki se je izvajala na temo zasvojenosti in drugih izzivih mladostništva. Razredna ura je potekala v računalniški učilnici, kjer so raziskovali oblike zasvojenosti. Vsak učenec je izdelal kratek povzetek o poljubni zasvojenosti, nato pa ustvaril svoj zavihek v Padlet okolju (slika 6).

Slika 6: Izdelava razrednega Padleta

Pri delu so učenci uporabljali računalnik za iskanje podatkov, za shranjevanje predstavitve v določenem formatu, za izmenjavo informacij in sporazumevanje ter sodelovanje v skupnem omrežju. Ob koncu razredne ure so poročali o svojih ugotovitvah, nato pa skupaj z razrednikom naredili povzetek.

3.5 Varna pot v šolo

Učenci četrtega razreda so na začetku šolskega leta spoznali publikacijo s pravili šolskega reda, vzgojnim načrtom in načrt varne poti v šolo. Razredna ura je potekala tako, da so učenci najprej spoznali tiskano publikacijo, nato pa vse dokumente poiskali na šolski spletni strani. Pri tem so se učili poiskati določene informacije na šolski spletni strani, raziskali so posamezne zavihke in poiskali določene informacije kot npr. jedilnik, seznam šolskih potrebščin, urnik šolske knjižnice. Dalje so v Google Earth poiskali OŠ Vide Pregarc v Ljubljani in si ogledali okolico (slika 7).



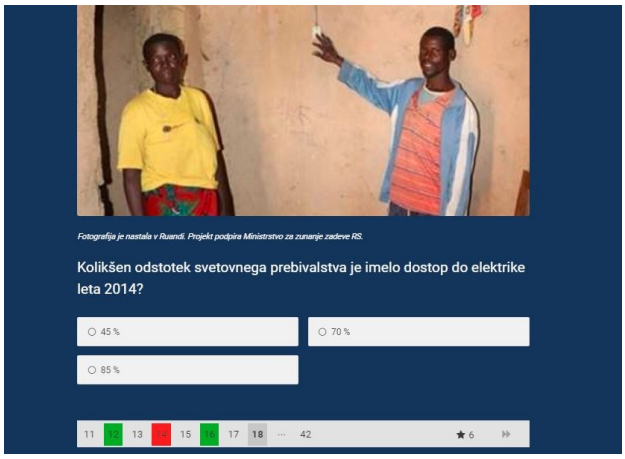
Slika 7: Pregled poti v šolski okolici

Ponovili so znanje o orientaciji in nato na projiciran zemljevid na beli tabli narisali pot, po kateri gredo v šolo. Označili so točke na zemljevidu, ki so se jim zdele nevarne ali nepregledne. Dobljen razredni zemljevid so nato primerjali z načrtom varnih poti in ugotovili, da ima veliko skupnih značilnosti, saj so učenci prepoznali nevarne odseke ali nepregledne prometne poti. Ob koncu razredne ure so pripovedovali o svojih izkušnjah z zemljevidi oz. z navigacijo. Preizkusili so se v iskanju lokacije znotraj meja države ter poiskali razdalje med Ljubljano in drugimi mesti. Podobno razredno uro je smiselno ponoviti v petem razredu, ko se učenci pripravljajo na kolesarski izpit.

3.6 Cilji trajnostnega razvoja

Učenci šestih razredov so izvedli razredno uro na temo ciljev trajnostnega razvoja v računalniški učilnici. Zaradi velikega števila učencev tujcev v oddelku je bilo potrebno spregovoriti o kulturnih raznolikostih, strpnosti, migracijah in večjezičnih okoljih.

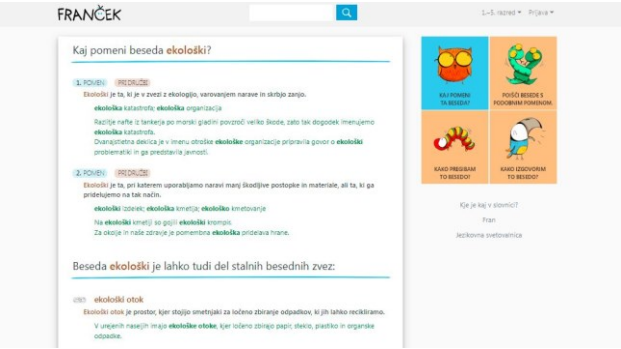
Najprej so šestošolci v Padlet-u napisali na lističe, kaj si želijo. Nastal je nabor želja, pri katerem se je lahko avtor oglasil in kaj dodal ali pojasnil, ali pa je ostal anonimen. Nato smo želje na lističih razvrstili v dve skupini, in sicer v materialno in nematerialno. Pod materialno so učenci oblikovali dve skupini: (elektronske) igrače in hišni ljubljenčki. Pri nematerialnem pa so tudi prepoznali dve obliki želja: dosežki in osnovne človekove potrebe. Posebej sta namreč izstopali dve želji, »varnost« in »da ne bi bilo več vojn«, ki sta sprožili čustven odziv sošolcev, da so začeli spreminjati svoje želje. S pomočjo spletnih strani Projekta MIND (https://www.karitas.si/projekt-mind-migracije-povezanost-razvoj/) in Ciljev trajnostnega razvoja Združenih narodov (https://unis.unvienna.org/unis/sl/topics/sustainable_development_goals.htm) so šestošolci spoznavali težave in izzive, s katerimi se sooča tako Slovenija kot preostali del sveta. Ob zaključku ure so se učenci pomerili v spletnem kvizu (slika 8), ki je prosto dostopen na naslovu https://take.quiz-maker.com/QU1WXA0X. Kviz s sedemnajstimi vprašanji je prosto dostopen, saj je bil del nagradne igre, ki je potekala leta 2021, a je še vedno dobro orodje za preverjanje, saj se pravilni odgovori beležijo in podajajo utemeljitve odgovorov.



Slika 8: Primer reševanja kviza

3.7 Ekološke vsebine

Učenci četrtih razredov so izvedli razredno uro na daljavo in se povezali s šolsko knjižničarko, saj so se vsebine ure nanašale na ekologijo. Najprej so po navodilih razredničarke vstopili v spletno učilnico Knjižnica ter poiskali nabor prosto dostopnih spletnih besedil z ekološko vsebino. Izbrali so tri besedila in jih prebrali. O prebranem so imeli možnost poročati preko Zooma na dveh terminih, po povratku v šolske klopi pa so četrtošolci opravili še dve nalogi v šolski knjižnici. Prva naloga je bila v spletnem slovarju Franček poiskati določen pojem, ki ga je knjižničarka pripravila na lističu (slika 9). Delo s tiskanimi in spletnimi slovarji je obenem tudi cilj knjižnično-informacijskega znanja, kjer mladi bralci spoznavajo referenčno zbirko.



Slika 9: Primer iskanja pomena besede ekološki

Druga naloga je bila reševanje spletnega kviza Velika Grinijeva pustolovščina (slika 10), ki je dostopen na naslovu https://www.grini.si/igralnica/velika-grinijeva-pustolovscina. Z reševanjem kviza so učenci preverili svoje znanje o razvrščanju odpadkov, načine varčevanja z energijo, uporabi ekoloških otokov ter zbirnih centrov.

Slika 10: Primer reševanja spletnega kviza na temo ekologije

4 ZAKLJUČEK

Prikazani primeri iz prakse potrjujejo, da se proces digitalnega opismenjevanja lahko načrtno izvaja v celotnem oddelku pri razrednih urah. Ker so razredne ure zasnovane z življenjskimi tematikami, učitelj razrednik lahko posega po različnih spletnih orodjih, ki jih integrira v vsebine. Učenci lažje sodelujejo in spoznavajo uporabnost spletnih orodjih, če se le-ta uporabljajo v nekem življenjskem kontekstu.

Da bi pridobili povratne informacije, so udeleženci rešili kratko spletno anketo (slika 11), v kateri so izrazili svoje mnenje, pripombe in pobude na izpeljane učne ure.

Slika 11: Primer reševanja spletne ankete

Anketa je za učence vsebovala tri preprosta vprašanja. Na vprašanje, kaj bi pohvalili pri izvedenih razrednih urah, smo pri četrtošolcih dobili odgovore, ki smo jih razvrstili v dve skupini. 92 % učencev je odgovorilo, da jim je pri razrednih urah bila najbolj všeč uporaba računalnikov, aplikacij in spletnih strani. Med omenjenimi spletnimi aplikacijami je bila v 90 % največkrat omenjena aplikacija Google Earth, ki so jo učenci imeli najraje. Ostalih 8 % je pohvalilo izbrane tematske sklope (ekologija in trajnostni razvoj). Odgovori na vprašanje, kaj bi pri izvedenih razrednih urah spremenili, so bili zelo enolični. Kar 98 % pravi, da sicer ne bi ničesar spreminjali, bi si pa želeli več takšnih ur, kjer se uporablja digitalna orodja. 76 % jih je učiteljici sporočilo, da si želijo sodelovanja in uporabo digitalnih orodij tudi v prihodnjem šolskem letu, od tega jih 90 % predlaga, da bi se podobne ure izvajale tudi pri drugih predmetih.

Prav vsi učenci od 6. do 9. razreda so ob koncu izpeljanih razrednih ur pohvalili spletne ankete. Zapisali so, da jim je velikokrat mnogo lažje stvari zapisati kot povedati, še posebej, če je anketa anonimna. Posebej so pohvalili spletno anketo Spihalnik, saj so imeli občutek, da lahko povedo prav vse, kar jih moti, pa si v živo ne upajo povedati na glas. Vsi učenci so bili navdušeni nad spletno anketo Dobre lastnosti posameznikov, saj jim zelo veliko pomeni izdelan srček z njihovimi dobrimi lastnostmi. Zapisali so, da ga bodo shranili na posebno mesto. 96 % učencev je pohvalilo delo v Padletu, saj zelo radi ustvarjajo skupaj z ostalimi učenci enoten plakat. Poudarili so, da so jim bile všeč izbrane teme. Kot pomanjkljivost so zapisali, da so nekateri sošolci počasni in jih je potrebno čakati. 100 % učencev si želi, da bi več učiteljev večkrat letno imelo anonimno anketo Želim, da bi učiteljica vedela … To se učencem zdi dobra priložnost, da poveš, kar ne moreš v razredu pred ostalimi. Vpogled v NPZ jim po večini (53 %) ni bil zanimiv, so se pa vsi strinjali, da je nujen, če želijo videti svoje izdelke NPZ. Pri izvedbi Svetovnega dne otroka so pohvalili predvsem udeležbo predsednika RS Boruta Pahorja. Pri predavanju Otroci po svetu pa je vseh 100 % poudarilo, da jim je bilo všeč, ker je bila izvajalka delavnice oseba, ki je bila izredno energična. Splošno za vse razredne ure, ki so bile izvedene na tak način, pa so učenci zapisali, da jim je bilo všeč predvsem delo po skupinah, sodelovanje med vsemi deležniki. Vseh 100 % si želi še več razrednih ur izpeljanih na tak način.

Za učence je bila že sama uporaba digitalne opreme motivacija za delo, poleg tega pa so imeli možnost sodelovanja, (so)ustvarjanja, anonimnosti in varnosti. Ker so v razredne ure bili vključeni vsi učenci v oddelku, so res imeli vsi možnost prispevati svoje ideje in uporabljati spletna orodja v skladu s svojo stopnjo digitalne pismenosti. Razrednik je lahko vsebine in navodila diferenciral ter ponudil boljšim učencem zahtevnejše naloge, poleg tega so dejavnosti bile zasnovane tako, da so vključevale vse otroke – od učencev s posebnimi potrebami do učencev tujcev. Izbrani tematski sklopi so bili življenjski in blizu učencem, niti ni bilo potrebno imeti predznanja, kar je omogočilo večji dvig aktivnosti kot pri rednih urah. Povratna informacija učencev ne glede na starost vedno znova sporoča, da si želijo več dinamike, aktivnega vključevanja in uporabe digitalnih orodij. Poleg tega izpostavljajo tudi to, da želijo biti slišani, kar je pomemben element pri oblikovanju varnega učnega okolja.

LITERATURA IN VIRI

[1] Vesna Lešnik Štefotič, 2021. Digitalne kompetence – stanje in prihodnost. Mednarodno inovativno poslovanje = JournalofInnovative Business and Management, 13(1). 79-88. Dostopno na naslovu https://www.dlib.si/stream/URN:NBN:SI:DOC-IR8SEUYR/0d0c7541-a8c0-4f1c-85df-4bcc188606b9/PDF(1.8.2022)

[2] e-šolstvo: Pot do e-kompetenstnosti. Dostopno na naslovu https://projekt.sio.si/wp-content/uploads/sites/8/2015/01/E-solstvo_pot_do_e-kompet_BILTEN_2012_final_web_pot_do_ekomp.pdf (1.8.2022)

[3] Petra Javrh (Ur.). 2018. Digitalna pismenost. Andragoški center Slovenije. Dostopno na naslovu https://www.dlib.si/stream/URN:NBN:SI:DOC-NKZPZO9Q/80497777-6718-41ff-99a2-b186288f388f/PDF (1.8.2022)

Pandemija COVID-19 in digitalne kompetence študentov

COVID-19 Pandemic and Digital Competencies of Students

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POVZETEK

Digitalne kompetence so v 21. stoletju ključne, saj omogočajo varno in učinkovito uporabo informacijske tehnologije pri delu in v prostem času. Digitalne kompetence so se v času pandemije Covid-19 izkazale za pomembne tudi v visokem šolstvu. Zaradi razmer je študij potekal na daljavo, zato so si morali študenti zagotoviti ustrezno delovno okolje, da so se lahko vključili v pedagoški proces na daljavo. Na podlagi rezultatov raziskave ugotavljamo, da imajo anketirani slovenski študenti dokaj visok nivo osnovnih digitalnih kompetenc in da so si v času pandemije COVID-19 le nekoliko izboljšali že obstoječe digitalne kompetence.

KLJUČNE BESEDE

Digitalne kompetence, študij na daljavo, študenti, COVID-19

ABSTRACT

In the 21st century digital competencies became crucial as they enable effective use of information technology at work and in leisure time. During the COVID-19 pandemic digital competencies have also proved to be essential in higher education. Due to the circumstances, distance learning was established and the students had to ensure an appropriate working environment in order to be able to participate in the pedagogical process. Based on the results from our survey we can conclude that Slovenian students who respond to the survey have a fairly high level of basic digital competencies and that they only slightly improved their existing digital competencies during the COVID-19 pandemic.

KEYWORDS

Digital competencies, distance learning, students, COVID-19

1 UVOD

Izsledki raziskav zadnjih let poudarjajo pomembnost razvoja digitalnih kompetenc [1]. Pandemija COVID-19 je tako mišljenje še dodatno okrepila [2]. Pandemija COVID-19 ni vplivala le na vsakdanje življenje, ampak tudi na izobraževalne sisteme po vsem svetu. Izobraževalne ustanove so bile primorane čez noč vzpostaviti ali nadgraditi izobraževanje na daljavo, kar je predstavljalo velik izziv za visoko šolstvo [3]. Med drugim so si morali študenti zagotoviti ustrezno delovno okolje, da so se lahko vključili v pedagoški proces na daljavo. Pri tem so bili zaznani različni nivoji digitalnih kompetenc, saj nekateri študenti pri vzpostavitvi delovnega okolja za študij na daljavo niso imeli težav, drugim pa je to predstavljalo velik izziv.

Digitalne kompetence lahko merimo s pomočjo evropskega okvira digitalnih kompetenc za državljane (DigComp 2.1), ki je primeren za uporabo v različnih sektorjih in disciplinah [4]. Okvir DigComp 2.1 sestavlja pet sklopov oz. glavnih področij kompetenc: informacijska pismenost, komuniciranje in sodelovanje, izdelovanje digitalnih vsebin, varnost in reševanje problemov. Vsak sklop sestavlja 3 do 6 kompetenc (skupaj 21), za vsako od teh kompetenc je opredeljenih 8 ravni doseganja kompetenc. Te ravni so povezan z Bloomovo taksonomijo učnih dosežkov. Obstajajo tudi drugi okvirji merjenja digitalnih kompetenc, npr. globalni okvir digitalne pismenosti (Digital Literacy Global Framework ali krajše DLGF) in Avstralski model okvirja temeljnih veščin (Australian Core Skills Fremework ali krajše ACSF). DLGF je nadgradnja okvirja kompetenc DigComp 2.0 [5], medtem ko ACSF digitalno pismenost v svoj model uvršča kot šesto veščino, ki poleg učenja, branja, pisanja, ustne komunikacije in računanja, igra pomembno vlogo za posameznikovo vključevanje v družbo in delo [6].

Mnogi (npr. [7]–[9]) izpostavljajo, da je imela pandemija COVID-19 velik vpliv na študij, vendar je malo znanega ali je posledično vplivala tudi na razvoj digitalnih kompetenc, zato nas je zanimalo: (1) kakšen so trenutne digitalne kompetenc študentov v Sloveniji, ter (2) mnenje študentov glede vpliva pandemije COVID-19 na razvoj digitalnih kompetenc. Da bi odgovorili na zgoraj zastavljeni vprašanji, smo med slovenskimi študenti v zadnji četrtini leta 2021 izvedli raziskavo.

2 METODOLOŠKI PRISTOP

Ker smo želeli raziskati digitalne kompetence študentov in njihovo mnenje o vplivu pandemije COVID-19 na razvoj digitalnih kompetenc, smo se odločili, da izvedemo kvantitativno raziskavo. Pri pripravi vprašalnika smo izhajali iz DigComp 2.1 okvira. Za vsak sklop kompetenc smo pripravili pet trditev, ki

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smo jih nekoliko prilagodili in dopolnili skladno z razvojem informacijske in komunikacijske tehnologije. Uporabili smo 5-stopenjsko lestvico Likertovega tipa. Dodali smo vprašanja s katerimi smo želeli pridobiti mnenja o vplivu pandemije COVID-19 na študij ter nekaj demografskih vprašanj. Za lažje zbiranje podatkov smo vprašalnik pripravili s pomočjo orodja za spletno anketiranje 1KA-i [10].

Da bi dosegli čim več slovenskih študentov, ki dobro predstavljajo populacijo, smo anketo delili s pomočjo spletnih omrežjih (Facebook in Instagram), s pomočjo elektronske pošte in z objavo ankete na forumu. Uporabili smo tudi metodo snežne kepe [11], kar pomeni, da smo naslovnike prosili, da anketo delijo naprej med svoje prijatelje in znance.

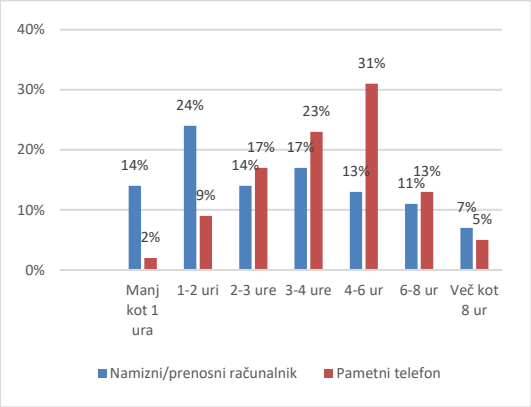
Mnenja smo zbirali dober mesec in prejeli skupaj 81 v celoti izpolnjenih anket. Slabši odzivnosti anketirancev pripisujem kompleksnosti vprašalnika. Za namen tega prispevka smo podatke izvozili in jih analizirali s pomočjo programa Microsoft Excel.

3 REZULTATI

V raziskavi je sodelovalo 63 % žensk in 37 % moških. 19 % je mlajših od 20 let, največ (47 %) je starih med 21 in 23 let, 11 % med 24 in 26 let, le 5 % je starih več kot 26 let. Več kot polovico (51 %) obiskuje Univerzo v Ljubljani, 31 % obiskuje Univerzo v Mariboru, 7 % obiskuje Univerzo na Primorske, sledita Nova univerza in Univerza v Novi Gorici. Med njimi je 67 % dodiplomskih in 33 % podiplomskih študentov. Večin jih je vpisana na redni študij (86 %), manjši delež (14 %) na izredni študij.

3.1 Uporaba informacijske in komunikacijske tehnologije

Študenti dnevno uporabljajo informacijsko in komunikacijsko tehnologijo (IKT). 94 % uporablja pametni telefon, 91 % namizni oz. prenosni računalnik in 18 % tablični računalnik. Če bolj natančno pogledamo uporabo pametnega telefona in namiznega oz. prenosnega računalnika (Slika), lahko vidimo, da kar 68 % študentov uporablja mobilni telefon več kot tri ure, medtem ko namizni oz. prenosni računalnik več kot tri ure uporablja le 48 % študentov. 92 % jih ima širokopasovno internetno povezavo.



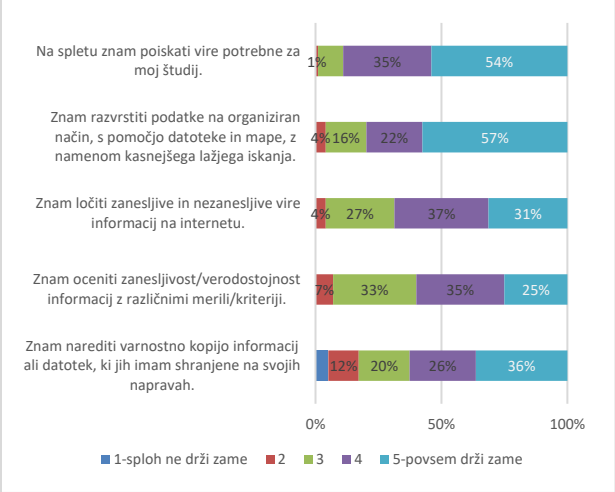
Slika 1: Uporaba računalnika in pametnega telefona po urah

Kljub dokaj dobremu nivoju opremljenosti z IKT, pa 21 % študentov ni imelo na voljo ustrezne strojne in programske opreme za potrebe študija na daljavo. Kar se tiče orodja preko katerih so spremljali predavanja in vaje, so največ uporabljali Zoom (52 %), sledil je MS Teams (42 %), 1 % jih je uporabljajo Skype, med drugimi orodji (5 %) po omenjajo BigBlueButton in Google Meet.

3.2 Digitalne kompetence

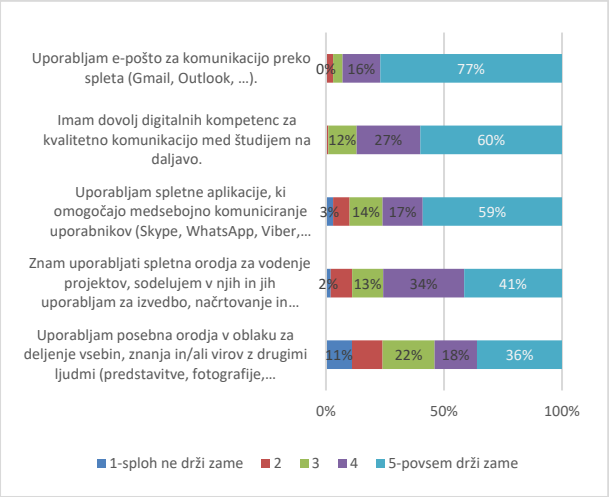
Rezultati bodo predstavljeni ločeno, po posameznih sklopih digitalnih kompetenc: informacijska pismenost, komuniciranje in sodelovanje, izdelovanje digitalnih vsebin, varnost in reševanje tehničnih težav.

Informacijska pismenost razumemo kot zmožnost, da posameznik zna brskati, iskati in filtrirati informacije, ocenjevati informacije ter shranjevati in obdelati informacije [4]. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo s trditvama, da znajo poiskati informacije za študij in jih ustrezno organizirati z namenom kasnejšega lažjega iskanja, medtem ko se najmanj strinjajo s trditvijo, da znajo narediti varnostno kopijo informacij ali datotek, ki jih imajo shranjene na svojih napravah. Manj se strinjajo tudi s trditvama, ki sta vezani na oceno zanesljivosti informacij na internetu.



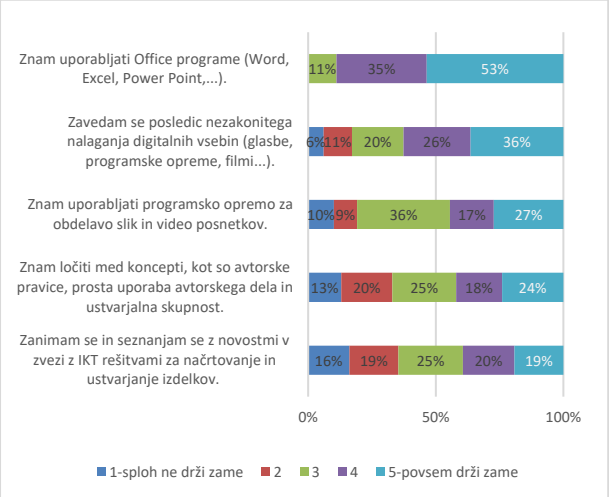
Slika 2: Samoocena kompetenc na področju informacijske pismenosti

Komuniciranje in sodelovanje razumemo kot zmožnost, da se posameznik zna sporazumevati in sodelovati z uporabo digitalne tehnologije, pozna spletni bonton in zna upravljati z digitalno identiteto [4]. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo, da znajo uporabljati e-pošto in druga orodja za kvalitetno komunikacijo, medem ko so manj vešči pri uporabi spletnih orodij za vodenje projektov in deljenje vsebin, znanja in/ali virov z drugimi ljudmi.



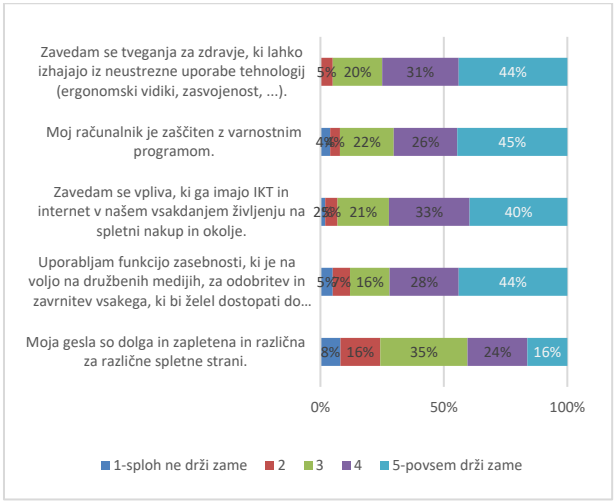
Slika 3: Samoocena kompetenc na področju komunikacije in sodelovanja

Izdelovanje digitalnih vsebin razumemo kot zmožnost, da posameznik zna razviti, umeščati in poustvariti digitalne vsebine, spoštuje avtorske pravice in licence ter zna programirati [4]. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo s trditvami, da znajo uporabljati Office programa, se zavedajo posledic nezakonitega nalaganja digitalnih vsebin in znajo obdelati slike in video posnetke, medem ko imajo več težave pri ločevanju konceptov vezanih na avtorske pravice in licence. Najmanj pa se strinjajo s trditvijo, za jih zanima in so seznanjeni z novostmi v zvezi z IKT rešitvami za načrtovanje in ustvarjanje izdelkov.



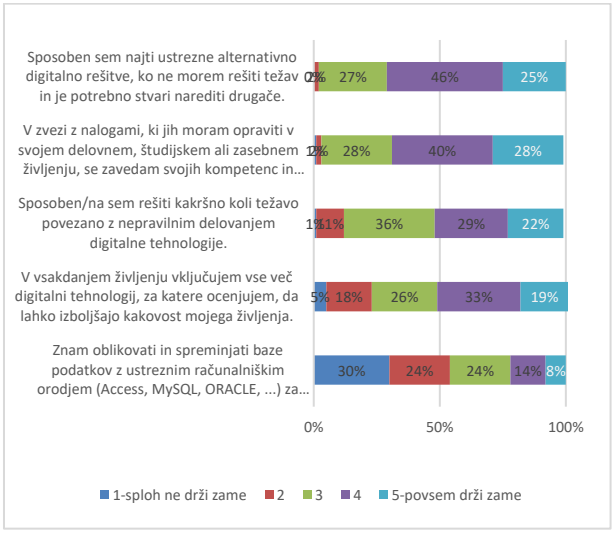
Slika 4: Samoocena kompetenc na področju izdelovanja digitalnih vsebin

Varnost razumemo kot zmožnost, da posameznik zna zaščititi svoje naprave in osebne podatke ter se zaveda vpliva digitalne tehnologije na zdravje in dobro počutje ter okolje [4]. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo s trditvami, da se zavedajo vpliva digitalne tehnologije na zdravjem vsakdanje življenje in okolje ter imajo računalnik zaščiten z varnostnim programom. Mnogi tudi uporabljajo funkcijo zasebnosti, ki je na voljo na družbenih medijih, medtem ko v manjši meri uporabljajo dolga in zapletena gesla za dostop do različnih spletnih strani.



Slika 5: Samoocena kompetenc na področju varnosti

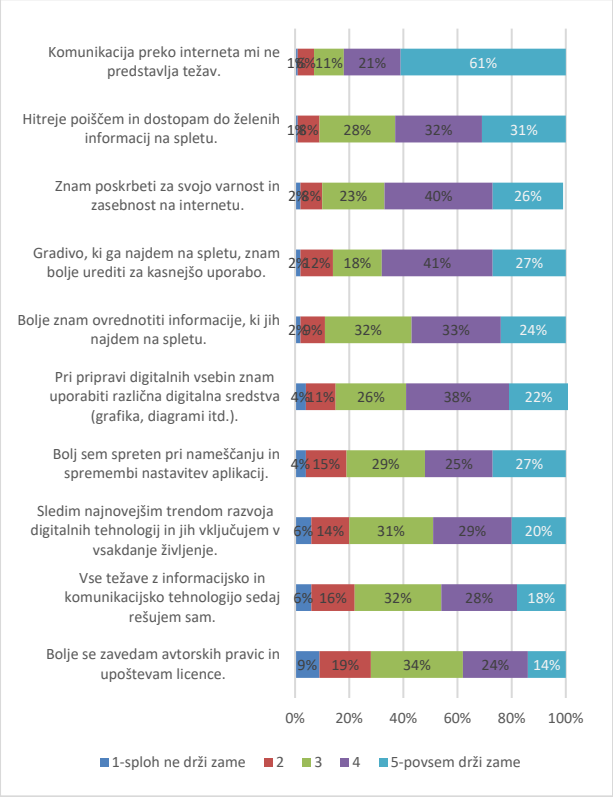
Reševanje problemov razumemo kot zmožnost, da posameznik zna rešiti tehnične probleme, poiskati najustreznejše rešitve glede na potrebe, uporabiti tehnologijo na inovativen in kreativen način ter identificirati manjkajoča digitalna znanja [4]. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo s trditvama, da so sposobni najti ustrezne alternativne digitalne rešitve, ko je potrebno rešiti težave drugače in se zavedajo svojih kompetenc in morebitnih pomanjkljivosti na digitalnem področju. Manj pa se strinjajo s trditvama, da znajo delati z bazami podatkov in da v vsakdanje življenje vključujejo vse več digitalnih tehnologij.



Slika 6: Samoocena kompetenc na področju reševanja problemov

4 Vpliv pandemije COVID-19 na razvoj digitalnih kompetenc

Anketirani študenti so ocenjevali trditve, ki se navezujejo na pet glavnih sklopov kompetenc. Rezultati (Slika) kažejo, da se anketirani slovenski študenti najbolj strinjajo s trditvami, da so se jim izboljšale kompetence povezane s komunikacijo in sodelovanjem, informacijsko pismenostjo in varnostjo. Nekoliko manj se strinjajo s trditvami, da so se jim izboljšale kompetence na področjih izdelovanja digitalnih vsebin in reševanja problemov s pomočjo digitalne tehnologije.



Slika 7: Samoocena študentov glede vpliva pandemije COVID-19 na dvig njihovih digitalnih kompetenc

5 SKLEP

Anketirani slovenski študenti svoje digitalne kompetence ocenjujejo dokaj visoko, saj je bila povprečna ocena nižja od 3 le pri eni izmed 25 trditev. To je generacija Z oz. net generacija, ki naj bi bili iznajdljivi v svetu komunikacije, vešči klikanja, všečkanja in brskanja po internetu, itd. [12], zato rezultati niso presenetljivi. Predpostavljamo, da so se njihove digitalne kompetence, zaradi dosežene že dokaj visoke stopnje digitalnih kompetenc, med pandemijo COVID-19 le nekoliko izboljšale (npr. povprečna ocena trditve »Menim, da sem bolj spreten pri uporabi IKT kot pred pandemijo COVID-19.« je 3,5 na 5-stopenjski lestvici). Ugotavljamo, da so anketirani študenti pridobili predvsem kompetence na področjih komunikacije in sodelovanja ter informacijske pismenosti. Morda je to rezultat študija na daljavo, ki je zahteval visok nivo teh kompetenc. Zanimivo je, da se stanje na področjih ustvarjanja vsebin in reševanja problemov ni bistveno izboljšalo. Vsekakor bi bilo potrebno nadalje raziskati razloge za take rezultate.

Kljub številnim prednostim pa ima študij na daljavo tudi slabosti. Študenti, ki so sodelovali v raziskavi, se strinjajo, da je veliko lažje slediti predavanjem v živo, kot pa na daljavo ($\bar{x}$=3,8) in da se kvaliteta študija na daljavo ne more primerjati s študijem na fakulteti ($\bar{x}$=3,9). Iz tega lahko zaključimo, da kljub razvoju IKT in novim pristopom izobraževanja, študij na daljavo še ne bo zamenjal študija na fakulteti. Le-ta naj bo zaenkrat le del celotnega proces izobraževanja na fakulteti. Vsekakor pa velja razmisliti o primernosti takega pristopa za izredne študente, ki jim velikokrat, zaradi službenih obveznosti, primanjkuje časa in bi se lahko v primeru študija na daljavo lažje udeleževali predavanj in vaj ter posledično sproti opravljali študijske obveznosti.

Za namen raziskave o digitalnih kompetencah slovenskih študentov smo razvili dokaj kompleksne vprašalnik, ki nudi priložnosti za nadaljnje analize podatkov, ki pa so izven okvira tega prispevka. Nadaljnje analize bodo usmerjene v primerjavo med načini, vrstami, letniki študija, spolom, itd. Zavedamo se tudi omejitev. Ena je majhen vzorec. Druga, ki jo želimo izpostaviti, je sam vprašalnik. Le-ta temelji na predhodnih raziskavah, kar ponuja primerljivost, vendar ugotavljamo, da bi morale biti vključene dodatne/novejše digitalne kompetence, kot so veliki podatki, robotika in umetna inteligenca [13].

LITERATURA IN VIRI

[1] C. Fulton and C. McGuinness, Digital Detectives: Solving Information Dilemmas in an Online World. Elsevier Inc., 2016.

[2] J. Lai and N. O. Widmar, "Revisiting the Digital Divide in the COVID-19 Era," Appl. Econ. Perspect. Policy, vol. 43, no. 1, p. 458, Mar. 2021.

[3] J. Crawford et al., "COVID-19: 20 countries' higher education intra-period digital pedagogy responses," J. Appl. Learn. Teach., vol. 3, no. 1, pp. 09–28, Apr. 2020.

[4] S. Carretero, R. Vuorikari, and Y. Punie, "The Digital Competence Framework for Citizens With Eight," Publ. Off. Eur. Union, no. May, p. 48, 2017.

[5] N. Law, N. Law, D. Woo, and G. Wong, "A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2," 2018.

[6] Australian Government, "Digital Literacy Skills Framework - Department of Education, Skills and Employment, Australian Government," 2020.

[7] C. M. Toquero, "Challenges and Opportunities for Higher Education amid the COVID-19 Pandemic: The Philippine Context," Pedagog. Res., vol. 2020, no. 4, pp. 2468–4929, 2020.

[8] W. Cao et al., "The psychological impact of the COVID-19 epidemic on college students in China," Psychiatry Res., vol. 287, p. 112934, May 2020.

[9] S. Saniuk et al., "Higher Education in and after COVID-19: The Impact of Using Social Network Applications for E-Learning on Student' Academic Performance," Sustain. 2022, Vol. 14, Page 5195, vol. 14, no. 9, p. 5195, Apr. 2022.

[10] "1KA | Spletne ankete." [Online]. Available: https://www.1ka.si/. [Accessed: 06-Jul-2022].

[11] L. A. Goodman, "Snowball Sampling," https://doi.org/10.1214/aoms/1177705148, vol. 32, no. 1, pp. 148–170, Mar. 1961.

[12] S. Tejedor, L. Cervi, A. Pérez-Escoda, and F. T. Jumbo, "Digital Literacy and Higher Education during COVID-19 Lockdown: Spain, Italy, and Ecuador," Publ. 2020, Vol. 8, Page 48, vol. 8, no. 4, p. 48, Nov. 2020.

[13] EU Science Hub, "Upskilling for life after the pandemic: Commission launches new digital competence guidelines," 2020. [Online]. Available: https://joint-research-centre.ec.europa.eu/jrc-news/upskilling-life-after-pandemic-commission-launches-new-digital-competence-guidelines-2020-07-13_en. [Accessed: 08-Jul-2022].

Sodobni pristopi poučevanja na daljavo pri poučevanju kardiovaskularnega sistema v srednji šoli

Modern Approaches in Distance Learning the Cardiovascular System in High School

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POVZETEK

Poučevanje je dandanes postavljeno pred številne izzive. Na eni strani so dijaki, ki jih je vedno težje motivirati za učenje, na drugi strani pa nas je zdravstvena situacija prisilila v izvajanje pouka na daljavo, kar je v nasprotju s tem, kar smo bili vajeni od nekdaj. Pri izvajanju pouka na daljavo se je izkazalo, da je strukturirano načrtovanje učnega procesa ključnega pomena. S pomočjo uporaba formativnega spremljanja z aplikacijo GoFormative in kamere IPEVO VZ-R je bila učna snov kardiovaskularnega sistema predstavljena na način, ki je sodoben in dijakom zanimiv. Z uporabo teh dveh orodij je bil cilj kljub izvajanju pouka na daljavo zasledovan brez večjih ovir in ni prinesel statistično pomembnih razlik v znanju dijakov pri pouku na daljavo ali pouku v šoli. S pomočjo kamere IPEVO VZ-R je pouk na daljavo potekal nemoteno in z veliko manj ovirami, kot to omogočajo grafične tablice, ki imajo številne omejitve. Formativno spremljanje dijakov je eden izmed ključnih načinov, kako lahko natančno spremljamo napredek posameznih dijakov v učnem procesu, aplikacija GoFormative, pa nam sicer analogno spremljavo dijakov digitalizira in olajša delo tako dijakov kot tudi učiteljev. Uporaba teh dveh pripomočkov se je v času pouka na daljavo izkazala za zelo dobrodošlo, njuna uporaba pa je tudi med poukom v šoli smiselna.

KLJUČNE BESEDE

Pouk na daljavo, digitalna pismenost, biologija, kardiovaskularni sistem

ABSTRACT

Teaching today is faced with many challenges. On the one hand, there are students who are increasingly difficult to motivate to learn, and on the other hand, the health situation has forced us to conduct distance learning, which is contrary to what we have always been used to. When conducting distance learning, it has been proven that structured planning of the learning process is crucial. With the help of formative monitoring with the GoFormative application and the IPEVO VZ-R camera, the learning material of the cardiovascular system was presented in a way that is modern and interesting to the students. With the use of these two tools, the goal was pursued without major obstacles despite the implementation of distance learning and did not result in statistically significant differences in students' knowledge in distance learning or in-school classes. With the help of the IPEVO VZ-R camera, distance learning took place smoothly and with much fewer obstacles than is possible with graphics tablets, which have many limitations. Formative monitoring of students is one of the keyways in which we can accurately monitor the progress of individual students in the learning process, and the GoFormative application digitizes the otherwise analog monitoring of students and makes the work of both students and teachers easier. The use of these two devices has proven to be very welcome during distance learning, and their use also makes sense during lessons at school.

KEYWORDS

Distance learning, digital literacy, biology, cardiovascular system

1 UVOD

Poučevanje na daljavo je oblika poučevanja z dvema temeljnima značilnostma: učitelj in učenec sta med poučevanjem prostorsko ločena, komunikacijo med njima in komunikacijo med učenci samimi pa omogočajo različne vrste tehnologij [3]. Unesco opredeljuje izobraževanje na daljavo kot »vzgojno-izobraževalni proces in sistem, v katerem pomemben delež pouka izvaja nekdo ali nekaj, ki je časovno in prostorsko odmaknjeno od učenca« [2]. Pri poučevanju na daljavo je tehnološka podpora v celoti in načrtno integrirana v celoten vzgojno-izobraževalni proces, tako v pedagoško kot administrativno podporo ter učno gradivo, kar omogoča izvajanje učnega procesa ob fizični ločenosti učitelja in učenca [1].

Učinkovito poučevanje na daljavo zahteva strukturirano načrtovanje, dobro strukturirane učne enote, specialne didaktične strategije in komunikacijo prek elektronskih ali drugih tehnologij (prav tam). Unesco poudarja, da poučevanje na daljavo zahteva »visok nivo samouravnavanja in veščin učenja, kar naj bi učitelji podprli z novimi poučevalnimi, učnimi in usmerjevalnimi strategijami«. [10]

Dva načina predstavitve učne teme kardiovaskularnega sistema bosta predstavljena tudi v članku.

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2 PREGLED LITERATURE

Pouk je namerno, načrtovano in organizirano izobraževanje, kar velja tudi za poučevanje na daljavo. Pri načrtovanju, izvajanju in evalvaciji poučevanja na daljavo je potrebno upoštevati t. i. didaktični model, ki ga sestavljajo snovna, pedagoško-psihološka, metodična / specialnodidaktična ter tehnična in organizacijska izhodišča [5].

Snovna izhodišča didaktičnega modela temeljijo na pripravi učnih gradiv in usmerjajo učitelja v širino in globino potrebnih znanj. Njihov namen je podati bistveno vsebino ter analizirati znanstvenost in sodobnost učne snovi, ki bo posredovana učencem [5].

Pedagoško-psihološka izhodišča povezujejo učitelja z učenci, saj se nanašajo na predznanje učencev. Pomembno je, da učitelj razmisli o obstoječem predznanju učencev, njihovih izkušnjah s samostojnim delom, uporabo informacijske tehnologije idr. Poleg tega pa ima učitelj ves čas v mislih tudi vzgojno vrednost, ki jo bo prek učnih gradiv posredoval učencem [5].

Metodična izhodišča izobraževanja na daljavo so temelj za pripravo učnih/študijskih gradiv. Znotraj teh izhodišč imajo pomembno vlogo operativni vzgojno-izobraževalni cilji, ki jih želi doseči učitelj. Pomembno je, da tako učenci kot učitelj natančno poznajo svojo vlogo in zadolžitve pri doseganju zastavljenih vzgojnoizobraževalnih ciljev. Pri poučevanju na dalajvo mora učno gradivo vključevati vse faze vzgojno izobraževalnega sistema: ponovitev stare snovi, osmišljanje posredovanega znanja, spodbujanje in motiviranje udeležencev; podajanje, razlago in pojasnjevanje nove učne snovi, ponavljanje in utrjevanje, spodbujanje učencev, da usvojeno znanje prenesejo v prakso, preverjanje in ocenjevanje znanja. [5]

Ob vseh načelih poučevanja na daljavo, upoštevanju didaktičnih modelov, pa ne smemmo pozabiti na digitalno pismenost učencev. »Digitalna pismenost je temeljna zmožnost posameznika, da se znajde v digitalnem svetu. Digitalno pismen posameznik pozna in uporablja digitalne aparature in pripomočke, razume zakonitosti digitalnega socialnega okolja in se znajde v njem.« [8].

Pri tem je temeljno računalniško znanje, kot je uporaba računalnika za iskanje, ocenjevanje, shranjevanje, proizvodnjo, predstavitev in izmenjavo informacij ter za sporazumevanje in sodelovanje v skupnih omrežjih na internetu, zgolj podlaga, ki omogoča spoznavanje drugih, hitro razvijajočih se digitalnih orodij. [6]

Mednarodno združenje za tehnologijo v izobraževanju (ISTE) je merila za določanje veščin digitalne pismenosti razvrstilo v naslednje sklope veščin:

- ustvarjalnost in inovativnost,
- komunikacija in sodelovanje,
- raziskovanje in informacijska pretočnost,
- kritično mišljenje,
- reševanje problemov in odločanje,
- tehnološke operacije in koncepti. [7],

Ferrari [4], digitalno pismenost definira kot nabor znanj, veščin in navad (zmožnosti, strategije, vrednote in zavedanja), ki jih ob uporabi IKT potrebujemo za izvajanje nalog, reševanje problemov, komuniciranje, upravljanje informacij, sodelovanje, ustvarjanje in izmenjavo vsebin ter uspešno, učinkovito in kritično izgradnjo lastnega znanja.

Stanojev in Florjančič [9] ugotavljata, da pri gimnazijcih med intenzivnostjo uporabe IKT pri pouku in digitalno pismenostjo dijakov ni statistično značilne povezanosti, prav tako tudi višja intenzivnost uporabe IKT pri pouku ni statistično značilno povezana z rezultatom digitalne pismenosti dijakov.

Z opisi definicij digitalne pismenosti se pojavlja smiselnost uporabe IKT pri poučevanju. Kot nujna za preživetje v sodobnem času jo spodbujamo tudi v šolskem prostoru s prenovami izobraževalnih programov, žal pa se je v času COVID-19 izkazalo, da se dijaki ne dosegajo zadovoljivo te kompetence znanja. [8]

Eden od načinov spremljanja napredka in obvladovanja učne snovi posameznega dijaka je v aplikaciji “Go Formative”, druga pa za lažje posredovanje zapiskov kot tabelna slika z uporabo kamere za posredovanje dokumentov v realnem času (IPEVO – VZ-R).

3 REZULTATI

3.1 Go Formative

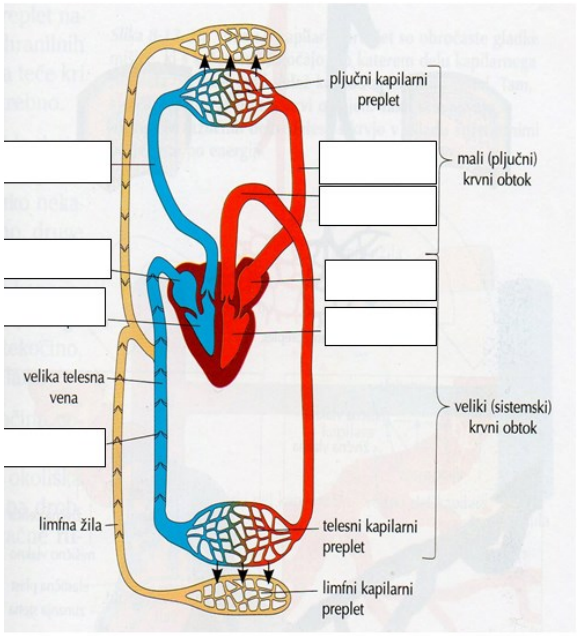
Ob poplavi spletnih orodij, ki se jih učitelji poslužujemo za izboljšanje zanimanja dijakov do pouka in s tem tudi kvalitete pouka, je težko ločiti zrno od plevela. Na spletu je moč najti večje število tako brezplačnih kot tudi plačljivih orodij, ki nam lahko pomagajo pri izvedbi določene aktivnosti pri pouku. Številna spletna orodja so teoretično zelo dobra, vendar zaradi suhoparnosti in manj primernega vmesnika, pri učencih niso dobro sprejeta in posledično med poukom ne dosežejo željenih učinkov. Številni programi in aplikacije pa so za dijake izredno atraktivne in imajo boljše vmesnike, ki jim omogočajo enostavno uporabo, vendar so didaktično veliko slabše.

Uporaba spletnih orodij je v času izobraževanja na daljavo doživela razcvet, kjer je bila motivacija dijakov in čim bolj nemoten proces poučevanja glaven namen učiteljev. Tudi tisti učitelji, ki so bili navajeni frontalnega poučevanja, so bili prisiljeni poseči po drugih prijemih.

Eno izmed orodij, ki se je v času pouka na daljavo izkazalo kot zelo dobrodošlo je aplikacija GoFormative. S pomočjo aplikacije lahko učitelj preverja in ocenjuje naloge in vprašanja različnih kognitivnih ravni. Tiste naloge, kjer z vprašanji preverjamo znanje na nižji kognitivni ravni, se pravilnost le teh samodejno preverja, naloge višjih kognitivnih ravni, kot so vprašanja odprtega tipa, pa mora učitelj preverjati in ovrednotiti naknadno. Aplikacija nam omogoča, da glede na smernice formativnega spremljanja, lahko dodelimo določene naloge le eni skupini dijakov, za katere menimo, da jih v določenem koraku učnega procesa potrebujejo – le to storimo z različnimi kodami, ki jih ustvarimo v aplikaciji. V aplikaciji imamo možnost ustvariti nalogo, kjer dijaki na skico vnašajo svoje rešitve. Prav tako nam aplikacija omogoča dodeljevanje različnega števila točk nalogam, kar v praksi pomeni, da naloge, ki so kompleksnejše, prinašajo večje število točk, kot naloge, ki so po Bloom-u na nižji taksonomski stopnji. V aplikaciji ima učitelj nad rešenimi nalgami neposreden vpogled, tako v času reševanja, da spremlja napredek dijaka, kot tudi kasnjeje.

Aplikacija GoFormative je bila uporabljena pri učnem procesu obravnave človeškega kardiovaskularnega sistema, pri pouku biologije v 1. letniku. Učna ura je bila načrtovana tako, da so dijaki s pomočjo aplikacije GoFormative preverili svoje

dosedanje znanje o človeškem kardiovaskularnem sistemu. Dijaki so s pomočjo mobilnih telefonov obiskali spletno mesto GoFormative, kjer so vpisali v naprej posredovano kodo, s katero so lahko dostopali do nalog. Nato so imeli 15 minut časa, da so samostojno rešili zahtevane naloge. Med reševanjem nalog so se rezultati oz. pravilnost nalog neposredno prikazovali le učitelju, kar omogoča takojšno povratno informacijo o znanju dijakov. Dijaki o pravilnosti njihovega reševanja niso bili seznanjeni. Hitra analiza rezultatov s tem omogoča učitelju prilagoditi izvedbo učnega procesa za določeno učno snov. Po uvodnem preverjanju znanja so bili dijaki razporejeni v skupine po štiri. Skupine so bile formirane tako, da so bili dijaki z najslabšim znanjem dodeljeni k dijakom, ki so na uvodnem preverjanju dosegali boljše rezultate. S tem je bila omogočena medvrstniška pomoč. Nato so bili dijaki pozvani k zastavljanju ciljev učnega sklopa – kaj želijo izvedeti in kaj je za njih pomembno. Pri zastavljanju ciljev so bili upoštevani tudi minimalni standardni znanja in nameni učenja. Vse skupine so nato prejele učno gradivo z vprašanji, ki se nanašajo na minimalne standarde znanja. Vsaka skupina pa je nato prejela individualizirana vprašanja po temah, ki so jih izbrali pri zastavljanju ciljev učnega sklopa in temah, ki so bili na začetnem preverjanju dosegala najnižje število točk.



Slika 1: Primer naloge uporabljen v aplikaciji GoFormative.

Po 30 minutah dela v skupinah so dijaki predstavili svoje delo ostalim dijakom, ki so si med predstavitami izvedlovali samostojne zapiske. Po vsaki predstavitvi je sledila še razprava o ugotovitvah, ki so jih skupine predstavile in uporabni vrednosti znanja v vsakdanjem življenju.

Nato so bili dijaki znova pozvani, da s pomočjo aplikacije GoFormative ponovno rešijo vse naloge. Z analizo rezultatov so bili dijaki tokrat seznanjeni, kar jim je omogočilo ugotoviti, kaj so se novega naučili in kakšno znanje o določeni temi zdaj premorejo.

Kasnejša analiza znanja dijakov pri tej temi ni pokazala statistično pomembnih razlik med znanjem dijakov, ki so bili vključeni v izboraževanje na daljavo in med dijakom, ki so znanje pridobili v šoli.

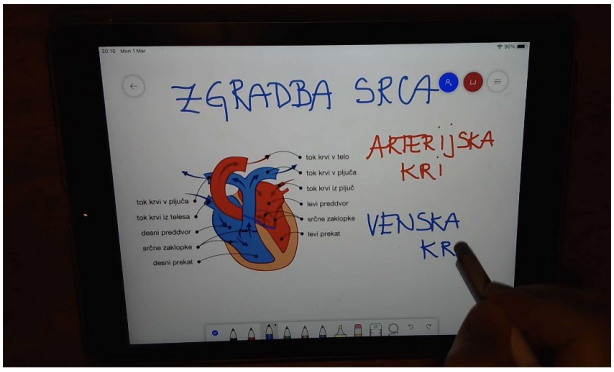
3.2 Učenje kardiovaskularnega sistema s pomočjo kamere IPEVO VZ-R

Z dijaki smo v času pouka na daljavo poleg uporabe GoFormative za lažje posredovanje učne snovi in bolj sistematično razlago uporabljali spletno kamero znamke IPEVO, model VZ-R (v nadaljevanju kamera).

Z dijaki srednjega strokovnega izobraževanja je bila izvedena učna ura na temo kardivoaskularnega sistema z uporabo kamere za natančnejšo in bolj sistematizirano razlago, za spremljanje napredka dijakov pa aplikacija GoFormative, s pomočjo katere smo preverjali predznanje in usvojeno znanje glede na strukturirane naloge po Bloom-ovi taksonomiji.

Slika 2: Uporaba kamere VZ-R

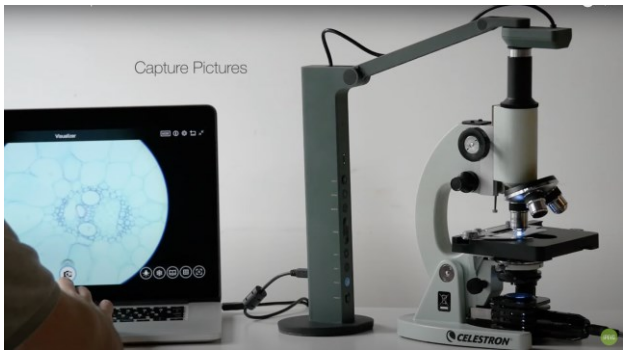
Sama uporaba kamere je zelo preprosta, odtehta pa nam marsikatero napačno razumevanje ali dilemo. Priklopimo jo preko USB-A vhoda na prenosni ali stacionarni računalnik. Na Sliki 3 vidimo, da lahko dijakom sliko učbenika, shemo, ki smo jo narisali, pokažemo neposredno na njihovem zaslonu. Kamera prepozna branje dokumentov, slik, posnetkov ... skratka vseh analognih in digitalnih vsebin.



Slika 3: Prenos slike s tablice na računalnik.

Pri pouku smo uporabili kombinacijo kamere, tablice in računalnika, kot kaže slika 3.

Na Sliki 4 je predstavljen še en način uporabe in sicer kamero lahko neposredno povežemo z mikroskopom, tega pa z računalnikom. Ta način uporabe nadomesti nameščanje dragih kamer in lup za posredovanje mikroskopskega preparata na tablo ali pametno tablo, kjer enostavneje prikažemo preparat, hkrati pa vsi dijaki naenkrat vidijo sliko pod mikroskopom.



Slika 4: Posredovanje mikroskopske slike.

Dijakom smo z uporabo kamere olajšali delo, zapiske so delali sproti, hkrati pa smo posnetek učne ure in razlago lahko tudi snemali in kasneje naložili na spletno učilnico v Moodle ali na MS Teams.

4 ZAKLJUČEK

Primer učne praske z uporabe digitalnih orodij GoFormative in kamere ni samo primer dobre prakse, ki smo jo izvajali v času poučevanja na daljavo, temveč se kaže kot dober način poučevanja na daljavo v primeru izobraževanja odraslih, v primeru, ko je dijak bolnišnično odsoten dalj časa, lahko spremlja nekatere vsebine in razlago, na roditeljskih sestankih, pa tudi v času priprav na različna tekmovanja, saj dijaki različnih razredov zaključujejo pouk ob različnih urah, preko poučevanja na daljavo pa vsem omogočimo prisostvovanje na pripravah ali pa kasnejši ogled predavanja na spletni učilnici.

LITERATURA IN VIRI

[1] Bregar, L., Zagmajster, M. in Radovan, M. (2020). Eizobraževanje za digitalno družbo. Ljubljana: Andragoški center Slovenije. https://www.acs.si/digitalna-bralnica/eizobrazevanje-za-digitalno-druzbo/ (10. 8. 2022)

[2] Burns, M. (2011). Distance Education for Teacher Training: Modes, Models, and Methods. Washington, DC: Education Development Center, Inc.

[3] Encyclopedia Britannica. @2020 Encyclopedia Britannica, Inc. https://www.britannica.com/topic/Britannica-Online (11. 8. 2022)

[4] Ferrari, Anusca. 2012.Digital Competence in Practice: An Analysis of Frameworks. jrc Technical Reports. Luxembourg: Publications Office of the European Union.

[5] Gerlič, I. (2002). Didaktična izhodišča izobraževanja na daljavo. V Gerlič, I., Debevc, M., Dobnik, N., Šmitek, B. in Korže, D. (ur.),. Načrtovanje in priprava študijskih gradiv za izobraževanje na daljavo (str. 83–92). Maribor: Fakulteta za elekrotehniko, računalništvo in informatiko.

[6] Gilster, Paul. 1997. Digital Literacy. New York: Wiley.

[7] ISTE. Areas of focus. https://www.iste.org/ (12. 8. 2022)

[8] Javrh, P., Možina, E., Bider, K., Kragelj K., Volčjak, D., Sepaher, G., Gjerek, L., Matavž, H., Rejec, P., Babič Ivaniš, N., Brecelj, V. (2018). Digitalna pismenost. Ljubljana: Andragoški center Slovenije. https://pismenost.acs.si/wp-content/uploads/2018/09/Digitalna-pismenost-e-verzija.pdf (12. 8. 2022)

[9] Stanojev, S, Florjančič, V. (2018). Digitalna pismenost srednješolcev. Koper: Založba Univerze na Primorskem.

[10] UNESCO COVID-19 Education Response. (2020).

[11] https://en.unesco.org/covid19/educationresponse/ (12. 8. 2022)

Fizikalni poskusi z in brez informacijsko-komunikacijske tehnologije

Physics Experiments With or Without ICT

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POVZETEK

V zadnjih dveh desetletjih številni predavatelji in pedagoški delavci iščemo nove metode podajanja učne snovi s pomočjo informacijsko-komunikacijske tehnologije (v nadaljevanju IKT). V času epidemije pa je delo na daljavo postalo edini način, ki je sploh omogočil izobraževalni proces. Po vrnitvi v šolske klopi smo učitelji lahko izbirali med klasičnim poučevanjem ter uporabo digitalnih oblik poučevanja. Čeprav smo v času dela na daljavo vsi pogrešali klasičen pouk, je jasno, da si pouka brez IKT ne predstavljamo več. Učitelj mora tako smiselno presoditi, katere metode dela izbrati za določene vsebine, da bo učencem snov čimbolj nazorno predstavljena in da znajo povezati teoretično znanje s prakso. Ko učenje temelji na konkretni izkušnji, govorimo o izkustvenem učenju. Če želimo, da učenci pridobijo iz izkušenj nova znanja, morajo biti prisotni tako fizično, kot čustveno. To pomeni, da morajo o izkušnji razmišljati, jo razumeti in povezati z dosedanjim znanjem in pridobljenimi izkušnjami.

M. Garvas (2010) je zapisala, da je izkustveno učenje način, kako se povežeta teorija in praksa, bistveno vlogo pa ima seveda osebna izkušnja, saj je za izkustveno učenje značilno, da se najbolje učimo, če nekaj naredimo sami. Govorimo o transformaciji spoznanj na podlagi novih izkušenj. S takšnim pristopom dosegamo trajnejše znanje ter drugačen način razmišljanja in delovanja. Pomembno je, da znamo praktične izkušnje povezati s teoretičnim znanjem, kar omogoča prenos teorije v prakso in spodbuja učenje avtonomnega delovanja. Tako znanje učencev postaja še kakovostnejše, širše, bogatejše in uporabnejše.

V prispevku bom predstavila izvedbo dneva dejavnosti na temo elektrike, kjer so učenci izvajali poskuse po klasični metodi s pomočjo didaktičnih pripomočkov in s pomočjo brezplačnega internetnega programa, ki nam omogoča simulacije poskusov. Predstavila bom tudi učinkovitost dela pri posamezni metodi, kdaj lahko govorimo o izkustvenem učenju in katera metoda je bila učencem bolj všeč. Pri vsaki metodi bom opredelila prednosti in slabosti le-te, podala praktične primere, kjer je smiselna uporaba ene in druge metode, ter s pomočjo evalvacije, ki sem jo naredila z učenci presodila še njihovo izkustvo.

KLJUČNE BESEDE

Izkustveno učenje, fizikalni poskusi, e-gradiva, spletne aplikacije, simulacija fizikalnih eksperimentov

ABSTRACT

Teachers have been looking for new ways to incorporate ICT into their teaching methods in the last two decades. It became clear during distance learning that ICT is crucial to achieve educational goals. After returning to schools the teachers were able to choose between the established teaching methods and the use of methods supported by ICT. Although traditional classroom education was sorely missed during distance learning it became clear that education without the use of ICT is no longer possible, however the teacher should be the one to determine the best teaching methods for their students. When learning is based on a concrete experience we talk about experience based learning or empirical learning. If we want the students to acquire new knowledge based on experiences they need to be present physically as well as emotionally. They need to think about the experience, understand it and connect it to their previous knowledge and experiences.

M. Garvas (2010) wrote that experience based learning provides a way to connect theory and practice, a major part of it being a personal experience. It is well known that students learn better when they experience something themselves. In that case we can talk about a transformation of lessons learnt through new experiences. By including experience based learning the students' knowledge acquires a more lasting value. It is important to be able to relate practical experiences to theoretical knowledge which in turn enables the transfer of theory into practice and it also encourages autonomous learning. In this way the knowledge that the students get is the widest posible knowledge as well richer and more useful.

This paper presents an activity day where the students carried out electricity experiments using didactical aids and a free online program. The paper presents the efficiency of each method and the experience based learning. Furthermore, it evaluates which of the methods described were better recieved by the students. The pros and cons of each method as well as practical examples of usage are also presented. Students' evaluations are also included in the paper to present their experiences.

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KEYWORDS

Experience based learning, Physics experiments, E-learning materials, Online applications, simulation of physical experiments

1 UVOD

Učitelji pri podajanju učne snovi želimo pomoč računalnika v vzgojno-izobraževalnem procesu vključiti tam, kjer je mogoče in smiselno. Pri pouku fizike je zelo pomembno, da se učenci seznanijo tako s teoretičnimi, kot tudi s praktičnimi vsebinami. Pri vsebinah, ki so za učence preveč abstraktne, so nam za učinkovitejše podajanje snovi v pomoč animacije, računalniški programi, simulacije. Za optimalno učinkovitost pri pouku je potrebna »prava mera« različnih metod dela. Da učenci ponotranjijo snov, se morajo srečati s konkretnimi primeri. Že star kitajski pregovor pravi: *Povej mi in bom pozabil, pokaži mi in se bom spomnil, vključi me in bom razumel*. To najbolje opiše pomen izkustvenega učenja, ki ga pri učencih želimo doseči. Izkustveno učenje se je povečalo v zadnjih nekaj desetletjih kot odgovor na učenje, ki je zasnovano na knjigah, torej abstraktno učenje. Izkustveno učenje je način, kako se povežeta teorija in praksa, bistveno vlogo pa ima seveda osebna izkušnja, saj je za izkustveno učenje značilno, da se najbolje učimo, če nekaj naredimo sami (Garvas, 2010). [3].

Predstavila bom potek dneva dejavnosti (naravoslovni dan), kjer smo uporabili različne metode eksperimentiranja, prednosti in slabosti obeh ter evalvacijo dela pri učencih. Raziskovalna tema je bila elektrika. Učenci so teoretičen del predhodno obravnavali pri pouku fizike, na dnevu dejavnosti pa so svoje znanje uporabili za dokazovanje lastnosti elektrike z eksperimenti in meritvami. Razdeljeni so bili v skupine (po štiri oz. po trije učenci) in so krožno izvajali naslednje delavnice:

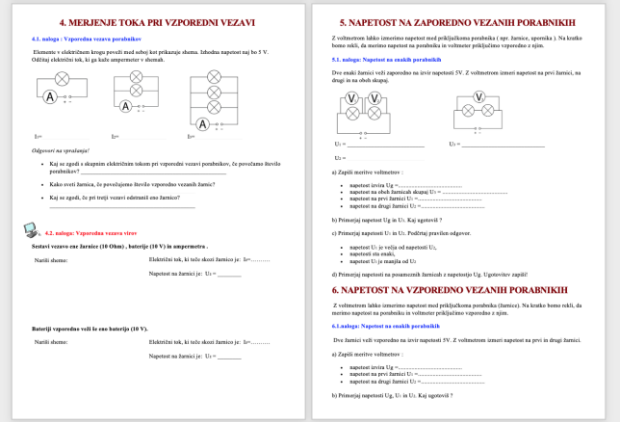
1. delavnica: Vezave električnih krogov s pomočjo vezavnih plošč. Učenci so na šolski malonapetostni vir vezali različne vezave s porabniki in merili električni tok in napetost.
2. delavnica: Vezave električnih krogov s pomočjo računalniškega on-line programa. Učenci so s pomočjo programa sestavili električni krog z uporom in merili električni tok in napetost. Dobljene rezultate so predstavili z grafom.
3. delavnica: Zaporedna in vzporedna vezava virov in porabnikov ter lastnosti magnetizma.

Na sliki 1 je del učnega lista z navodili za eksperimentiranje, ki ga učenci dobijo ob začetku dneva dejavnosti. Tu so zbrane naloge po sklopih z navodili za eksperimentiranje s klasičnimi eksperimenti ter računalniškimi simulacijami.

2 POTEK DNEVA DEJAVNOSTI IN PRIMERJAVA UČINKOVITOSTI POUČEVANJA S KLASIČNIM EKSPERIMENTIRANJEM IN Z UPORABO ANIMACIJ

Ker je ura fizike prekratka za učinkovito eksperimentiranje po skupinah, že nekaj let organiziram naravoslovni dan za učence 9. razreda, kjer svoje teoretično znanje uporabijo pri praktičnih nalogah. Tako za iskanje lastnosti vzporednih in zaporednih vezav porabnikov je zagotovo bolj priporočljivo in nazorno eksperimentiranje z didaktičnimi pripomočki. Gre za princip izkustvenega učenja, kjer prihaja do povezovanja med teoretičnim in praktičnim delom in omogoča učinkovitejše dojemanje pojmov in novih spoznanj. Čeprav imajo učenci v času poskusov že predznanje o vezavah, so vsakič presenečeni o svetilnosti žarnic ter toku in napetosti, ki ga izmerijo na njih. S svojim znanjem lahko predvidijo, kakšne bodo meritve, te pa največkrat malo odstopajo od pričakovanih. Za natančne meritve, dokazovanje zakonov in risanje grafov se bolj nagibam k uporabi animacij in računalniških programov. Te učencem pomagajo pri predstavitvi abstraktnih vsebin, vendar pa jih ne začutijo tako kot klasične poskuse. Pri uporabi animacij spodbujam učence, da preizkusijo stvari, ki so sicer tvegana (kratek stik, napačna vezava baterij ...).

V naslednjem delu bom še bolj podrobno predstavila delo pri vsaki od delavnic ter prednosti in slabosti posameznih metod dela.



Slika 1. Primer navodil za učence (učni list)

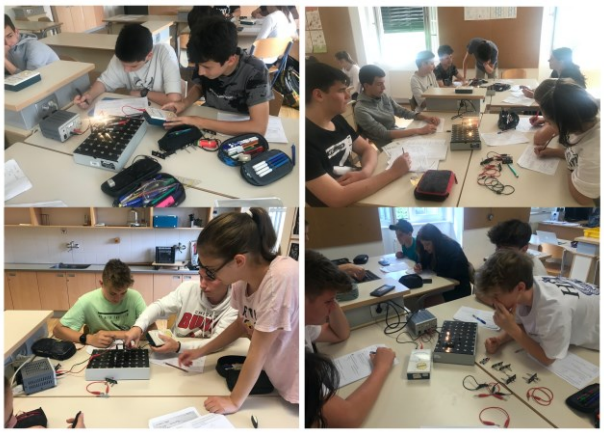
2.1 Klasično eksperimentiranje s pomočjo didaktičnih pripomočkov

Učenci so se prvič rokovali s sestavljanjem električnih vezij, zato sem jih v začetku vodila frontalno, kasneje pa so poskušali izvajati eksperimente samostojno. Učenci so s pomočjo sestavljenih vezij ugotavljali lastnosti vzporednih in zaporednih vezav porabnikov. Pri sestavljanju so bili zelo motivirani, saj so vsi v skupini prišli do izraza z delitvijo vlog. Dobro so se izkazali učenci, ki jim računanje ne gre najbolje od rok oz. kot sami pravijo, jim fizika »ne leži«. Izjemno zanimanje za praktični del elektrike pokažejo fantje. Največkrat se radi preizkusijo še pri sestavljanju kompleksnejših vezij in imajo pri tem tudi veliko praktičnih vprašanj. Tukaj se izrazito opazijo učinki izkustvenega učenja, kjer se učenčeva neposredna izkušnja pretvarja v pomembno in zanesljivo znanje ter pri tem povezuje spoznavni, čustveni in akcijski vidik.

Na podlagi teoretičnega predznanja so učenci po beleženju meritev kmalu prišli do ugotovitve, da dejanske meritve odstopajo od pričakovanih in da pri realnih poskusih prihaja do izgub. Tako se tok pri zaporedno vezanih žarnicah ne razpolovi oz. pri vzporedni vezavi podvoji, kot vedo iz teorije, ampak dobijo približek temu. Presenečeni so bili tudi, da gonilna napetost ni bila enaka napetosti na izviru in v nadaljevanju imeli razpravo, zakaj je do razlik sploh prišlo.

Pri meritvah uporabljamo analogne merilnike, kjer morajo učenci določati merilna območja in s pomočjo izbranih skal pravilno odčitati meritev. Pomembno je, da kljub možnosti uporabe digitalne opreme spodbujamo rokovanje z analognimi merilniki, saj le-ti spodbujajo boljše razumevanje rezultatov.

Ker so kakovostni kompleti za fizikalne poskuse zelo dragi, jih imamo na šoli manj, posledica tega pa so številčne skupine. Zato pri pouku izvajamo le krajše frontalne poskuse in uporabo računalniških animacij, za eksperimentiranje po skupinah pa izkoristim naravoslovni dan, ki traja pet šolskih, kjer so učenci razdeljeni v manjše skupine. Na sliki 2 je prikazano, kako učenci izvajajo poskuse s škatlami za eksperimentiranje, na sliki 3 pa zajem zaslona računalniške simulacije, kjer so učenci raziskovali lastnosti vzporednih in zaporednih vezav virov ter prevodnost materialov.



Slika 2. Klasično eksperimentiranje po skupinah

Prednosti klasičnega eksperimentiranja:

- učenci so zelo motivirani za delo,
- primerno za raziskovanje lastnosti vzporednih in zaporednih vezav porabnikov in virov,
- nazorna uporaba ampermetra in voltmetra,
- elektrika ni več tako abstraktna,
- izkustveno učenje.

Slabosti klasičnega eksperimentiranja

- Pri rednih urah so prevelike skupine
- Meritve niso natančne

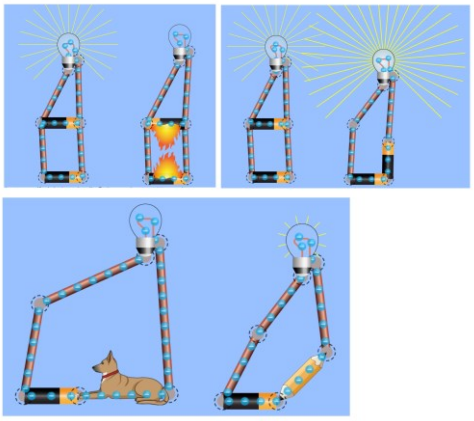
2.2 Sestavljanje vezij s pomočjo spletnega programa in animacij

Za sestavljanje vezij na računalniku smo uporabili brezplačen internetni program PhET (https://phet.colorado.edu/) [1].

Učenci so s pomočjo programa sestavili vezja (vzporedna in zaporedna vezava žarnic, uporov ter baterij), opravili meritve ter tako natančno ugotovili lastnosti posameznih vezij, dokazali Ohmov zakon in s pomočjo meritev narisali graf. Preizkusili so tudi veljavnost formule za vzporedne in zaporedno vezane porabnike, opazovali smer potovanja elektronov in smer električnega toka, nazorno opravili meritve za vzporedno in zaporedno vezavo dveh virov, naredili kratek stik, opazovali in spreminjali fizikalne parametre na žarnicah in opazovali svetilnost le teh.

Prednosti fizikalnih poskusov s pomočjo računalniških programov:

- skupine so lahko številčnejše,
- natančne meritve,
- učenci lahko program uporabljajo tudi kot pripomoček pri preverjanju računskih nalog,
- enostavna ponazoritev abstraktnih stvari (potovanje elektronov in smer električnega toka),
- možnost preizkušanja (česar v realnosti raje ne počnemo),
- uporabnost programa tudi doma.



Slika 3. Primer vzporedne in zaporedne vezave virov ter prevodniki in neprevodniki

Slabosti fizikalnih poskusov s pomočjo računalniških programov:

- učenci ne dobijo realnega občutka uporabe elektrike,
- za sestavljanje vezij niso bili tako motivirani kot pri klasični metodi.

3 ZAKLJUČEK

V prispevku sem želela orisati pozitivne in negativne lastnosti aplikacije na eni strani in klasično eksperimentiranje na drugi strani. Ker na naravoslovnem dnevu izvajam obe metodi dela, ju zlahka lahko primerjamo. Tako se pokaže, kdaj je smiselno za eksperimentiranje uporabiti klasično metodo in kdaj podporo računalničkih animacij. Mnenje učencev ob koncu dneva je bilo, da jim je bilo bolj zanimivo eksperimentiranje po klasični metodi, ker je bilo to za njih nekaj novega in so bili zato bolj motivirani.

Celovite učenčeve vpletenosti v izkušnjo ne more nadomestiti nobeno še tako doživeto pripovedovanje ali branje o izkušnjah nekoga drugega. Seveda pa ni samoumevno, da je vsako izkustveno učenje kakovostno. Treba je znati ustvariti ustrezna učna okolja in omogočiti učni proces, v katerem pride do integracije zaznavanja, čustvovanja, delovanja in razmišljanja pri ustvarjanju znanja in osebnostnem oz. profesionalnem razvoju [2].

Iz pedagoškega vidika menim, da sta obe metodi dela z učenci dobri, naloga učitelja pa je, da dobro razmisli, katere cilje bomo bolj nazorno približali učencem s klasično metodo oz. z uporabo računalniških programov oz. animacij.

LITERATURA

[1] Spletna aplikacija PhET. Pridobljeno 7. 8. 2021 https://phet.colorado.edu/

[2] Barica Marentič Požarnik, Marjeta Šarić, Barbara Šteh, 2021. Izkustveno učenje. Oddelek za pedagogiko in andragogiko

[3] Garvas, M. (2010). Izkustveno učenje kot praksa in teorija izobraževanja in usposabljanja strokovnih delavcev v vrtcu Trnovo. Andragoška Spoznanja, 16 (1), 35–46. https://doi.org/10.4312/as.16.1.35–46

Recept, navodilo, algoritem

Recipe, Instruction, Algorithm

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POVZETEK

Prispevek bo prikazal, kako smo se z učenci 8. razreda lotili dela na tehniškem dnevu, posvečenem programiranju. Vsebinsko smo dodali tudi ponavljanje in usposabljanje učencev za oblačno računalništvo. V primeru, da bi pouk ponovno potekal na daljavo, smo poglobili pomembno znanje uporabnega računalništva. Vsebinsko pa smo obogatili in razbili monotonost z različnimi dejavnostmi. Za proces učenja smo za najobsežnejši del tehniškega dneva zbrali igrifikacijo. Gre za način dela, kjer posameznik s pomočjo igre razvija računalniško razmišljanje in pridobiva znanje. Ta dan smo obogatili še na način, da smo dodali dejavnost, ki je povezovala digitalno in fizično delo ter obdelali računalniške koncepte s pomočjo igre v fizični obliki. V prispevku bo predstavljena igrifikacija, motivacija, organizacija dneva dejavnosti in različna orodja za igrifikacijo, ki lahko pomagajo pri digitalnih kompetencah. Rezultat tovrstnega pristopa je, da so učenci ta dan ne samo uživali, ampak smo jih tudi opolnomočili za soočenje z novimi izzivi na nov način. Nekateri so poročali tudi o tem, da jim sedaj, ko vedo, kako razdeliti veliko nalogo na manjše dele, reševanje problemov dela manj težav.

KLJUČNE BESEDE

Igrifikacija, tehniški dan, računalniško razmišljanje, programiranje, algoritem

ABSTRACT

The paper presents the work done on the technical day. The topic of the technical day was programming, to which we added repetition and training of students for cloud computing as well. In the event that the lessons were to be taught remotely again, we deepened the important knowledge of applicable computing. We enriched the content and took the monotony away with various activities. For the learning process, we have chosen gamification for the major part. This is a way of working where an individual develops computational thinking and acquires knowledge with the help of a game. We enriched this day in the way that we added an activity that connected digital work as well as physical work and processed computer concepts with the help of a game in physical form. The paper will present gamification, motivation, organization of the activity day and various gamification tools that can help with digital competences. As a result, the students not only enjoyed the day – they have also become empowered to face new challenges in a new way. Some have also reported that now that they know how to break down a large task into smaller parts, they find problem solving less difficult.

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KEYWORDS

Gamification, technical day, computational thinking, programming, algorithm

1 UVOD

Naloga učitelja je konstantno razmišljanje o tem, kako učence navduševati, spodbuditi, motivirati in angažirati za delo ter učenje. To nikakor ni preprosta in samoumevna naloga, vendar je vredna vloženega truda. Uspešna izpeljava te naloge je odvisna od izobraževanja in iskanja novih načinov dela. Eden izmed takšnih načinov dela, ki vključuje diferenciacijo in individualizacijo, je igrifikacija. Igrifikacijo za osnovno šolo lahko razumemo kot igro, največkrat digitalno, ki omogoča, da se učenci med igranjem nekaj naučijo. Vsi tega pojma ne razumejo na tak način. Igrifikacijo različno opredeljujejo tudi strokovnjaki, saj gre za razmeroma nov način dela.

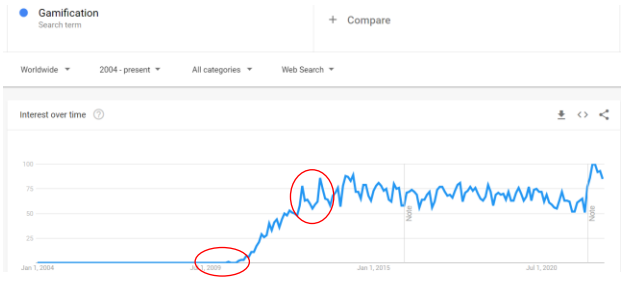
Izziv, s katerim smo se soočili, je dan dejavnosti izpeljati za učence na način, da bi utrdili znanje za možne prihajajoče šolanje na domu. Obenem pa smo želeli predstaviti računalniško razmišljanje in programiranje s pomočjo igrifikacije. Tako smo povezali navezavo recept – navodilo – algoritem: recept za peko palačink, navodilo za peko in algoritem, ki bi ga razumel računalnik.

2 IGRIFIKACIJA

2.1 Opredelitev pojma

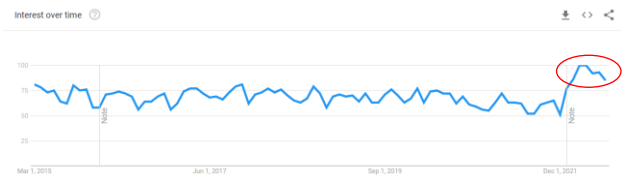
Igrifikacijo, ki je precej sodobna besedna skovanka, lahko razumemo različno. Razlogov za to je več. Eden izmed njih so lahko jezikovne razlike. Pojem je bil povzet iz angleščine (*gamification*), kjer so za različne tipe iger različni izrazi, kar vpliva na različno razumevanje pojma. Poznamo veliko različnih tipov iger: lahko so športne, glasbene, video igre, uganke, igre v obliki stav … [1]. V opredelitvi igrifikacije se razlikujejo tudi mnenja strokovnjakov, četudi se pri vseh pojavljajo enotni ključni elementi. Enotni elementi so napredovanje v naslednje nivoje, točkovanje, nagrajevanje ipd. Burke igrifikacijo opredeli kot »uporabo igralne mehanike in oblikovanje izkušenj za

digitalno angažiranje in motiviranje ljudi za dosego svojih ciljev« [2]. Pojem igrifikacija je skoval britanski raziskovalec Nick Pelling leta 2002. Pelling je programer, ki je ustvarjal igre, in je bil zadolžen za razvoj igri podobnega vmesnika za bankomate in prodajne avtomate. Besedo bi naj namensko ustvaril kot »grdo besedo« - tako jo je opisal Nick Pelling. Uporabil jo je za opis pospešenega uporabniškega vmesnika podobnega igri [3]. Tako beseda kot način dela sta se hitro prijela. To dokazuje tudi Google Trends (Slika 1), ki kaže, da sta prvi večji preboj beseda in iskanje le-te doživela šele leta 2010, dve leti kasneje pa dosegla največjo rast v zgodovini besede. Iskanje se je drastično dvignilo kot tudi priljubljenost dela na tak način.



Slika 1: Google Trends 2004 –

Opaziti je tudi, da se je zanimanje za igrifikacijo povečalo v zadnjih letih. Temu je gotovo botrovalo to, da so ljudje preživeli več časa doma tudi zaradi obsežnejšega dela na daljavo in pandemije Covid-19. To je razvidno z naslednjega grafa (Slika 2) [4].



Slika 2: Google Trends 2015 -

2.2 Motivacija

Motivacija je duševni proces, ki s pomočjo različnih motivov ali teženj, to so lahko potrebe, vrednote, želje, ideali ali nagoni, vodi vedenje ljudi in jih usmerja k določenim ciljem.[11] Delimo jo na notranjo in zunanjo motivacijo. »O zunanji motivaciji govorimo, kadar se učimo zaradi zunanjih posledic, kadar cilj ni v dejavnosti sami, ampak zunaj nje. Zunanja motivacija po navadi ni trajna, pogosto je povezana s pritiski, zaskrbljenostjo, posebej kadar ciljem, ki si jih zastavimo, nismo kos. Pri notranji motivaciji je cilj delovanja v dejavnosti sami in vir podkrepitve v nas. Prednost notranje motivacije je v vztrajnosti v zadovoljstvu, ko dosežemo cilj. Notranjo motivacijo povezujemo s spontanostjo, ustvarjalnostjo in širjenjem interesov. V ljudeh se prepletata želja po uspehu in strah pred neuspehom. Otrok se začne zavedati posebnosti storilnostne situacije po tretjem letu, srečni in zadovoljni otroci so običajno zdravi, sreča pa je vir motivacije za dejavnost.« [6]

2.3 Motivacija pri igrifikaciji

Huang in Soman trdita, da igrifikacija pomaga pri ljudeh, ki izgubijo motivacijo ali je sploh nimajo. Zakaj pride do tega?

Motivacija in zavzetost sta običajno predpogoja za dokončanje naloge ali spodbujanje določenega vedenja. Pri izobraževanju, učenju ipd. so razlogi za nižjo uspešnost po navadi dolgočasje ali pomanjkanje angažiranosti, večkratna odsotnost (ki se stopnjuje: večkrat je otrok odsoten, bolj je težko vzpostaviti motivacijo in zavzetost), zaradi česar posameznik ni pripravljen, da se posveti temi. Največkrat otroke moti tehnologija, kot so na primer pametni telefoni, internet … Podobno kot učenci v šoli, se s takimi izzivi soočajo tudi zaposleni, oziroma izvajalci programov za usposabljanje zaposlenih. Učenci ali zaposleni lahko kažejo nezanimanje ali minimalno zanimanje in s tem tudi majhno pozornost pri prejemanju znanja. To po navadi vodi v stres in vpliva na slabše razumevanje celotnega razreda oziroma skupine. Dodatno lahko vodi tudi v skupinsko nezadovoljstvo in slabe rezultate.

Igrifikacija kot oblika spodbujanja motivacije je današnjim generacijam v digitalni dobi zelo blizu. Gre za priljubljeno taktiko za spodbujanje določenega vedenja in povečanje motivacije ter angažiranosti. Najpogosteje jo najdemo v tržnih strategijah, obenem pa jo vključujemo že v številne izobraževalne programih v šolah, saj učiteljem pomaga najti ravnovesje med doseganjem ciljev in zadovoljstvom pri učencih [5].

Ljudje se velikokrat lažje poistovetijo z glavnim likom v igri in se na ta način hitro ubranijo oviram, kot so depresija, ciničnost ali razočaranost. Pri igrah se namreč lahko vključijo sami in se lažje s tem motivirajo ter tudi brez posledic igro večkrat poskusijo igrati. Z igro se dolgočasne ali vsakdanje naloge spremenijo v zanimive in jih lažje osmislijo. Motivirajo pa se lahko preko predstavitve praktičnih izzivov, spodbujanja, napredovanja po ravneh (stopnjah), vodenih izzivov in si tako sami prizadevajo dosegati najboljše rezultate. Igrifikacija omogoča vse te načine zraven doseganja zastavljenih ciljev preko vključevanja na čustveni ravni (poistovetenje z glavnim likom) to še dodatno motivira. Dodatno razbija večje naloge na manjše praktične izzive in igralce spodbuja, da napredujejo po ravneh do cilja: naučiti se nekaj novega. [5]

Na tak način se notranja in zunanja motivacija povežeta. Zunanja motivacija so ravni, točke, nagrade, misije … S tem spodbujajo naravno notranjo motivacijo, saj se posameznik odloči ali bo ukrepal ali ne. [7]

3 DAN DEJAVNOSTI

Ministrstvo za izobraževanje, znanost in šport (v nadaljevanju MIZŠ) je dneve dejavnosti dodelilo in opredelilo leta 1998. Opredelili so jih kot del obveznega programa osnovne šole in vsebujejo določene atribute kot so medpredmetno povezovanje, usvajanje in nadgrajevanje pridobljenega znanja z različnih področij, nadgrajevanje znanja s praktičnim učenjem, odzivanje na aktualne dogodke idr. Vsakemu dnevu dejavnosti je dodeljeno 5 pedagoških ur. Osmi razredi imajo 4 tehniške dni (v nadaljevanju TD). Izhodišča za dneve dejavnosti so vzpodbujanje vedoželjnosti, ustvarjalnost in samoiniciativnost učenk in učencev, usposabljanje za samostojno opazovanje in pridobivanje izkušenj ter znanja, za razvijanje spretnosti ter za

samostojno reševanje problemov. Pri TD učenci in učenke opazijo tehniški problem, ga raziščejo in zanj poiščejo rešitev ter jo preverijo. TD se povezujejo s cilji tehnike in tehnologije ter gospodinjstva. [8] Tehnika in tehnologija sta se od leta 1998 spremenili, kakor so se zamenjale določene vsebine. V tehniki je novost robotika, kjer se fizično računalništvo sreča s tehniko. Na podlagi tega smo se na osnovni šoli Antona Martina Slomška Vrhnika odločili, da naredimo na robotiki osnovane TD z vsebino, ki smo jo poimenovali programiranje. Vsebino smo predstavili osmim razredom.

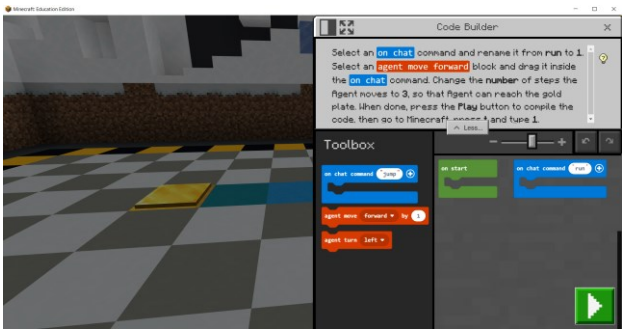
3.1 Organizacija in opredelitev TD programiranje

TD smo organizirali za učence osmih razredov, ki smo ga strukturirali na udeležencem čim bolj jasen način. Najprej smo predstavili, kako bo potekal celoten dan dejavnosti. Navedli smo, da se bodo spoznali z že znanimi temami, ki jih obnovimo, ponovimo ali morda za nekatere predstavimo na novo. Teme so obsegale oblačno računalništvo, spletne učilnice, varnost, deljenje dokumentov … Po predstavitvi tem smo prešli na programiranje s pomočjo igrifikacije.

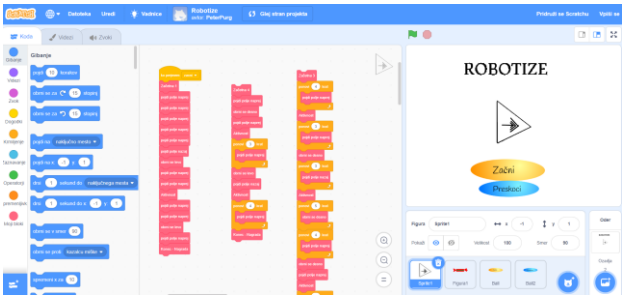
Tako kot večini ljudem, ki prvič slišijo besedo programiranje, je tudi veliko učencem to nekaj eksotičnega, morda celo nekaj, kar lahko malenkost odvrača. Še posebej tiste, ki so nevešči uporabe računalnika. Naslov članka razkriva, kako smo programiranje na čim lažji način predstavili učencem. Naš postopek je bil: recept, navodilo, algoritem. Za začetek smo učence pripravili na to, da zagotovo vedo, kaj skuhati ali speči. Nato smo jih prosili, da nam predstavijo recept za jed, ki so si jo morali sami izbrati (izbrali so si palačinke). Za tem smo primerjali, kako bi lahko to spisali kot navodilo, ki bi ga lahko razumel robot na višji taksonomski stopnji. Za razliko od recepta je to navodilo moralo biti veliko bolj natančno, sicer se bi lahko zgodilo, da bi ponev pri peki palačink ostala na štedilniku, brez da bi vklopili grelno telo. Takoj za tem pa smo dali učencem nalogo, da poskusijo to zapisati tako, da bi razumel računalnik. Takrat še pojma algoritem niso poznali. SSKJ pravi, da je »algorítem -tma m (í) mat. navodilo, ki določa vrsto in zaporedje operacij v računskem postopku: določiti algoritem; algoritem za deljenje večmestnih števil …« [9]. S tem smo jih želeli opolnomočiti, da računalniški jezik ni tako težek. Pomagali smo jim tudi z diferenciacijo po predznanju in jim dali različno težke naloge. Na voljo je veliko orodij, mi smo izbrali naslednje: Minecraft education edition, Pišek ACM, Poliglot, Vidra.si in nekaj, kar smo s pomočjo fizične aktivnosti in računalnika Robotize izumili sami. Slednje bo v nadaljevanju članka podrobneje opisano. Orodja smo jim postopoma prikazali in dali možnost izbire, da so lahko delovali po najboljših močeh. Seveda element učiteljske ali mentorske spodbude in vodenja ni manjkal. Bili smo prisotni, pozorni, jih bodrili, ko je to bilo potrebno in dajali ustrezne nasvete za nadaljevanje ter reševanje nalog.

4 ORODJA ZA UČENJE PROGRAMIRANJA

Večina orodij je zgrajenih tako, da s pomočjo igrifikacije uporabnika vodijo do znanja. Velikokrat koncentracija vseeno opeša, zato smo si zamislili, da morebitno monotonost prekinemo s posebnimi aktivnostmi. Zelo dobre so bile vsebine s strani Vidra.si, kjer preko nalog, ki se ne izvajajo na računalniku, poskusimo razložiti koncepte delovanja računalnika. Minecraft (Slika 3), Scratch (Slika 4), Pišek (Slika 5), Poliglot (Slika 6) in druga orodja so po navadi igre za učenje programiranja ali pa igri dodajo izobraževalni del za še dodatno motivacijo udeležencev z že znanim izgledom in načinom upravljanja. Za konec smo si pustili še Robotize – program, zapisan v Scratchu in je narejen tako, da vsebuje še fizični poligon ter nagrado.

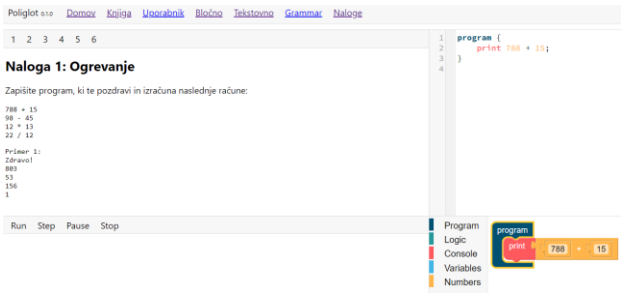


Slika 3: Minecraft education edition



Slika 4: Scratch in Robotize

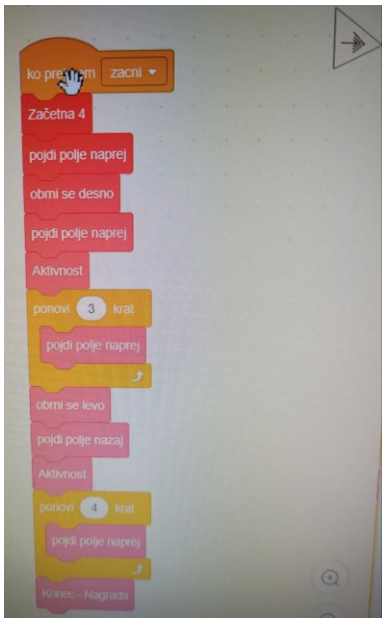
Slika 5: Pišek ACM



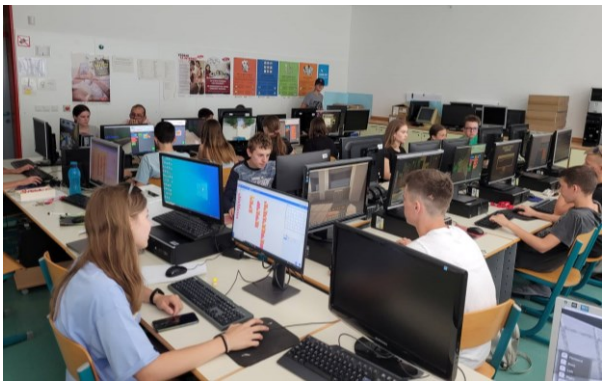
Slika 6: Poliglot

5 POVEZOVANJE DIGITALNE IN FIZIČNE IGRE

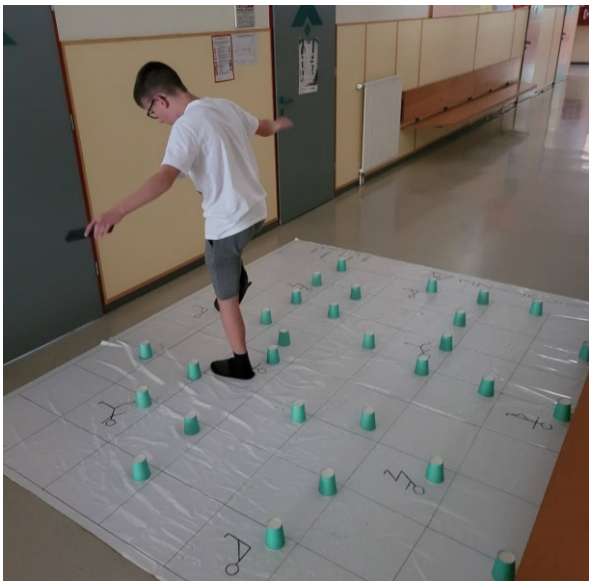
Za čim bolj kakovostno in razgibano izpeljavo omenjenega TD (Slika 8) smo v zaključek umestili igro, ki smo jo s svojimi bloki naredili v Scratchu in je oblika zgoraj opisane igrifikacije. Tako smo povezali še digitalno igro z fizičnim doživetjem (Slika 9) in dodali dva elementa presenečenja. Prvi element presenečenja je aktivnost na poti do cilja. Sam cilj pa zraven pohvali in uspeh podkrepi s sladkim presenečenjem. Ideja za Robotize je narejena na način kot iskanje skritaga zaklada. Za izvedbo je potrebno delo učencev v dvojicah in porazdelitev vlog, ki se nato lahko zamenjajo. Udeleženca se v paru dogovorita, kdo bo prevzel vlogo reševalca naloge in kdo programerja. Programer robotizira svojega partnerja tako, da mu pokaže kodo (Slika 7), s katero pride do cilja. Ta si jo fotografira bodisi s telefonom bodisi s tablico. Tako postane »robot«, ki izvaja nalogo po ideji programerja. V primeru, da je pravilno sledil algoritmu, na koncu dobi sladko nagrado. [10] Tako smo še dodatno razmigali učence in na kreativen ter igriv način zagotovili utrjevanje znanja, ki so ga pridobivali tekom TD.



Slika 7: Robotize algoritem



Slika 8: Del TD



Slika 9: Fizična aktivnosti pri Robotize

6 REZULTATI

Učitelji smo z uporabo igrifikacije in še posebej pripomočka Robotize izjemno zadovoljni. Nivo zadovoljstva smo preverili tudi pri udeležencih. Povratne informacije učencev so bile zelo dobre. Eden od pokazateljev njihovega zadovoljstva je tudi to, da se jih je na izbirne predmete računalništva vpisalo več kot prejšnja leta.

Učenci so z vpeljavo igrifikacije usvajali znanja in pridobivali kompetence, ki jih pri drugih predmetih v šoli ne pridobivajo. Urili so se v računalniškem mišljenju, kar pomeni, da so se spoznali z novimi metodami. Te metode udeležencem pomagajo pri spopadanju s čustvi, ko je učno okolje frustrirajoče. To pomaga pri vztrajanju ob neuspehu, kar so učenci prav tako potrdili. Velika večina je poročala o tem, da so nadaljevali z nalogami tudi, ko jim je padla koncentracija. Najbolj so jim bile všeč naloge, kjer so lahko iskali in popravljali napake programa. Tudi to je način učenja, ki ga drugače ne morejo izkusiti in jim je bil zelo všeč. TD in učenje računalniškega mišljenja jim je omogočil, da so spoznali samoregulacijsko učenje, reševanje velikega problema z razdelitvijo na manjše delčke, kako vztrajati

kljub neuspehom ter na tak način bolj kakovostno učenje in višanje psihološke odpornosti.

Za učitelja priprava takšnega TD predstavlja velik izziv. Tri različne razrede je potrebno razporediti na tri različne dni, saj je omejitev velikost učilnice. Dodatna omejitev je znanje ostalih učiteljev. Tema je zelo specifična in mora eden od učiteljev TD prevzeti kot glavni organizator in izvajalec. Njegova naloga je, da dobro premisli, kako bodo podane vsebine, da bodo postopne. Izbrati mora tudi prava orodja, da učencem ne bo pretežko ali prelahko in hkrati nekaj kar že poznajo, da jih pritegne. Odziv je bil zelo pozitiven in dobili smo dodatno motivacijo, da bi tak TD še naredili in morda vključil ostale učitelje. Tako bi lahko tak način dela vpeljali tudi pri drugih predmetih. Velika prednost igrifikacije je, da lahko z igrami motiviramo več starostnih skupin učencev. Kot slabost bi izpostavili predvsem tehnični vidik, saj morajo računalniki ali tablice delati brezhibno. V primeru, da ne delujejo brezhibno, hitro izgine motivacija, ki jo predstavlja igranje igre in hkrati učenje. Kot druga slabost, ki jo vidimo, je obvezno dodatno izobraževanje kadra, da bi lahko izpeljali TD za več razredov.

Kljub vsemu, je bila izkušnja tako dobra, da jo priporočamo vsem, ki so se pripravljeni lotiti nekaj novega ali nekaj drugačnega.

7 ZAKLJUČEK

Za učitelja je največja motivacija videti, da naš pristop zagotovi želene rezultate pri pridobivanju znanja za učence in načinu dela ter v tem, da pri učencih opazimo zadovoljstvo. Pri pripravi TD smo dejavnosti načrtovali tako, da bi učenci bili ves čas aktivni – miselno kot tudi fizično. Še posebej smo si obetali uspehe, saj novejši način poučevanja z metodo igrifikacije zunanje motivira udeležence tako, da spodbudi tudi notranjo motivacijo. Igrifikacija lahko na prvi pogled deluje zelo enoznačno. Vendar se v kratki zgodovini pojma, od leta 2002, spreminja in razume različno tako s strani strokovnjakov kot tudi zaradi jezikovnih razlik. Mi smo jo tolmačili kot digitalno ali fizično igro, ki je namenjena pridobivanju znanja. Gre torej za hvaležno obliko igre, ki se jo uporabi v izobraževalne namene. Učencem smo ponudili individualni pristop in prilagajanje vsebin glede na predhodno znanje. Monotonost, ki bi se lahko pojavila, smo razbili s fizično aktivnostjo, oziroma igro, ki je povezala digitalno in fizično sfero delovanja.

Metoda igrifikacije se je v našem primeru izkazala za izjemno koristno. Izpostavili bi, da je izid TD bil izjemno uspešen in je odtehtal možne pomanjkljivosti, ki jih lahko igrifikacija ima. Priporočili bi vpeljavo tudi pri drugih predmetih za usvajanje nove ali ponavljanje stare snovi.

Izzivi za naprej so gotovo usposabljanje večjega števila učiteljev in navduševanje za tako obliko dela. Morda bo ravno igrifikacija pripeljala do izboljšanja rezultatov učencev na prijazen način.

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LITERATURA IN VIRI

[1] Csabaa R., Damsab A. Kristófc G. A., Gamification on the edge of educational sciences and pedagogical methodologies. Dostopno na naslovu http://real.mtak.hu/74171/1/12.pdf (30.7.2022)
[2] Burke B., 2014. Gamify: how gamification motivates people to do extraordinary things. Bibliomotion, Inc., 109(1), 5–10. Dostopno na naslovu https://doi.org/10.1017/CBO9781107415324.004
[3] Pelling N., 2017. The (Short) Prehistory of "Gamification. Dostopno na https://nanodome.wordpress.com/2011/08/09/the-short-prehistory-ofgamification/ (2. 8. 2022)
[4] Google.com, Google Trends. Dostopno na naslovu https://trends.google.com/trends/explore?date=all&q=%2Fm%2F0cm8xv9 (29. 7. 2022)
[5] Huang W. H. and Soman D., 2013. A Practitioner's Guide To Gamification Of Education. Dostopno na naslovu https://mybrainware.com/wp-content/uploads/2017/11/Gamification-in-Education-Huang.pdf (5. 8. 2022)
[6] Podplatnik V., Motivacija. Dostopno na naslovu http://www.solazaravnatelje.si/ISBN/978-961-6637-29-9/61-62.pdf (1. 8. 2022)
[7] Muntaen C. I., Raising engagement in e-learning through gamification. 2011. Dostopno na naslovu http://icvl.eu/2011/disc/icvl/documente/pdf/met/ICVL_ModelsAndMethodologies_paper42.pdf (29. 7. 2022)
[8] Nacionalni kurikularni svet in Strokovni svet Republike Slovenije za splošno izobraževanje, Dnevi delavnosti, 1998. Dostopno na naslovu https://www.gov.si/assets/ministrstva/MIZS/Dokumenti/Osnovna-sola/Ucni-nacrti/Drugi-konceptualni-dokumenti/Dnevi_dejavnosti.pdf (30. 7. 2022)
[9] Inštitut za slovenski jezik Frana Ramovša ZRC SAZU in avtorji, Slovar slovenskega knjižnega jezika, 1970–1991, 1994, 1997, 1998, 2000, 2008, 2010, 2014. Dostopno na naslovu https://fran.si/iskanje?FilteredDictionaryIds=130&View=1&Query=algoritem (7. 8. 2022)
[10] ZRSŠ, Zbornik povzetkov SIRIKT, 11. mednarodna konferenca – Skupaj v izzive, 82-83, 2018. Dostopno na naslovu https://www.zrss.si/pdf/Sirikt2018.pdf (1. 8. 2022)
[11] Nanut P. A. in Škorjanc B. D., Umetnost učenja, 2013. Dostopno na naslovu http://www2.arnes.si/~lukoper9/umetnost_ucenja/kaj_je_motivacija.html (7.8.2022)
[12] Mikrosoftove izobraževalne vsebine https://education.minecraft.net/en-us
[13] Spletni pripomoček Vidra.si http://vidra.si/
[14] Spletni pripomoček Scratch https://scratch.mit.edu/
[15] Spletni pripomoček Poliglot https://poliglot.um.si/
[16] Spletni pripomoček Pišek https://pisek.acm.si/contents/4903/

Protokoli za preverjanje pristnosti uporabnikov

User Authentication Protocols

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POVZETEK

Pri razvoju programske opreme nenehno uporabljamo preverjanje pristnosti uporabnikov na podlagi gesel. Uporabniška gesla moramo varno shraniti tako, da se uporabniki lahko prijavijo, preverijo pristnost in spremenijo svoje geslo, hkrati pa napadalci ne morejo dešifrirati shranjenih gesel nazaj v čisto besedilo, tudi če jim uspe pridobiti dostop do baze podatkov, ki vsebuje uporabniške račune. Če uporabljamo ali razvijamo spletna mesta ali spletne aplikacije, imamo dostop po prijavi na podlagi uporabniškega imena in gesla. Enako lahko dostopamo z mobilnimi aplikacijami, spletnimi storitvami in drugimi sistemi zaščitenimi z gesli, saj vsi potrebujejo varno shranjevanje gesel. Razvijalci pogosto shranjujejo uporabniška gesla na svoja spletna mesta, aplikacije ali druge sisteme v zbirki podatkov, tako kot vse druge uporabniške podatke, vendar večina sistemov uporablja shemo zgoščevanja, šifriranja ali avtentikacije gesla. Članek med drugim ponuja pregled uporabe zgoščevalnih funkcij, razloži njihove lastnosti in uporabo v različnih domenah, možne napade in slabosti, kot tudi načine za okrepitev in izboljšanje zgoščevalnih funkcij. Predstavljena je pimerjalna analiza algoritmov zgoščevanja z namenom olajšati uporabniku izbiro najvarnejših algoritmov za svoje potrebe.

KLJUČNE BESEDE

Protokoli, preverjanje pristnosti, zgoščevalne funkcije

ABSTRACT

Password-based user authentication is used continuously in software development. User passwords must be stored securely so that users can log in, authenticate and change their passwords, while attackers cannot decrypt stored passwords back to plain text, even if they manage to gain access to the database containing the user accounts. If we use or develop websites or web applications, we have access by logging in with a username and password, the same as with mobile apps, web services and other password-protected systems, as they all need secure password storage. Developers often store user passwords on their websites, applications or other systems in a database like any other user data, but most systems use hash functions, encryption or authentication scheme. There are many ways to implement password storage for password-based authentication. The paper provides an overview of the use of hash functions, explains their properties and use in different domains, possible attacks and weaknesses, as well as ways to strengthen and improve hash functions. A comparative analysis of compaction algorithms enables users to choose the safest algorithms for their needs.

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KEYWORDS

Protocols, authentication, hash functions

1 UVOD

Sodobna kriptografija je namenjena izdelavi in analizi protokolov, ki premagajo grožnje informacijski varnosti. Zgoščevalna funkcija je ključna komponenta številnih aplikacij, od prevajalnikov, baz podatkov ali internetnih brskalnikov do videoiger ali omrežnih naprav. Nize različnih dolžin pretvori v nize s fiksno dolžino, znane kot zgoščene vrednosti ali povzetki. Ne glede na vhod je izhod pri zgoščevalni funkciji enake velikosti; če zgostimo eno besedo ali celo knjigo, bo izhod enake velikosti.

Zgoščevanje je algoritem, ki izračuna vrednost bitnega niza fiksne velikosti iz datoteke. Datoteka vsebuje bloke podatkov, ki jih zgoščevanje pretvori v veliko krajšo vrednost ali ključ s fiksno dolžino, ki predstavlja izvirni niz. Ena glavnih nalog zgoščevanja je primerjava dveh datotek med seboj. Ne da bi ju morali odpreti in primerjali besedo za besedo, bo izračunana zgoščena vrednost teh datotek takoj pokazala, ali sta različni. Zgoščevalno vrednost je mogoče obravnavati kot povzetek v datoteki [1].

V nadaljevanju bomo razložili uporabo zgoščevalnih funkcij, njihove lastnosti in uporabo v različnih domenah, možne napade in slabosti ter načine za okrepitev in izboljšanje zgoščevalnih funkcij. Osredotočili se bomo na primerjavo nekaterih algoritmov zgoščevalnih funkcij, s pomočjo katere lahko uporabnik izbere najvarnejše algoritme za svoje potrebe.

2 POSTOPKI ZGOŠČEVANJA

Zgoščevalne funkcije so kriptografski protokoli, ki temeljijo na bločnih šifrah in imajo pomembno vlogo pri varovanju sodobnih komunikacijskih sistemov, saj zagotavljajo preverjanje pristnosti podatkov. Uporablja se jih za varno kreiranje in shranjevanje gesel, iskanje podvojenih zapisov, anonimne kriptografske transakcije, hitro shranjevanje in pridobivanje podatkov ter v varnostnih aplikacijah, kot so digitalni podpisi, kode za

preverjanje pristnosti sporočil (MAC) in druge oblike avtentikacije. Močne zgoščevalne funkcije zagotavljajo celovitost podatkov, zaščitijo pred nepooblaščenimi spremembami, zaščitijo shranjena gesla in delujejo pri različnih hitrostih, da ustrezajo različnim namenom [1].

Zgoščevanje in šifriranje zagotavljata zaščito občutljivih podatkov, vendar je treba v skoraj vseh okoliščinah gesla zgostiti, ne le šifrirati. Zgoščevanje je enosmerna funkcija (nemogoče je "dešifrirati" zgoščevanje in pridobiti izvirno vrednost v navadnem besedilu) in je primerna za preverjanje gesla. Tudi če napadalec pridobi zgoščeno geslo, ga ne more vnesti v polje za geslo aplikacije in se prijaviti kot žrtev. Šifriranje je dvosmerna funkcija, kar pomeni, da je mogoče pridobiti izvirno odprto besedilo. Primerno je za shranjevanje podatkov, kot je naslov uporabnika, saj so ti podatki prikazani v navadnem besedilu v profilu uporabnika. Zgoščevanje njihovega naslova bi povzročilo popačeno zmešnjavo. Šifriranje se uporablja samo v primerih, ko je potrebno pridobiti izvirno geslo v navadnem besedilu.

Kot del postopka zgoščevanja je geslu lahko dodano soljenje (Salting), to je edinstven, naključno ustvarjen niz bitov. Ker je sol edinstvena za vsakega uporabnika, mora napadalec razbiti zgoščene vrednosti eno za drugo z uporabo ustrezne soli, namesto da enkrat izračuna zgoščeno vrednost in jo primerja z vsako shranjeno zgoščeno vrednostjo. Zaradi tega je razbijanje velikega števila zgoščenih vrednosti bistveno težje. Sol prav tako ščiti pred napadalcem, ki vnaprej izračuna zgoščene vrednosti z uporabo mavričnih tabel ali iskanj v bazi podatkov. Zaradi soljenja je nemogoče ugotoviti, ali imata dva uporabnika isto geslo, ne da bi razbili zgoščene vrednosti, saj bodo različne soli povzročile različne zgoščene vrednosti, tudi če sta gesli enaki. Sodobni algoritmi zgoščevanja, kot so Argon2id, Bcrypt in PBKDF2, samodejno solijo gesla.

Za dodatno zaščito lahko poleg soljenja uporabimo poper (Peppers). Namen popra je preprečiti napadalcu, da bi vdrl v katero koli zgoščeno vrednost, če pridobi dostop do baze podatkov, na primer, če je izkoristil ranljivost vbrizgavanja SQL ali pridobil varnostno kopijo baze podatkov.

Ena od strategij zgoščevanja je zgoščevanje gesel z uporabo algoritma za zgoščevanje gesel, ki se mu doda HMAC ali šifriranje zgoščenih vrednosti s simetričnim šifrirnim ključem, preden se zgoščena vrednost gesla shrani v bazo podatkov, pri čemer ključ deluje kot poper. Strategije popranja ne vplivajo na funkcijo zgoščevanja gesel. Za razliko od soli, pri popranju geslo ne sme biti shranjeno v bazi podatkov, temveč ga je potrebno hraniti v "skrivnih trezorjih" ali HSM-jih (Hardware Security Modules).

3 ALGORITMI ZGOŠČEVANJA

Pomembna naloga algoritmov zgoščevanja je preverjanje celovitosti sporočila. S primerjavo povzetkov sporočil izračunanih pred in po prenosu lahko ugotovimo, ali so bile v sporočilu narejene kakršne koli spremembe. Glavna razlika med algoritmi zgoščevanja je zgoščena vrednost, ki jo ustvari vsak algoritem. Varnostne lastnosti nekaterih najbolj pogosto rabljenih algoritmov so opisane v nadaljevanju.

MD5 je peta različica algoritma preusmeritve sporočil za izdelavo 128-bitnega povzetka sporočila. Je precej hitrejši kot druge različice povzetka sporočil MD. Na podlagi varnostnih anliz so številne varnostne organizavije ocenile, MD5 ni več varen za uporabo [5].

SHA je algoritem varnega zgoščevanja in je spremenjena različica MD5, ki se uporablja za zgoščevanje podatkov in potrdil. SHA je bil razvit in objavljen s sodelovanjem NIST in NSA leta 1993 kot zvezni standard za obdelavo informacij (FIPS PUB 180).

Zgoščevalne funkcije z oznako SHA (angl. Secure Hash Algorithm) so funkcije, ki se najpogosteje uporabljajo v kriptografiji. Hkrati z razvojem računalnikov kot tudi z razvojem različnih algoritmov kriptoanalize, so bile kriptografske funkcije vedno močnejše. Tako je NIST izdal standarde SH-0, SH-1, SH-2 in SH-3. Trenutno je še vedno najbolj aktualna uporaba funkcij iz družine SHA-2, v kateri so štiri zgoščevalne funkcije SHA-224, SHA-256, SHA-384 in SHA-512, ki so imenovane po dolžini prstnega odtisa, ki ga dobimo kot rezultat zgoščanja. SHA-2 je v osnovi sestavljen iz dveh zgoščevalnih algoritmov SHA-256 in SHA-512. SHA-224 je različica SHA-256 z različnimi začetnimi vrednostmi in okrnjenim izhodom. SHA-384 in manj znani SHA-512/224 in SHA-512/256 so vse različice SHA-512. SHA-512 je varnejši od SHA-256 in je običajno hitrejši od SHA-256 na 64-bitnih napravah, kot je AMD64. Zaenkrat SHA-2 še vedno velja za varnega in se pogosto uporablja. Bitcoin in nekatere kriptovalute uporabljajo SHA-256 v procesu rudarjenja.

SHA se uporablja pri vseh digitalnih podpisih in certifikatih, ki se nanašajo na povezave SSL/TLS. SHA uporabljajo aplikacije SSH, S-MIME (varne/večnamenske razširitve internetne pošte) in IPSec. SHA-ji se uporabljajo tudi za razpršitev gesel, tako da si mora strežnik zapomniti zgolj hashe in ne gesel

RIPEMD (RACE Integrity Primitive Evaluation Message Digest) je družina kriptografskih zgoščevalnih funkcij, z dolžinami 128, 160, 256 in 320 bitov. Temelji na principih oblikovanja, uporabljenem v MD4, in je po zmogljivosti podoben bolj priljubljenemu SHA-1.

Whirlpool je kriptografska zgoščevalna funkcija, ki temelji na bistveno spremenjeni različici naprednega standarda šifriranja (AES). To je funkcija razprševanja blok šifre, ki je zasnovana po kvadratni blok šifri. Vnese manj kot 2256 bitne dolžine in jo pretvori v 512-bitno razpršitev (64 bajtov).

Bcrypt je algoritem, zasnovan za shranjevanje gesel z enosmerno funkcijo zgoščevanja, ki se je izkazal za zanesljivega in varnega. Ta funkcija zgoščevanja gesel je bila zgrajena za upočasnitev napadov s surovo silo. Sol je vključena v postopek zgoščevanja, ki ščiti shranjene zgoščene vrednosti pred napadi z mavričnimi tabelami. Pogost primer uporabe je pretvorba gesla v n-bitni kriptografski ključ, ki se nato lahko uporabi za varno preverjanje pristnosti. Bcrypt zagotavlja zelo omejeno varnost in njegove slabosti so v veliki meri odpravljene z algoritmom za shranjevanje Scrypt [6][11].

Scrypt je počasna funkcija, zasnovana za ustvarjanje močnih kriptografskih ključev, npr. zasebnega ključa iz gesla, kjer je novi zasebni ključ daljši in varnejši. Zanaša se na visoke zahteve glede pomnilnika in ne na visoke zahteve glede procesorske moči. Scrypt je boljši od Bcrypt in ima široko uporabo z implementacijo tehnologij GPU, ASIC in FGPA. Od pojava algoritma Scrypt uporabljajo številne kriptovalute za implementacijo znotraj svojih protokolov. Scrypt nedvomno izboljša slabosti Bcrypta, vendar zaščita, ki jo zagotavlja, še

zdaleč ni popolna. Vrzeli Bcrypt in Scrypt so privedle do razvoja algoritmov za shranjevanje Argon2 [7].

Argon2 je sodoben kriptografski algoritem, ki je namenjen šifriranju gesel in omogoča varno shranjevanje vnosov. Velja za enega najbolj varnih in ga priporoča Open Web Application Security Project (OWASP). Zagotavlja visoko raven obrambe pred napadi, ki temeljijo na GPU, napade stranskega kanala ali celo oboje. Šteje se za izboljšavo algoritmov Bcrypt in Scrypt. Argon2 je optimiziran za arhitekturo x86 ter izkorišča predpomnilnik in pomnilniško organizacijo novejših procesorjev Intel in AMD.

Za ustvarjanje gesel Argon2 uporablja tri parametre: čas, pomnilnik in niti. Vsakega od njih je mogoče prilagoditi glede na potrebe in strojne vire, vendar se morajo vrednosti prilagoditi tudi glede na zmogljivosti strežnika [8].

Argon2i je učinkovit pri zaščiti pred napadi stranskih kanalov, Argon2d uporablja dostop do pomnilnika, ki je odvisen od podatkov, zaradi česar je primeren za kriptovalute in aplikacije varne pred grožnjami. Argon2i uporablja izoliran dostop do pomnilnika, ki je najboljši za shranjevanje gesel. Hibridna različica združuje prednosti 2i in 2d, da zagotovi popolno varnost. Argon2id deluje kot 2i vsaj 50 odstotkov prve iteracije v pomnilniku in kot 2d za preostale operacije [8].

BLAKE2 se tako kot BLAKE opira na algoritem ChaCha in je določen v RFC 7693. BLAKE2 je na voljo v sledečih različicah: BLAKE2b, BLAKE2 in BLAKE2x [3].

BLAKE3 je kriptografska zgoščevalna funkcija, ki temelji na Bao in BLAKE2. BLAKE3 je algoritem z veliko zaželenimi lastnostmi (vzporednost, XOF, KDF, PRF in MAC). Število krogov zmanjša z 10 na 7. Poleg tega lahko BLAKE3 učinkovito izkorišča večjedrne arhitekture in večnitnost, kar mu zagotavlja odlično razširljivost [4].

KangarooTwelve omogoča vzporedno zgoščevanje velikih datotek. Ima vgrajen vzporedni način, ki učinkovito izkorišča vzporednost ukazov pri več jedrih ali SIMD za dolga sporočila, ne da bi to vplivalo na zmogljivost kratkih sporočil. Zahteva manj računskega napora, medtem ko še vedno nudi udobno varnostno rezervo. Splošna varnost KangarooTwelve je zagotovljena z uporabo kodiranja Sakura za zgoščevanje drevesa [2].

PBKDF2 (Password-Based Key Derivation Function 2) je preprosta funkcija izpeljave kriptografskih ključev, ki je odporna na slovarske napade in napade mavrične tabele. Temelji na večkratni ponovitvi izpeljave HMAC. PBKDF2 preprečuje, da bi orodja za razbijanje gesel optimalno uporabljala grafične procesne enote (GPU), s čimer zmanjša hitrost ugibanj s sto tisoč ugibanj na sekundo na manj kot nekaj deset tisoč ugibanj na sekundo [9].

4 PRIMERJALNA ANALIZA

Predpostavljamo, da bo potreben kateri koli način zgoščevanja gesla v prihodnosti nadgraditi. Zagotoviti je potrebno, da bo nadgradnja algoritma zgoščevanja čim enostavnejša. Za prehodno obdobje je potrebno omogočiti kombinacijo starih in novih algoritmov zgoščevanja. Uporaba mešanice algoritmov zgoščevanja je lažja, če sta algoritem za zgoščevanje gesel in delovni faktor shranjena z geslom v standardni obliki, na primer modularni format niza PHC.

Glavne varnostne funkcije, ki so zdaj nepogrešljive za najsodobnejši način zgoščevanja gesla, vključujejo odpornost proti trkom, odpornost na podaljšanje dolžine in naključni izhod.

MD5 in SHA sta izjemno hitra, ko gre za izračun podatkov, vendar to ni nujno dobro za shranjevanje gesel. Hitrejše računalništvo olajša prevlado napadov s surovo silo. MD5 in SHA ne omogočata obvezne soli kot dodatne zaščite za shranjevanje zgoščenih gesel.

Bcrypt za razliko od MD5 in SHA vključuje dodatno zaščito, ki onemogoča prevlado napadov s surovo silo. Bcrypt se pogosto imenuje CPU algoritem, kar pomeni, da izračun ene zgoščene vrednosti v sistemu Bcrypt zahteva več ciklov procesorja. Za razliko od MD5 in SHA, Bcrypt poveča težavnost in neprepustnost vstopa v sistem s surovo silo. Bcrypt omogoča načrtovanje številnih iteracij z uporabo posebnih dejavnikov dela, ki upočasnjujejo hitrost računanja. Je tudi zahteven za hekerje, saj morajo uporabiti zelo drago opremo in porabiti ogromno časa za vdor v sisteme Bcrypt.

RIPEMD-160 je trenutno najbolj varen in temelji na konstrukciji Merkle–Damgård. Je okrepljena različica algoritma RIPEMD, ki proizvede 128-bitni razpršeni rezultat, medtem ko algoritem RIPEMD-160 ustvari 160-bitni izhod (20 bajtov). Do sedaj še niso zabeležili vdora v RIPEMD-160.

SCrypt je boljša izbira kot BCrypt, saj je bolje zasnovan zlasti v smislu pomnilnika.

Strinjamo se z mnenjem avtorjev [5], da je velika prednost Argona2 možnost izbire med načini zaščite. Drugi algoritmi nimajo te prilagodljivosti.

Bcrypt uporablja sol in je dražji kot Argon2 ter za ustvarjanje zgoščene vrednosti porabi več časa. Edina pomanjkljivost uporabe Bcrypt je, da je občutljiv za napade stranskih kanalov [11].

Bcrypt pa ne priporočamo za nove modele, kjer je vhodna vrednost žeton, ki ga ustvari človek (npr. geslo) in je v modelu groženj brez povezave, ker ima pomanjkanje pomnilniške trdnosti.

Scrypt je podoben Argonu 2 na način, da za računanje potrebuje čas, pomnilnik in niti. Prav tako zahteva veliko več pomnilnika v primerjavi z Bcrypt. Izhodni hash, ki ga uporablja scrypt, je vedno edinstven. Razbiti ga z uporabo surove sile bi bilo veliko težje kot razbiti geslo Bcrypt [11].

Priporočamo Scrypt, kjer je to najpreprostejša možnost za shranjevanje gesel v jeziku ali ogrodju, ki ga uporabljamo, na primer, če je že vgrajena možnost za zaščito uporabniških gesel.

Bilo je kar nekaj dokumentov, ki so preučevali varnostne dokaze Argona2, veliko več pa je preučevalo možne načine za pospešitev algoritma na namenski strojni opremi. Doslej je zelo dobro prestal nadzor.

Argon2i ni ranljiv za napade stranskega kanala, v nasprotnem primeru pa Argon2d je ranljiv za časovne napade. Lahko uporabimo hibridni pristop Argon2id, da dobimo najboljše iz obeh algoritmov. Priporočamo, da v prihodnje ne uporabljate PBKDF2 ali BCrypt in zato Argon2 priporočamo (po možnosti Argon2id) za novejše sisteme. Scrypt je lahko druga izbira v sistemih, kjer ima Argon2 določene pomankljivosti [8].

Argon2 je zgrajen okoli šifre AES, večina sodobnih procesorjev x86_64 in ARMv8 pa izvaja razširitev niza navodil AES. To pomaga zapolniti vrzel v zmogljivosti med predvidenim sistemom in namenskim sistemom za razbijanje. Novejše

različice Argona2 morda niso združljive z implementacijo AES v razširitvah strojne opreme.

Argon2 je še posebej odporen na napade kompromisov, ki presegajo pomnilniški delež ene tretjine, zaradi česar je veliko težje pospešiti na FPGA. To je zato, ker so rešitve za razbijanje, ki temeljijo na FPGA, večinoma omejene s pasovno širino pomnilnika, z zasnovo Argon2 pa mora napadalec porabiti veliko računskega časa, da zmanjša zahteve glede pasovne širine pomnilnika, zaradi česar je kompromis neučinkovit. Parametre trdote pomnilnika in trdote procesorja je mogoče konfigurirati ločeno, skupaj s faktorjem vzporednosti. To vam omogoča, da bolje prilagodite varnost, vezano na primer uporabe, kot je strežnik z zmerno močjo procesorja in veliko količino RAM-a.

PBKDF2 obstaja že dolgo časa in ni varen za uporabo: enostavno vzporeden na večjedrnih sistemih (GPE) in trivialen za prilagojene sisteme (FPGA/ASIC) [8].

V primerjavi s PBKDF2 in Bcrypt je Scrypt najbolj odporen na ranljivosti, povezane s pomnilnikom [8]

Scrypt obstaja že dlje, kar mu daje večjo izpostavljenost in več časa za odpravo morebitnih hroščev ali zapletov. Poleg tega teoretični rezultati o trdoti pomnilnika kažejo, da je Scrypt dobro zasnovan in zmanjšuje možnost katastrofalne okvare. Po drugi strani pa ima Scrypt dve veliki slabosti. Algoritem je odvisen od podatkov, kar pomeni, da obstaja možnost napada na stranskem kanalu.

V tem trenutku je SHA-2 standard za algoritme za razpršitev, čeprav bi bil lahko SHA-3. SHA-3 je na programski strani počasnejši, vendar je na strani strojne opreme vedno hitrejši od SHA-1 in SHA-2. Iz teh razlogov bodo organizacije prešle na SHA-3, ko bo SHA-2 postal nevaren ali zastarel.

BLAKE2 je kriptografska zgoščevalna funkcija, hitrejša kot MD5, SHA-1, SHA-2 in SHA-3, vendar je vsaj tako varna kot standardni SHA-3. Zaradi visoke hitrosti, varnosti in preprostosti so BLAKE2 sprejeli številni uporabniki.

BLAKE3 je zasnovan tako, da je veliko hitrejši kot MD5, SHA-1, SHA-2, SHA-3 in BLAKE2 ter varnejši od MD5 in SHA-1; avtorji trdijo, da je 128-bitno varen za vse varnostne cilje. To pomeni, da je BLAKE3 enako varen kot SHA3-256 in druge zgoščene vrednosti, ki ciljajo tudi na 128-bitno varnost. Eden od avtorjev BLAKE3 Jean-Philippe Aumasson trdi, da veliko simetričnih kriptografskih algoritmov uporablja preveč krogov in bi jih bilo mogoče narediti hitrejše z manj krogi, ne da bi to vplivalo na njihovo varnost.

Upoštevati je potrebno, da čeprav BLAKE3 močno prekaša druge zgoščene vrednosti, kot sta BLAKE2 in SHA-2/3, to ni edina kriptografska funkcija, ki zagotavlja takšno raven zmogljivosti. KangarooTwelve doseže približno enako prepustnost kot BLAKE3. KangarooTwelve je hitra in varna zgoščevalna funkcija, izpeljana iz Keccaka in je namenjena višjim hitrostim kot funkcije SHA-3, hkrati pa ohranja svojo prilagodljivost in osnovo za varnost. Ima 12 krogov namesto 24 in zmogljivost 256 bitov. Tabela 1 ponuja primerjavo tu analiziranih algoritmov glede na število besed, število blokov, izhodov in število krogov.

Bistvenega pomena pri shranjevanju gesel je način, ki preprečuje, da bi gesla napadalec pridobil, tudi če je aplikacija ali zbirka podatkov ogrožena. Poskušali smo analizirati in povzeti najnovejše kriptografske algoritme in se strinjamo z nekaterimi avtorji [5], da so KangarooTwelve, Scrypt, Bcrypt, BLAKE3 in Argon2 primerni, medtem ko MD5, SHA1, PBKDF2 in SHA256 niso preveč primerni za shranjevanje gesel.

Tabela 2: Primerjava zgoščevalnih algoritmov

Algoritem	Leto	Število besed	Število blokov	Število izhodov	Število krogov
ARGON2	2015	512	8192	1024	12
bcrypt	1999	184	96	128	16
BLAKE2	2012	32/64	1024	224/256/384/512	10/12
BLAKE3	2020	32	512	neomejeno	7
Kangaroo Twelve	2016	512	8192	neomejeno	12
MD4	1990	32	512	128	48
MD5	1992	32	512	128	64
RIPEMD	1992	32	512	128	48
RIPEMD-160	1996	32	512	160	80
RIPEMD-320	1996	32	512	320	80
SHA0	1993	32	512	160	80
SHA1	1995	40	512	160	80
SHA2	2002	32/64	512/1024	234/256/384/512	64/80
SHA3	2015	64	1152/1088/832/576	224/256/384/512	24
Whirlpool	2004	8	512	512	10

5 ZAKLJUČEK

Članek ponuja obsežen pregled kriptografskih zgoščevalnih protokolov. Zgoščevanje je bistveno orodje za računalniško varnost. Pomaga varovati podatke in ponuja pregled pri spreminjanju datotek in podatkov. Poleg tega njegove edinstvene lastnosti preprečujejo napadalcem, da bi izkoristili obratno inženirstvo za ogledovanje navadnega besedila ali izvirnih vhodnih podatkov. V kombinaciji z drugimi kriptografskimi orodji, kot je šifriranje, funkcija zgoščevanja podpira avtentikacijo, nezavrnitev podpisnika in celovitost podatkov pri uporabi digitalnih podpisov [10].

Zgoščevanje je zelo koristno kriptografsko orodje za preverjanje digitalnih podpisov, celovitosti datotek ali podatkov, gesel v informacijski tehnologiji. Kriptografske zgoščevalne funkcije se razlikujejo glede na funkcionalnosti in aplikacije za posebne namene. Velik del uporabe zgoščevanja vključuje razumevanje, katere algoritme zgoščevanja uporabiti (ali se jim izogniti) v določenih kontekstih [7].

Čeprav niso popolne, kriptografske zgoščevalne funkcije služijo kot odlične kontrolne vsote in mehanizmi za preverjanje pristnosti. Kot metodo za varno shranjevanje gesel (če je uporabljena tehnika soljenja) na način, ki je preveč nepraktičen, da bi jih kibernetski kriminalci poskušali spremeniti v nekaj uporabnega [6][7].

Namen članka je bil olajšati uporabniku izbiro najvarnejših algoritmov za svoje potrebe. Zato smo na tem mestu opisali, primerjali in povzeli najnovejše kriptografske algoritme. Ugotovili smo, da so KangarooTwelve, Scrypt, Bcrypt, BLAKE3 in Argon2 primerni, medtem ko MD5, SHA1, PBKDF2 in SHA256 niso preveč primerni za shranjevanje gesel. Upamo, da bodo te ugotovitve bralcem v pomoč.

LITERATURA IN VIRI

[1] Azad U:, Cryptographic Hash Functions, 2021, Dostopno na naslovu: https://linuxhint.com/cryptographic-hash-functions/ (22. 7. 2022)

[2] Bertoni G., Daemen J.: KangarooTwelve: fast hashing based on Keccak-p, 2022, Dostopno na naslovu: https://repository.ubn.ru.nl/bitstream/handle/2066/195384/3/195384.pdf (11. 7. 2022)

[3] BLAKE2, Fast secure hashing, 2017, Dostopno na naslovu: https://www.blake2.net/#co (11. 7. 2022)

[4] De Simone S.: BLAKE3 Is an Extremely Fast, Parallel Cryptographic Hash, 2020, Dostopno na naslovu: https://www.infoq.com/news/2020/01/blake3-fast-crypto-hash/ (11. 7. 2022)

[5] Fromaget P: What's The Best Algorithm For User Credential Storage In 2022? 2022, Dostopno na naslovu: https://infosecscout.com/best-algorithm-password-storage/ (20. 7. 2022)

[6] Preziuso M.: Password Hashing: Scrypt, Bcrypt and ARGON2, 2019, Dostopno na naslovu: https://medium.com/analytics-vidhya/password-hashing-pbkdf2-scrypt-bcrypt-and-argon2-e25aaf41598e (8. 7. 2022)

[7] Houston K.: Password hashing methods: PBKDF2, Scrypt, Bcrypt and ARGON2, 2021, Dostopno na naslovu: https://www-mo4tech-com.translate.goog/password-hashing-methods-pbkdf2-scrypt-bcrypt-and-argon2.html?_x_tr_sl=en&_x_tr_tl=sl&_x_tr_hl=sl&_x_tr_pto=op,sc (8. 7. 2022)

[8] Mehta, P.: What Is a Hash Function Within Cryptography, 2022, Dostopno na naslovu: https://securityboulevard.com/2022/06/what-is-a-hash-function-within-cryptography-quick-guide/ (15. 7. 2022)

[9] Owasp: PBKDF2, 2021, Dostopno na naslovu: https://cheatsheetseries.owasp.org/cheatsheets/Password_Storage_Cheat_Sheet.html#pbkdf2 (8. 7. 2022)

[10] Szostak, M.; How to improve user password security with Argon2? 2022, Dostopno na naslovu: https://www.boldare.com/blog/how-to-improve-user-password-security-with-argon2/ (8. 7. 2022)

[11] Wagner, L: Bcrypt Step by Step, 2020, Dostopno na naslovu: https://blog.boot.dev/cryptography/bcrypt-step-by-step/ (8. 7. 2022)

Finančno opismenjevanje v osnovni šoli

Financial Literacy in Primary School

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POVZETEK

V prispevku je predstavljen primer dobre prakse finančnega opismenjevanja na Osnovni šoli Antona Martina Slomška Vrhnika, ki poteka od 6. do 9. razreda pri pouku matematike in interesni dejavnosti Finančno opismenjevanje mladih. V okviru pouka matematike potekajo predstavitve, kjer učenci predstavljajo teme s področja financ. Izbirajo lahko med temami, ki jih ponudi učitelj ali pa si izberejo svojo. Pri interesni dejavnosti Finančno opismenjevanje mladih se celo šolsko leto pripravljamo na Nacionalni in evropski denarni kviz, ki se vsako leto izvede v mesecu marcu. Za potrebe kviza obravnavamo finančne pojme, tveganja, Evropsko unijo, denar, matematiko v financah in digitalno varnost. Zagotovo je za mlade zelo pomembno, da se izobražujejo tudi na področju financ, saj se bodo tako kot potrošniki bolj premišljeno odločali. Finančna pismenost v osnovni šoli je na zelo nizki ravni, zato bi morali v učne načrte vključiti več vsebin s področja financ.

KLJUČNE BESEDE

Finančna pismenost, osnovna šola, denarni kviz, Evropski teden denarja

ABSTRACT

The article presents an example of good financial literacy practice at the Elementary School, Antona Martina Slomška Vrhnika which takes place from the 6th to the 9th grade during mathematics lessons and Financial Literacy of Youth Club. Presentations are held as part of mathematics lessons, where students present topics from the field of finance. They can choose from the topics offered by the teacher or they can choose their own. In the Financial Literacy of Youth Club we prepare for the whole school year for the National and European financial quiz, which is held every year in the month of March. For the purposes of the quiz, we cover financial concepts, risks, the European Union, money, mathematics in finance and digital security. It is certainly very important for young people to be educated in the field of finance as well, as they, like consumers, will make more informed decisions. Financial literacy in primary school is at a very low level, so more financial content should be included in the curriculum.

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KEYWORDS

Financial literacy, primary school, money quiz, European Money Week

1 UVOD

Evropska komisija si je za eno izmed pomembnih prioritet postavila finančno opismenjevanje državljanov članic Evropske unije [1]. Finančna pismenost je v državah Evropske unije in ostalih državah sveta priznana kot pomemben element gospodarske in finančne stabilnosti ter razvoja.

V svetu in pri nas se v današnjih časih veča potreba po izobraževanju potrošnikov. Ti se v spremenjenih razmerah vse teže premišljeno odločajo. Še posebej to velja za področje finančnih storitev, ki je zaradi hitrega razvoja in pojavljanja vedno novih proizvodov izredno zapleteno. Potrošniki tako potrebujejo nekatere veščine, znanja in strategije, ki jim olajšajo vsakdanje odločanje [2].

2 FINANČNO OPISMENJEVANJE MLADIH

Finančna pismenost je zmožnost posameznika, da na osnovi finančnega znanja uporablja finančne pojme in postopke v različnih življenjskih situacijah; analizira, utemeljuje, vrednoti in učinkovito sporoča svoje zamisli in rezultate pri oblikovanju, reševanju in interpretaciji finančnih problemov v različnih življenjskih situacijah; sprejema odgovorne/utemeljene odločitve s prepoznavanjem razlik med željami, zmožnostmi in dejanskimi potrebami; pridobi zavedanje o vlogi finančnih veščin in pomenu ustreznega izobraževanja na tem področju za kakovostno vsakdanje in poklicno življenje [2].

Skoraj vsaka naša odločitev ima finančne posledice. Zelo pomembno je, da znamo racionalizirati naše finance, saj ima večina ljudi večje potrebe kot denarja na razpolago.

Finančno pismen posameznik ima pozitiven vpliv na družbo in če znamo upravljati s svojim premoženjem imamo zagotovljeno zadovoljno življenje.

Slabosti finančne nepismenosti so kupovanje neprimernih finančnih produktov, slabo razpršen denar, vlagatelji slabo poznajo zakonitosti varčevanja v delnicah, ljudje ne opravijo skrbnega pregleda naložbe pred vlaganjem, posamezniki imajo hudo nerealna pričakovanja, možnost finančnih piramid in prevar, poveča se stopnja zadolževanja in poslabša kvaliteta življenja.

Finančno znanje in razumevanje, veščine in sposobnosti ter odgovornost so brez pomena, če jih posameznik ne zna uporabljati v praksi, zato imajo vzgojno-izobraževalne ustanove

pomembno vlogo in nalogo na področju finančnega izobraževanja in finančne pismenosti [2].

3 OPIS DELA IN REZULTATI

3.1 Gradiva za učitelje

V nadaljevanju je prikazanih nekaj gradiv, kjer se učitelj lahko izobražuje na temo finančne pismenosti.

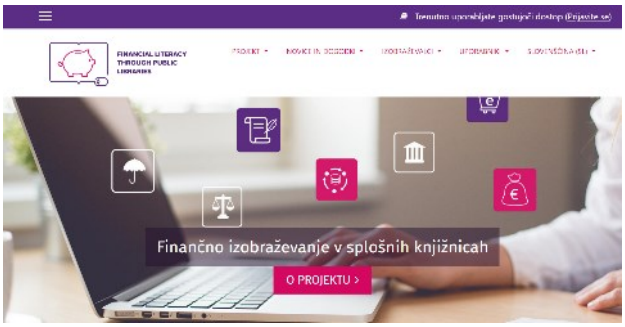
ZBS – Združenje bank Slovenije ima odlično spletno stran, ki je dostopna na https://www.zbs-giz.si/financno-opismenjevanje/. Spletna stran ima 3 zavihke (slika 1): Programi za OŠ, SŠ in odrasle, Nacionalni in evropski denarni kviz in Evropski teden denarja. Njihova gradiva uporabljamo pri interesni dejavnosti Finančno opismenjevanje mladih za pripravo na Nacionalni in evropski denarni kviz.

Slika 1: Spletna stran ZBS

Moje finance – ponujajo izobraževanje za učitelje, na katerega se prijavimo kar preko KATIS-a (slika 2). Seminar se imenuje Finančno izobraževanje učiteljev za mentorje finančnega opismenjevanja mladih. Seminar je plačljiv in v obsegu 20 ur. Na seminarju učitelj dobi dva priročnika za poučevanje, ki sta polna dobrih primerov in napisana kot priprava na učne ure. Stara spletna stran, kjer si lahko ogledate priročnika, je dostopna na naslovu https://mojefinance.finance.si/mf-narocam, nova spletna stran pa na naslovu https://www.financna-sola.si/. Oblikovali so Finančno šolo, kjer tudi najdemo koristne informacije za učitelje. Ponujajo tudi možnost sodelovanja šole v Tekmovanju iz finančne pismenosti.

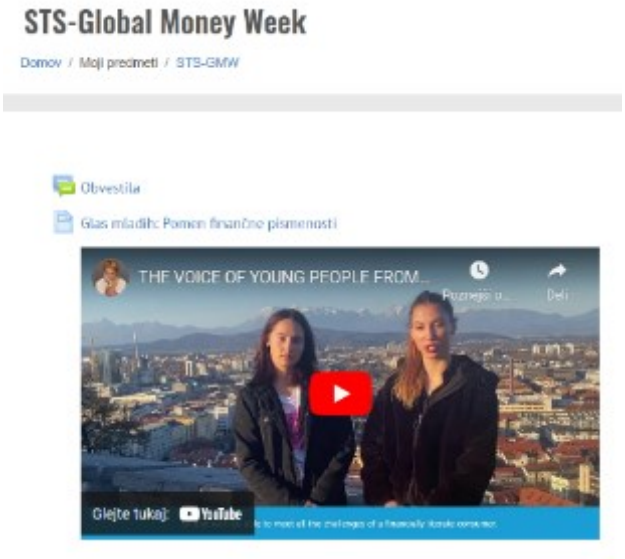
Slika 2: Izobraževanje za učitelje

FINLIT – Finančno izobraževanje v splošnih knjižnicah. Cilj projekta je zvišati stopnjo finančne pismenosti odraslih z novim pristopom preko številnih možnosti, ki jih nudijo splošne knjižnice kot neformalni izobraževalci, in preko ustanov za vseživljenjsko izobraževanje. Za uporabo spletne strani se moramo prijaviti, nato pa lahko izbiramo med več moduli. Več o projektu dostopno na https://finlit.eu/edu/?lang=sl (slika 3).



Slika 3: Spletna stran projekta FINLIT

ZRSŠ in projekt NA-MA – Del projekta NA-MA je tudi finančna pismenost. ZRSŠ je naredil gradivo, v katerem finančno pismenost opredeli in našteje gradnike. Publikacija je dostopna https://www.zrss.si/pdf/Financna_pismenost_gradniki.pdf. Prav tako se vsako leto pridružijo projektu Global Money Week (GMW), kjer lahko sodelujejo tudi šole, ki se prijavijo. Več o projektu dostopno na https://www.zrss.si/novice/o-financni-pismenosti-ki-jo-mladi-potrebujejo-za-uspesno-zivljenje/.
Projekt GMW ima tudi spletno učilnico, do katere dostopamo na https://skupnost.sio.si/course/view.php?id=10988. Za vstop v spletno učilnico sta potrebni AAI prijava in geslo. (slika 4). Tukaj najdemo odlična gradiva, ki jih lahko uporabimo v Svetovnem tednu izobraževanja o financah.



Slika 4: Spletna učilnica GMW

BANKARIUM – muzej bančništva na Slovenskem. Učence lahko peljemo na ogled muzeja, kjer se skupaj sprehodimo skozi zgodovino bančništva in denarja. Poleg ogleda muzeja ponujajo tudi različne finančne igrice in finančni labirint. Več o muzeju preberite na https://bankarium.si/.

BANKA SLOVENIJE – Banka Slovenije ponuja Izobraževalni dan, na katerem lahko izbiramo med več moduli in različnimi vsebinami. Več informacij na https://www.bsi.si/o-nas/izobrazevalni-dan. Mi smo Banko Slovenije že večkrat obiskali in bili zelo navdušeni nad delavnicami.

3.2 Predstavitve pri matematiki

V začetku šolskega leta smo učencem 6. – 9. razreda pri matematiki ponudili možnost, da izdelajo predstavitev na temo finančne pismenosti. Skupaj smo določili kriterije za izdelavo predstavitve. Učiteljica je ponudila nekaj tem, učenci pa so lahko izbrali tudi svojo temo. Izdelava ni bila obvezna za vse učence.

Prva predstavitev je bila raziskava o nakupu pametnega telefona. Učenki sta se spraševali pri katerem ponudniku telefonskih storitev najceneje kupiš nov telefon (Samsung Galaxy A22 5G) brez naročnine, kakšen je skupni strošek telefona in naročnine in v kateri spletni trgovini najceneje dobiš ta telefon brez vezave. Raziskali sta tudi prednosti in slabosti spletnega nakupovanja ter kaj pomeni zanesljiv ponudnik (slika 5). Učenki sta vse postavljene hipoteze zavrnili, saj sta v raziskavi prišli do ugotovitev, da je najcenejši ponudnik A1, skupaj z vezavo pa Telemach. Presenečeni sta bili tudi nad izrazom »navidezni nakup«, saj sta prvič slišali zanj in ga ob predstavitvi razložili.

Slika 5: Primer raziskave o nakupu pametnega telefona

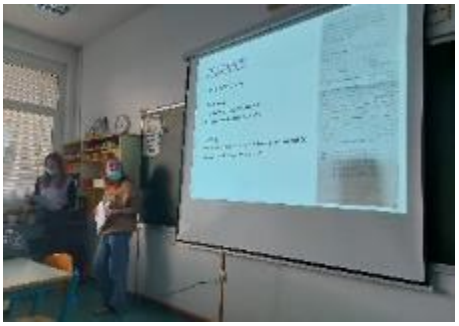
Učenci so raziskovali tudi, kako izbrati svoj sanjski poklic. To temo je izbralo več učencev. Zanimalo jih je, s čim si lahko pomagamo pri izbiri poklica, kateri so najbolj priljubljeni poklici, kakšna je razlika med bruto in neto plačo, kaj je poklic, kateri poklici izumirajo, katere poklice delodajalci najpogosteje iščejo, predstavili so kvize, ki pomagajo pri izbiri poklica ter predstavili nekaj poklicev. Naredili so tudi raziskavo med sošolci ter celo odigrali predstavitev različnih poklicev (slika 6).

Slika 6: Odigran prizor predstavitve poklica natakarja

Učenec 9. razreda je predstavil Banko Slovenije. Najprej je banko opisal, nato je povedal njeno zgodovino, predstavil Muzej Banke Slovenije in predstavil izobraževalne dneve, ki jih ponujajo (slika 7).

Slika 7: Predstavitev Banke Slovenije

Poslušali smo tudi predstavitve o davkih. Učenci so raziskali kaj je davek, zgodovino davkov, katere vrste davkov poznamo in opisali posamezno vrsto davka. Razložili so, zakaj je pomembno, da plačujemo davke ter kaj se zgodi, če davkov ne plačamo. Pokazali so plačilno listo in jo razložili. Učenci so naredili tudi primerjavo plačevanja davkov po državah EU (slika 8). Učenci so izvedli anketo med sošolci in ugotovili, da velika večina sošolcev pravilno ve, da plačujemo davke, da je bruto plača višja od neto plače in da večina sošolcev napačno misli, da če davka ne plačaš, ga kasneje plačaš dvojno.



Slika 8: Predstavitev o davkih

Raziskovali smo tudi poklice prihodnosti. Zanimalo nas je, kateri poklici so že izumrli, ali bo v prihodnosti več naravoslovnih ali družboslovnih poklicev, ali se bo v dvajsetih letih zmanjšalo število obrtniških del ter kateri zanimivo poklici bodo v prihodnosti pogostejši kot danes. Ugotovili smo, da se bodo pojavili nekateri poklici, ki jih danes sploh še ni na trgu (slika 9).

Slika 9: Predstavitev o prihodnosti poklicev

Učenki 6. razreda sta raziskali, kako s spletnim nakupom do najcenejše Milka čokolade (slika 10). Zanimalo ju je, katera vrsta Milka čokolade je najcenejša v spletnih trgovinah in kje najceneje kupimo Milka čokolado skupaj s poštnino. Ob koncu predstavitve sta nas postregli s koščkom čokolade in tako predstavitev še popestrili. Učenci so raziskovali še spletne nakupe nekaterih drugih izdelkov, kot so športni copati in računalniška miška.

Slika 10: Predstavitev spletnih nakupov

3.3 Interesna dejavnost Finančno opismenjevanje mladih

Vsako šolsko leto razpišemo interesno dejavnost Finančno opismenjevanje mladih. Prijavijo se lahko učenci 8. in 9. razreda. V sklopu interesne dejavnosti se pripravljamo na Nacionalni in evropski denarni kviz, ki ga organizira ZBS. Na interesni dejavnosti se dobimo vsak teden eno šolsko uro, pred kvizom pa večkrat po potrebi. Navadno se družimo v šoli, občasno tudi na Zoom urah. Na začetku šolskega leta naredimo uvod v finančno opismenjevanje, nato pa učenci na vsako uro prinesejo svoj pametni telefon, ki ga potrebujejo za pripravo na kviz. Učiteljica vsako šolsko uro projicira na tablo 2 – 3 kvize, ki jih učenci rešujejo preko telefona. Nato se o posameznih vprašanjih pogovorimo. Vprašanja, ki jih rešujemo, so v sklopih: finančni pojmi, tveganja, denar, digitalna varnost, Evropska unija in matematika. Vprašanja so prosto dostopna na https://www.zbs-giz.si/financno-opismenjevanje/. Učenci na interesni dejavnosti vsako leto zelo uživajo in se veliko novega naučijo. Marca se potem šola prijavi na tekmovanje, kjer tekmuje vsak učenec sam. (slika 11).

Slika 11: Nacionalni denarni kviz

V okviru interesne dejavnosti smo obiskali tudi Banko Slovenije, kjer smo poslušali zelo kvalitetna predavanja (slika 12). Izobraževanje poteka v prostorih Banke Slovenije na Slovenski 35 v Ljubljani. Mi smo izbrali teme: Kaj je Banka Slovenije?, Kaj so plačila in kako potekajo? (celostna ponazoritev prenosa denarnih sredstev med dvema subjektoma) in Gotovina (predstavitev aktivnosti pri izdajanju bankovcev in kovancev, količine denarja v obtoku, nadzora nad ponaredki ...). Predavanja so bila zanimiva in poučna, denar v rokah pa mamljiv. Izvedeli smo veliko novega. V času korone pa smo Finančno uro v 8. razredu izvedli kar na daljavo preko okolja Zoom.

Slika 12: Obisk Banke Slovenije

4 ZAKLJUČEK

Rezultati dodatnih preverjanj finančne pismenosti in reševanja problemsko zasnovanih situacij, ki so jih v Sloveniji izvedli v okviru raziskave PISA 2012, kažejo šibkejše rezultate slovenskih 15-letnikov od matematičnih in naravoslovnih dosežkov, ki so jih predstavili decembra 2013 [3].

V raziskavi PISA je Slovenija sodelovala leta 2012, kasneje ne več. Vendar iz prakse ugotavljamo, da je finančno znanje učencev šibko. Po večini se mladi ne zavedajo, da bodo za svoje finance odgovorni sami. V naših šolah moramo večji poudarek nameniti mladim, saj se samoiniciativno le redki izobražujejo o financah. Poslanstvo izobraževalnega sistema pa mora biti tudi zagotavljanje kakovostne finančne izobrazbe posamezniku. Na naši šoli bomo s finančnim izobraževanjem nadaljevali tudi v prihodnje in področje izobraževanja še razširili z obiskom različnih ustanov in predavatelji zunanjih inštitucij.

LITERATURA IN VIRI

[1] EPALE: Finančna pismenost. Dostopno na naslovu https://epale.ec.europa.eu/sl/taggar/financial-literacy (11.8.2022)

[2] ZRSS: Spodbujanje razvoja pismenosti v vrtcu in šoli. Dostopno na naslovu https://www.zrss.si/pdf/Spodbujanje_razvoja_pismenosti.pdf (11.8.2022)

[3] Pedagoški inštitut:Izhodišča merjenja finančne pismenosti v raziskavi PISA 2012 s primeri nalog. Dostopno na naslovu https://www.dlib.si/stream/URN:NBN:SI:DOC-XPSUSNHL/9e71ca13-b86e-4252-bce6-45d5b57e00df/PDF (11.8.2022)

Oglaševanje in izdelava oglasov na STŠ ŠC Kranj

Advertising and Creating Advertisements at STŠ ŠC Kranj

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POVZETEK

Izbira prave srednje šole in izobraževalnega programa je za posameznika zelo pomembna, vpis čim večjega števila dijakov pa je zaradi financiranje srednjih šol iz javnega proračuna po sistemu MOFAS zelo pomemben tudi za šolo samo. Prav zaradi tega se srednje šole borijo za vpis vsakega dijaka. Šola potrebuje splošno prepoznavnost s pozitivno konotacijo, ki pa jo je v času korona virusa težko izpostavila zaradi pomanjkanja različnih dogodkov, ki bi jih bilo možno oglaševati in organizirati. Članek opisuje načine oglaševanja, ki ga je izvedla Srednja tehniška šola iz Kranja in so se izkazali kot razlog za 9,56 % povečanje prejetih prijav v prvem vpisnem roku glede na preteklo leto in posledično skorajšnjo zapolnitev vseh razpisanih mest.

KLJUČNE BESEDE

Oglaševanje, marketing, šola, vpis, plakat

ABSTRACT

Choosing the right secondary school and educational program is very important for the individual, and the enrollment of as many students as possible is also very important for the school itself due to the financing of secondary schools from the public budget according to the MOFAS system. This is precisely why secondary schools strive to enroll every interested student. The school needs general recognition with a positive connotation, but during the corona virus it was difficult to highlight it due to the lack of various events. The article describes the methods of advertising carried out by the Secondary Technical School from Kranj, which proved to be the reason for the 9.56% increase in applications received in the first registration period compared to the previous year.

KEYWORDS

Advertising, marketing, school, enrollment, poster

1 UVOD

Na odpoved pouka, ki se je v preteklem letu zgodil zaradi pandemije korona virusa, marsikdo ni bil pripravljen. Tukaj govorimo tako o krovnih šolskih organizacijah kot tudi o šolah samih, učiteljih, učencih, starših in institucijah, ki s šolami neposredno sodelujejo [1].

Udeleženci izobraževalnega procesa so bili dokaj hitro primorani poglobiti nivo digitalne pismenosti ter usvojiti načine izvedbe pouka na daljavo, ki se je preselil iz učilnic v virtualni prostor. V virtualni prostor pa so se preselile tudi vse s poukom povezane aktivnosti, kot npr. roditeljski sestanki, govorilne ure, izvedba informativnih dni, ipd.

Srednješolsko izobraževanje je ena ključnih faz za razvoj posameznika tako v privatnem kot tudi v njegovem poklicnem življenju, zato je prava izbira srednje šole in izobraževalnega programa še kako pomembna.

2 PREDSTAVITEV PROBLEMA

Financiranje srednjih šol iz javnega proračuna po sistemu MOFAS, ki naj bi šolam omogočil predvsem učinkovitejšo organizacijo pouka zaradi večje avtonomije pri porabi denarja, s tem pa tudi njihovo odgovornost za porabo denarja in uspešnost, je pripeljalo do tega, da se srednje šole borijo za vpis vsakega dijaka.

Znano je dejstvo, da je najboljše priporočilo »od ust do ust«, zato je v prvi meri potrebno poskrbeti za kvalitetno izvedbo pouka, šolskih in obšolskih dejavnosti, dobre in korektne odnose, oz. na splošno ugodno šolsko klimo. Vendar pa vse prej zapisano še ni dovolj. Potrebna je tudi splošna prepoznavnost, ki je povezana s pozitivno konotacijo.

Predvsem v času korona virusa oz. z njim povezanega zaprtja javnega življenja, ko ni bilo organiziranih ekskurzij, športnih dni, kulturnih dni, prireditev, tekmovanj, ipd., je bilo potrebno najti inovativne načine za predstavitev šole v raznih medijih, ki bi med splošno javnostjo krepili pozitivno podobo šole, zainteresirano javnost pa nagovorili za obisk informativnega dne, ki po lastnih raziskavah v veliki meri vpliva na končno odločitev za vpis na srednjo šolo.

Kljub podobnosti pri načinih oglaševanja med različnimi šolami v npr. tiskanih medijih, radijskih objavah, televizijskih objavah, plakatih, objavah na družbenih omrežjih ipd., pa je vendar potrebno biti nekoliko drugačen. Ne želimo namreč biti eden izmed mnogih, pač pa pritegniti čim več pozornosti bodočih dijakov.

3 MARKETING IN OGLAŠEVANJE

Marketing in oglaševanje sta tesno povezani dejavnosti, vendar med njima obstajajo pomembne razlike. Oglaševanje je namreč le del marketinške celote, ki se neposredno nanaša na

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predstavitev organizacije. Razumevanje razlik med pojmoma pa lahko v veliki meri pomaga pri oblikovanju in izvedbi strategije za dosego zadanih ciljev.

O marketinškem ravnanju šol lahko govorimo, ko v šoli in zunaj nje potekajo dejavnosti, ki ji prinašajo konkurenčno prednost na trgu izobraževalnih storitev in so »raziskovalni element« do konkurenčnih šol. Marketing in marketinške dejavnosti v šoli se kažejo pretežno v [2]:

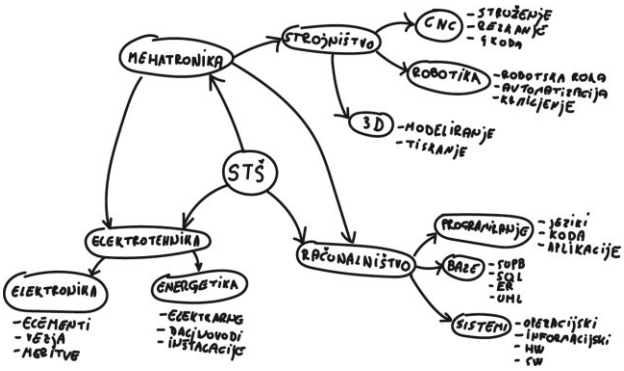
- pridobivanju učencev oziroma dijakov,
- približevanju dnevnih dejavnosti šole potrebam zunanjih odjemalcev in drugih sekundarnih uporabnikov,
- komercializmu v šolah.

Pojem oglaševanje bi lahko pojasnili tako, da bi rekli, da gre za plačano obliko komuniciranja znanega naročnika, ki uporabi različne medije, preko katerih želi vplivati na javnost. Ker gre za masovno komuniciranje, je oglaševanje neosebne narave [3]. Oglaševanje je zelo kompleksno, saj morajo oglaševalci doseči različne tipe ljudi. Nastanek enega oglasa zahteva ljudi z znanjem s področja ekonomije, oblikovanja, fotografije, filma, psihologije, jezikoslovja, umetnosti, kulture, računalništva... [4].

4 IZDELAVA OGLASOV

Če smo se v preteklem letu lahko izgovarjali da nas je situacija z zaprtjem šol presenetila, pa tega ne moremo reči tudi za letošnje šolsko leto, saj smo lahko pričakovali dokaj podoben scenarij. Devetošolcem, ki se vpisujejo v srednjo šolo, in njihovim staršem, ki v veliki meri vplivajo na njihovo odločitev o izbiri nadaljnjega šolanja, je torej potrebno kvalitetno predstaviti šolo in izobraževalne programe, za kar so dandanes potrebni inovativni pristopi.

Na Srednji tehniški šoli (v nadaljevanju STŠ) Šolskega centra Kranj smo se resno lotili oglaševalske kompanije, ki bi bila prilagojena tudi izvedbi informativnih dni na daljavo. Začelo se je s sestavo ekipe, ki je najprej izvedla viharjenje idej v povezavi z našo šolo. Tukaj smo želeli ugotoviti najbolj značilne elemente, ki bi jih vključili v oglaševane izdelke. Začetno viharjenje idej v obliki razvejanega miselnega vzorca omogoča iskanje in odkrivanje novih poti v prvih fazah oblikovalskega procesa [5]. Slika 1 prikazuje miselni vzorec viharjenja idej, ki smo ga narisali.



Slika 1: Miselni vzorec viharjenja idej

Sledila je opredelitev oglasnih medijev. Odločili smo se za izdelavo predstavitvenega filma, plakatov manjšega formata in plakata velikega formata. Vse izmed naštetih oglasov se lahko naknadno uporabi tudi kot digitalne oglase v spletnih medijih in na družabnih omrežjih.

Pri predstavitvenem filmu smo kot inovativnost oz. drugačnost od ostalih ravnatelja pretvorili v hologram. Na takšen način je predstavil šolo ter šolske in obšolske dejavnosti. Slika 2 prikazuje ravnatelja kot hologram v predstavitvenem videu.

Slika 2: Ravnatelj kot hologram

Plakate, ki smo jih izobesili po osnovnih šolah, krasijo fotografije najbolj tipičnih elementov posameznih smeri. Na vsaki sliki smo izkoristili učinke zunanjih dejavnikov pozornosti, npr. rdečo barvo, ki še posebej pritegne pozornost. Okvirji slik in povezave med njimi predstavljajo elektronsko vezje, vse skupaj pa predstavlja tudi črko »E«, ki neposredno predstavlja sodobno tehnologijo. Slika 3 prikazuje izdelan plakat manjšega formata.

Slika 3: Plakat manjšega formata

Za plakat večjega formata, ki je prikazan na sliki 4, smo izdelali novo grafiko, saj zanj veljajo posebna pravila, tako kar se tiče velikosti kot tudi dejavnikov pozornosti.

Slika 4: Plakat večjega formata

Podjetja imajo na razpolago ogromno kanalov preko katerih lahko oglašujejo: bodisi tradicionalni mediji ali pa kakšne novejše oblike oglaševanja, ki so v zadnjih letih močno porasle [4]. Z namenom, da bi oglasno sporočilo doseglo čim več potencialnih dijakov, smo ga objavili tudi v digitalni obliki na spletni strani in na družabnih omrežjih.

5 PREDSTAVITEV REZULTATOV

Merjenje rezultatov oglaševanja pri ne-spletnem oglaševanju je izredno zahtevno, zato si je pred začetkom oglaševanja najprej potrebno določiti specifične in merljive cilje. V našem primeru smo si zastavili cilj, da presežemo število pridobljenih prijav na našo šolo v primerjavi s preteklim šolskim letom v prvem vpisnem roku.

Tabela 1 prikazuje podatke pridobljenih prijav v vse programe na katerih smo imeli razpisana mesta, na dan 4. april v letih 2021 in 2022.

Tabela 1: Pridobljene prijave v letih 2021 in 2022

	2021	2022
Elektrikar	15	14
Mehatronik operater	23	30
Računalnikar	26	45
Elektrotehnik	22	38
Tehnik mehatronike	75	83
Tehnik računalništva	132	111
SKUPAJ	**293**	**321**

Iz tabele 1 je razvidno, da smo v letu 2022 prejeli kar 28 prijav oz. 9,56 % več kot v preteklem šolskem letu. Glede na podatke Statističnega urada republike Slovenije, da se je v prve letnike srednjih šol vpisalo zgolj 6,42 % več dijakov kot v preteklem šolskem letu (ponavljalci so iz tega odstotka izvzeti), zato lahko zaključimo, da je bil naš cilj v veliki meri dosežen.

6 ZAKLJUČEK

Prav zaradi vse večje ponudbe in konkurence na trgu izobraževanja se izobraževalne organizacije poslužujejo marketinga. Zavedajo se, da mora marketinški pristop temeljiti na potencialnih uporabnikih in njihovi odprti komunikaciji z morebitnim bodočim uporabnikom. Bistvenega pomena je, da ta komunikacija poteka tudi kasneje, ko so uporabniki že del te izobraževalne organizacije. Če želi šola pritegniti pozornost potencialnih uporabnikov, dobro predstaviti prednosti in koristi, ki jih bodo imeli uporabniki, če se vpišejo v določeno šolo, je pomembna učinkovita in uspešna promocija šole [2].

Izbira izobraževanja ni lahka, saj na trgu izobraževanja obstaja ogromno inštitucij in organizacij s takšnimi in drugačnimi izobraževalnimi programi, vse pa zagotavljajo, da je njihova institucija najboljša in da bomo z njihovo pomočjo dobili najboljše znanje za vse življenje. Na izbiro izobraževanja lahko vplivata starost otroka in omejitev vpisa. Vsekakor velja, da nižja kot je starost otrok, pomembnejši so starši. Oni so tisti, ki izberejo vrtec in osnovno šolo. Izbira srednje šole in fakultete pa je v večji meri odločitev učencev/dijakov, ima pa v tem primeru omejitev vpisa večji vpliv na izbiro institucije oz. izobraževalnega programa [2].

Na Srednji tehniški šoli Šolskega centra Kranj smo v šolskem letu 2022/23 na kar štirih od šestih programov (razvidno iz tabele 2) presegli omejitev vpisa. To na kratki rok pomeni, da bomo verjetno dobili dijake z boljšim učnim uspehom, na dolgi rok pa, da bomo v prihodnjem letu morali še dodatno iskati inovativne načine oglaševanja naših izobraževalnih programov.

Tabela 2: Razpisana mesta in število vpisanih dijakov v šolskem letu 2022/23

	Razpisanih mest	Vpis
Elektrikar	26	19
Mehatronik operater	26	36
Računalnikar	26	43
Elektrotehnik	56	47
Tehnik mehatronike	56	68
Tehnik računalništva	84	97

LITERATURA IN VIRI

[1] G. Strniša in drugi, "Discord kot platforma za izvedbo pouka na daljavo", Vzgoja in izobraževanje v informacijski družbi – Zbornik 24. mednarodne multikonference. Uredila: U. Rajkovič in B. Batagelj, Ljubljana, 8. oktober 2021. Institut "Jožef Stefan", Ljubljana.

[2] K. Pavec, "Vpliv informativnih dni na odločitev dijakov za nadaljevanje študija", diplomsko delo, Univerza v Mariboru, Fakulteta za organizacijske vede, Kranj, 2011.

[3] W. Wells, "Advertising, principles and practices. Engelwoods Cliffs: Prentice Hall, 1996.

[4] M. Krmelj, "Prikrito oglaševanje", magistrsko delo, Univerza v Mariboru, Ekonomsko-poslovna fakulteta, Maribor, 2015.

[5] D. Dabner in drugi, "Grafično oblikovanje: Priročnik za grafične oblikovalce tiskanih, digitalnih in večpredstavnih medijev", Tehniška založba Slovenije, Ljubljana, 2011.

Učenje risanja in spoznavanje novega IKT orodja

Learning To Draw and Getting To Know a New IKT Tool

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POVZETEK

V prispevku je predstavljeno projektno delo učenje risanja in spoznavanje z novim računalniškim orodjem v vrtčevski skupini petletnikov. Z otroki smo se pogovarjali o živalih (njihovem izgledu), si jih ogledali na spletu in se odločili, da lahko drugače, na bolj zanimiv način s pomočjo računalnika te živali tudi narišemo. Navaden papir smo zamenjali z računalniškim programom. Na mizo smo postavili računalnik, se seznanili z miško in odprli program za risanje (3D-slikar).

Omenjeni didaktični pristop je otroke motiviral, bili so bolj zbrani. Predstavljal jim je nov način učenja in je bil močno motivacijsko sredstvo, ki ni potreboval dodatnih stimulacij za delo. Pokazali so izjemno vztrajnost. Zavzeto so vlekli različne črte, krivulje in se trudili, da je njihova žival izgledala tako, kot jo vidimo v vsakdanjem življenju. Spoznali so slikarska orodja in se soočali z nagajivo miško. Rokovanje z njo ni bilo za vse najbolj enostavno. Predstavljala jim je izziv. Imeli so nekaj težav z vodenjem in s kliki. Dobro je bilo, ker so svoje umetnine lahko shranili in nadaljevali kasneje ali v naslednjih dneh. Pri dejavnosti so bili v ospredju otroci, ki so že imeli nekaj izkušenj z informacijsko-komunikacijsko tehnologijo od doma, zato smo jih spremljali in omogočili več ustvarjanja tudi ostalim, ki dela z računalnikom še niso bili vajeni. Delo je potekalo individualno in skupinsko. Spremljali so drug drugega in se izpopolnjevali. Med njimi je uspešno potekala komunikacija. Otroci so tako krepili fino motoriko in dobili nove izkušnje in znanje. Tako je bil naš cilj dosežen. Med dejavnostjo so aktivno sodelovali in si pomagali. Računalnik jim je bil zanimiv in zabaven vir informacij. Drug drugega so dopolnjevali. Njihova vztrajnost je bila nagrajena z uspehom. Nastale so zanimive umetnine, ki smo jih ob koncu aktivnosti tudi natisnili. Česa podobnega se bomo nedvomno še kdaj lotili, saj se je učenje risanja s pomočjo informacijsko-komunikacijske tehnologije izkazalo kot uspešen primer prakse, kjer je bilo prisotnega veliko smeha, sproščenosti, poglobljenega sodelovanja, vztrajnosti in uspešne komunikacije.

KLJUČNE BESEDE

Risanje, IKT, sodelovanje, sprostitev, predšolsko obdobje, učenje skozi igro

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ABSTRACT

The paper presents project work on learning to draw and getting to know a new computer tool in a kindergarten group of five-year-olds. We talked with the children about animals (their appearance), looked at them online and decided that we could draw these animals in a different, more interesting way with the help of the computer. We replaced ordinary paper with a computer program. We put the computer on the table, familiarized ourselves with the mouse and opened the drawing program (3D painter).

The mentioned didactic approach motivated the children, they were more collected. It presented them with a new way of learning and was a powerful motivational tool that did not need additional stimulation to work. They showed remarkable tenacity. They busily drew different lines, curves and tried to make their animal look like we see it in everyday life. They learned about painting tools and faced a mischievous mouse. Handling her was not the easiest for everyone. She presented them with a challenge. They had some management and click issues. It was good because they could save their artwork and continue later or in the following days. In the activity, the focus was on children who already had some experience with information and communication technology from home, so we accompanied them and enabled more creativity for others who were not yet used to working with computers. The work was carried out individually and in groups. They followed each other and improved. There was good communication between them. The children thus strengthened their fine motor skills and gained new experiences and knowledge. So that our goal was achieved. During the activity, they actively participated and helped each other. The computer was an interesting and fun source of information for them. They complemented each other. Their persistence was rewarded with success. Interesting works of art were created, which we also printed at the end of the activity. We will undoubtedly do something similar again, because learning to draw with the help of information and communication technology proved to be a successful example of practice, where there was a lot of laughter, relaxation, indepth cooperation, perseverance and successful communication.

KEYWORDS

Drawing, ICT, cooperation, relaxation, pre-school period, learning through play

1 UVOD

Pojem digitalna tehnologija povezujemo z različnimi predmeti, s katerimi se srečujemo v vsakdanjem življenju, od mobilnih telefonov, do tablic in računalnikov. Tako se že v zgodnjem obdobju življenja srečujejo z novodobno tehnologijo tudi otroci. Za razvijanje svojih potencialov pa potrebujejo spodbudno vzgojno-učno okolje (ugodna klima, miselni izzivi, sredstva) in kompetentne strokovne delavce [3].

Tehnologija je v zadnjih letih tako napredovala, da je smiselno, da se otrok z njo seznani že v zgodnjih letih. Informacijsko komunikacijska tehnologija ponuja veliko možnosti za razvoj otroka na različnih področjih. Na področju umetnosti lahko razvija umetniško predstavljivost, spoznava različne načine komuniciranja. Vse te cilje lahko dosežemo ob pravilni pripravi dejavnosti ter premišljeni izbiri aktivnosti s pripomočki digitalne tehnologije. Otroci so vse bolj spretni pri rokovanju s pametnimi napravami. Za uporabo moderne tehnologije so zelo motivirani, saj jih privlačijo številni multisenzorični dražljaji.

Kot pri vsakem vzgojnem izzivu tudi tehnologija ne pride kar naenkrat. Otroka moramo postopno navajati na vsebine, ki jih nudi IKT. Razumeti moramo vsako fazo otrokovega razvoja in ugotoviti, katero komponento tehnologije je treba v določenem trenutku obravnavati – na kaj je otrok pripravljen in, morda najpomembnejše, kako digitalni mediji prispevajo k zdravemu razvoju [1].

Kot vzgojiteljica predšolske vzgoje sem si zadala cilj, da izkoristim pozitivne lastnosti moderne tehnologije (večja motivacija otrok za izvajanje dejavnosti, dejavnosti so bolj razgibane, delovno okolje v igralnici je bolj dinamično, otroci so bolj motivirani in umirjeni).

Otrok v umetnosti ustvarja, izumlja, odkriva in oblikuje sliko. Tako lahko govorimo o otroški dejavnosti na področju umetnosti kot o umetniški dejavnosti otroka in o otroških umetnostnih delih. Taka dela nastanejo, ko ima otrok svobodo in se od njega pričakuje drugačnost, izvirnost. Prav to so odlike otroške umetnosti, ki jih gojimo in cenimo in po katerih jo tudi vrednotimo. Otrokova umetnost in okus sta izrazito osebne narave in se ju vedno opazuje, razume in presoja v okviru njegovega razvoja in življenjskega okolja [2].

2 POTEK DELA V SKUPINI

2.1 Uvodna motivacija

Z otroki smo se zbrali v jutranjem krogu. Pogovarjali smo se o živalih, ki jih imajo doma. Vsak izmed njih je povedal, katera žival ga spremlja, kako zanjo skrbi, kako izgleda in kaj si še želi. Drugi so ostalim zaupali, katero žival bi si želeli imeti ali katera žival se jim je najbolj vtisnila v spomin ob obisku živalskega vrta. Živali smo si ogledali v knjigah in kasneje tudi na spletu. Odprli smo program Google Chrome, vpisali v iskalnik ime živali in jo opazovali. Otroci so ugotovili, da nam računalnik nudi vse, kar nas zanima, in nam lahko poda kup informacij.

2.2 Glavni del (Uporaba 3D-slikarja)

Po ogledu vseh izbranih živali smo odprli računalniški program – 3D-slikarja in se seznanili z miško in vsemi ikonami, ki nam jih je program ponudil. Otroci so najprej preizkusili miško, kako gre naprej, nazaj, levo, desno. Morali so pridobiti občutek za drsenje. Miška se je pomikala iz ene strani proti drugi. Vse čas so urili koordinacijo ekran - miška. Drsenje po ekranu je bilo videti enostavno, a za posameznike ni bilo. Nekaj otrok se je prvič srečalo z njo in vztrajali so, dokler jim je bil računalnik na voljo.

S spretnostjo in vztrajnostjo so jo osvojili. Opazovali so drug drugega in se zabavali. Zanimanja ni manjkalo. Vsak posameznik si je nato ogledal 3D-slikarja in se poigraval z ikonami. Skupaj smo si ogledali 3D-oblike, čopiče, učinke, nalepke, kako izbrisati, če smo se zmotili, kako shranimo sliko, ki nam je všeč. Vse smo skupaj pregledali, preizkusili in se osredotočili na risanje izbranih živali. Vsak se je odločil, katera žival mu je najbolj všeč, in jo naslikal. Uporabili smo celo paleto barv. Sprva so bile živali bolj abstraktne in pisane. Z vajo pa so postale podobne tistim pravim iz živalskega vrta. Vsak posameznik je glasno razmišljal, kako jo bo pobarval in kakšen način barvanja uporabil. Otroci so izbirali med akvarelom, oljnim čopičem, pastelom, peresom, razpršilcem in označevalcem. Preizkusili so vse, kar smo si skupaj ogledali. Le miška ni vedno ubogala in črte so bile večkrat preveč ukrivljene in neenakomerne, tako da so žival večkrat pobrisali. Zabavno je bilo tudi radiranje. Tega ni manjkalo. Motivacije in zbranosti pa tudi ne. Med dejavnostjo so drug drugemu svetovali, kako naj riše in kakšno barvo uporabi. Vlekli so dolge sklenjene in nesklenjene črte. Poleg nasvetov, pa se je pojavila tudi kritika. Kako pa ti rišeš? Glej, tole ni podobno žirafi. Zakaj si naredil tako dolg rep? Toliko kot je bilo vprašanj, je bilo tudi odgovorov. Dejavnost je potekala 14 dni in še bi lahko nadaljevali. Vsak je narisal svojo najljubšo žival po svojem občutku in željah. Nastalo je veliko abstraktnih, unikatnih umetnij.

3 REZULTATI

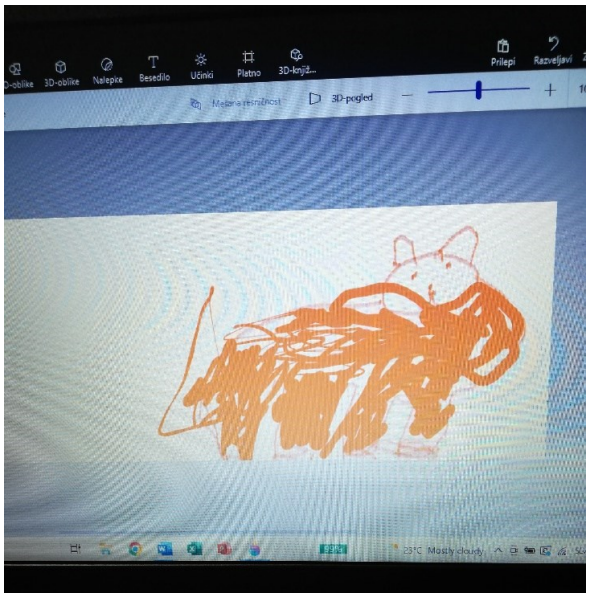
Otroci, stari pet let, so bili pri ustvarjanju svoje lastne umetnine dobro razpoloženi, vztrajni in osredotočeni na svoj cilj – kako narisati žival, ki so si jo izbrali. Koordinacija oko in miška sta bila v nenehni povezavi. Spremljali so vsak svoj klik in se učili. Iz dneva v dan jim je šlo lažje in rezultati so bili vidni. Raziskovali in uporabljali so vedno več ikon, kar je spodbudilo njihovo intelektualno rast. Krepili so ustvarjalnost in spomin. Kar pa je najpomembnejše, med dejavnostjo so zelo uživali. Primerjali so svoje umetnine, se smejali in se pogovarjali o izboljšavah. Izrazili so svoje težave in nazorno pokazali, kaj jim je bilo najtežje. Bili so zmožni samorefleksije. Nekateri rezultati so prikazani na slikah 1 do 4.

Na koncu smo vse izdelke shranili, natisnili in jih razstavili po igralnici. Nekaj le-teh je dodano spodaj v tej projektni nalogi.

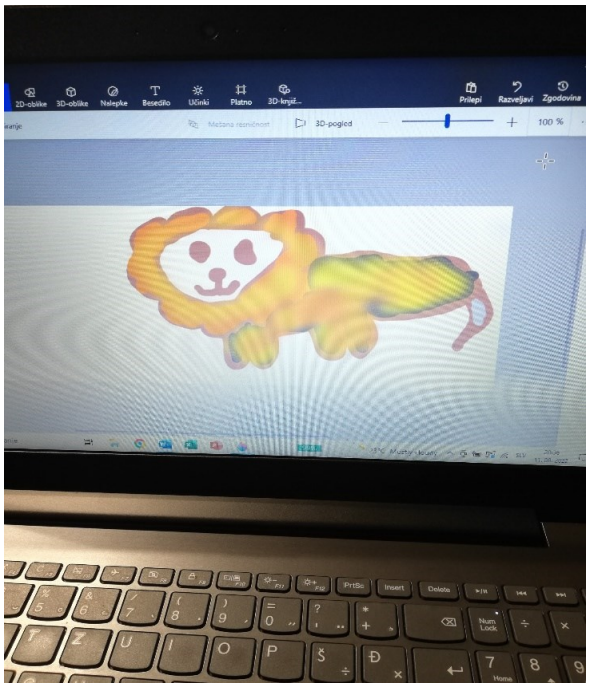
4 ZAKLJUČEK

Vključevanje IKT-orodja je zelo pomembo za vzgojno delo v današnjem času. Ko se otrok sooči z izzivom, se z vso pozornostjo in zavzetostjo usmeri k svojemu početju. Pri tem iz okolja vsrkava informacije, ki jih potrebuje za svoje ustvarjanje. Računalnik je močno motivacijsko sredstvo, ki ne potrebuje posebnih dodatnih stimulacij za delo. Skozi igro so otroci ves čas miselno aktivni in med seboj sodelujejo.

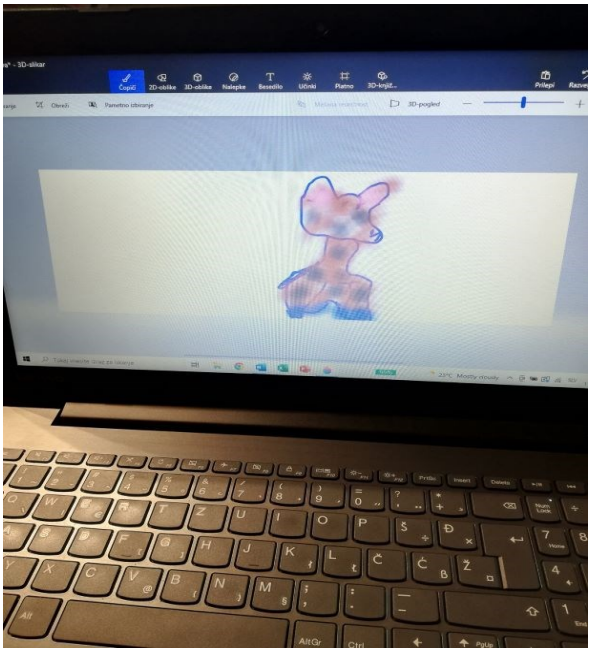
Likovno ustvarjanje s pomočjo računalnika v predšolskem obdobju predstavlja otrokom posebno doživetje. Spoznali so, da se ob računalniku lahko veliko naučimo. Projektno delo učenje risanja s pomočjo IKT-tehnologije se je izkazalo, kot nadvse uspešen primer prakse. Vsekakor je omenjeni didaktični pristop popestril vzgojno delo. Otrokom je bilo všeč procesno učenje ob učnem pripomočku, ki je multisenzoričen. Ob tem so spoznali, da se na računalniku lahko veliko naučimo, da nam ponuja mnogo možnosti. Postavili smo temelje in sedaj bomo gradili naprej. Zadovoljna pa sem bila tudi sama, saj so otroci pokazali veliko volje, vztrajnosti, kritičnega mišljenja, kreativnosti ter sposobnosti povezovanja in sodelovanja v skupini, kar je v današnjem času še kako pomembno. Tako so bili doseženi vsi predvideni vzgojni in učni cilji projektne dejavnosti.



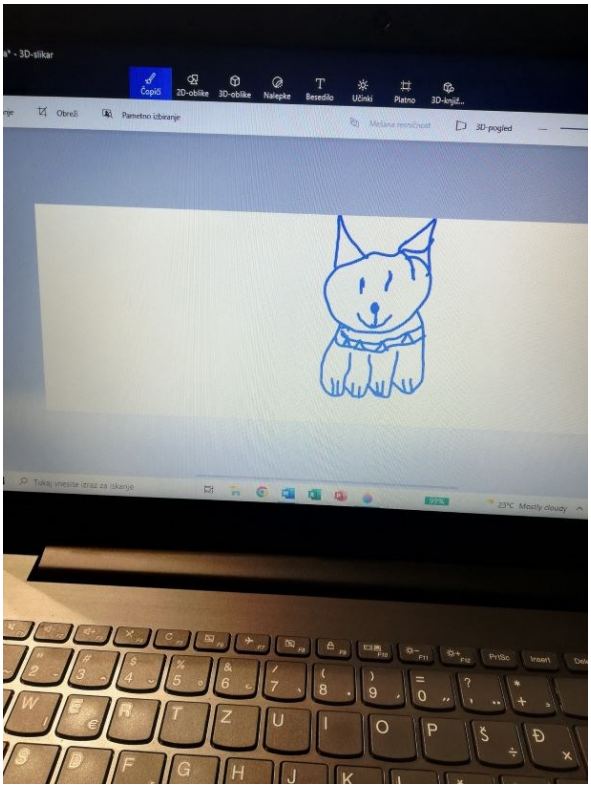
Slika 1: Gepard



Slika 2: Lev



Slika 3: Žirafa



Slika 4: Pes

VIRI IN LITERATURA

[1] Gold J. 2015. Vzgoja v digitalni dobi. Ljubljana: Založba Didakta.
[2] Kurikulum za vrtce. 2009. Ljubljana: Ministrstvo za šolstvo in šport, Urad Republike Slovenije za Šolstvo.
[3] Usar K., Jerše L. 2016. Smernice za vključevanje IKT v vrtcu. Ljubljana: ZRSŠ.

Razvijanje digitalne pismenosti na razredni stopnji s pomočjo aplikacije BookCreator

Developing Digital Literacy at the Class Level Using the BookCreator Application

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POVZETEK

Digitalna tehnologija je nujno zlo vsakega posameznika. Otroci se z njo rokujejo že zelo zgodaj, pri čemer je pomembno, da jim jo starši in kasneje strokovni delavci predstavijo na pravilen način ter da je njena uporaba nadzorovana. IKT otrokom z nižjo starostno stopnjo predstavlja predvsem igro, ki je v otroštvu najpomembnejša dejavnost, ki jo moramo spodbujati in podpirati. S pomočjo IKT lahko pri otrocih spodbujamo ustvarjalnost, logično razmišljanje, jezikovni razvoj, povečajo pa se tudi njihova samozavest, splošna razgledanost in socialne spretnosti. Kot učiteljica razrednega pouka se zavedam, da je treba otroke pravi čas digitalno opismeniti, jim ponuditi kakovostne in preverjene aplikacije, igre, spletna okolja, ki zagotavljajo celovit razvoj njihovih možganov in spodbujajo njihov razvoj tudi na vseh ostalih področjih. Na razpolago je ogromno orodij in aplikacij, zato je prav, da jih učitelj pred uporabo s pomočjo preglednic analizira, preveri njihovo učinkovitost in uporabo.

V prispevku bomo predstavili primer uporabe aplikacije BookCreator pri predmetu družba v četrtem razredu osnovne šole. S pomočjo aplikacije BookCreator smo skozi pouk o domači pokrajini vpeljali digitalno opismenjevanje, s tem pa zagotovili nov način spoznavanja snovi, pripomogli h kakovostnejši in raznovrstnejši vsakodnevni dejavnosti v razredu in zvišanju nivoja tehnološke pismenosti kot tudi samega učitelja.

KLJUČNE BESEDE

Digitalna pismenost, BookCreator, razredna stopnja

ABSTRACT

Digital technology is everyone's necessary evil. Children use it from a very early age, and it is crucial that parents and later professionals present it to them correctly and control its use. ICT for children with a lower age level is primarily a game, but it is the most important activity in childhood that we must encourage and support. With the help of ICT, creativity, logical thinking, and language development can be encouraged in children, and self-confidence, general awareness and social skills also increase. As a classroom teacher, I know how important it is to start digital literacy at the right time and offer them quality and proven applications, games, and online environments that ensure comprehensive brain development and encourage development in all other areas. There are many tools and applications available, so it is good for the teacher to analyse them with the help of spreadsheets before using them to check their effectiveness and use.

In this article, we will present an example of using the BookCreator application, in the subject social science, in the fourth grade of elementary school. By introducing the BookCreator application, we introduced digital literacy through the lessons of the home landscape, thereby providing a new way of learning the subject, contributing to higher quality and more diverse daily activities in the classroom and increasing the level of technological literacy as well as that of the teacher himself.

KEYWORDS

Digital literacy, BookCreator, grade level

1 UVOD

Potreba po tehnološkem opismenjevanju se vzpenja iz dneva v dan. Tehnološka rast, industrializacija in vse svetovne spremembe silijo tudi vzgojno izobraževalne ustanove, da omogočijo učenje in razvoj vseh tistih, ki bodo postali znanstveniki, inženirji, tehniki in delavci (Avsec in Sajdera, 2019; Herschbach, 1997).

Kadar govorimo o vključevanju digitalne pismenosti, je izredno pomembno, da se strokovni delavci zavedamo, da smo z njo v prvi vrsti suvereni ter da s tem omogočamo dodano vrednost in dobro motivacijo pri svojem delu.

Tehnološka pismenost obsega tri dimenzije: znanje, način razmišljanja o delovanju in zmožnosti. Obsega tudi sposobnost uporabe, razumevanja, vrednotenja in uporabe tehnologij (Garmire in Pearson, 2006).

Če želimo uvesti smiselne dejavnosti, je treba dobro poznati otrokov razvoj, otroke v svojem razredu in njihove želje, predvsem pa njihovo individualno sposobnost in zahtevnost. Na področju kognitivne psihologije je bilo ugotovljeno, da IKT otrokom omogoča optimalen razvoj njihove raziskovalne aktivnosti. Stopnja razvoja je odvisna od spodbud okolja in količine izkušenj otrok (Novak s sod., 2013).

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Veliko aplikacij je izdelanih v tujem jeziku, kar predstavlja dokaj velik problem uporabe na razredni stopnji, saj morajo biti aplikacije otrokom prijazne, sicer jih lahko njihova uporaba odvrne že na samem začetku. Učitelj mora izbirati aplikacije, primerne starostni stopnji, poskrbeti pa mora tudi, da jih pred uporabo učencem predstavi in jih seznani z njihovo uporabo.

2 PREDSTAVITEV APLIKACIJE BOOKCREATOR

BookCreator je preprosto orodje za oblikovanje digitalnih knjig. Orodje je uporabno tako za učitelja kot za učence. Učitelj lahko pripravlja različna gradiva, ki jih pri pouku uporabi za demonstracijo ali pa za nadaljnje delo učencev. Možno je tudi, da učenci samostojno ustvarjajo lastne izdelke. Izdelujejo lahko interaktivne zgodbe, digitalne portfolije, raziskovalna besedila, pesmi, znanstvena poročila, navodila za uporabo, predstavitve itd.

Orodje je za delo z računalnikom dostopno na spletni strani https://BookCreator.com/, lahko se uporablja tudi na tabličnem računalniku. Za iPad je dostopno na: https://itunes.apple.com/us/app/book-creator-for-ipad/id442378070?mt=8.

2.1 Primer dobre rabe pri pouku družba

Pri prvi učni uri smo se z učenci pogovarjali o naravni dediščini in si v domači pokrajini ogledali njene primere. V naslednji šolski uri so učenci samostojno prebrali krajše besedilo o pojavu iz naravne ali kulturne dediščine iz domače pokrajine. Na razpolago so imeli naslednje pojave: soteska Zelenjak, ribnik Trebče, Žurajev hrast, skalno okno, razvaline gradu Kunšperk, Kravaričeva domačija itd. V zvezek so si zapisali pomembne podatke.

Sledila je predstavitev orodja BookCreator in samostojno ustvarjanje strani v knjigi. Učenci so izdelali naslovno stran z risbo in zemljevidom, napovedali naravne in kulturne pojave ter en pojav tudi predstavili. Nekaj ur kasneje, po obravnavi poglavja dejavnosti, smo v knjigo dodali novo stran na temo dejavnosti v domači pokrajini. Učenci so morali narisati in napisati gospodarske in negospodarske dejavnosti v svojem okolju. Načrtujemo, da bodo učenci knjige dopolnjevali in e-knjižica bo do konca šolskega leta dobila svojo celostno podobo.

Delo z aplikacijo je potekalo individualno. Preden smo se lotili konkretnega dela, smo skupaj pregledali aplikacijo, prevedli določene ikone, izdelali vzorčni primer. Orodje je v angleščini, vendar vsebuje preproste besede in besedne zveze, poleg tega pa vsebuje nazorne ikone (slika, fotoaparat, besedilo, mikrofon, oblike, spletne povezave). Uporaba orodja je sicer zelo preprosta in učenci so jo hitro usvojili. Svojo knjigo so izdelovali s tabličnim računalnikom.

Pri pouku družbe so učenci z uvajanjem aplikacije BookCreator dosegli naslednje cilje:

- poznajo naravne osnove za nastanek in razvoj domačega kraja za življenje,
- spoznajo gospodarske in druge dejavnosti, različne poklice,
- prepoznajo in analizirajo varne in manj varne poti za pešce in kolesarje,
- poznajo različne dejavnike, ki vplivajo na ravnanje udeležencev v prometu, na primerih analizirajo in presojajo strategije ravnanja pešcev in kolesarjev,
- razumejo vlogo posameznika v skupnosti pri skrbi za urejenost domačega kraja,
- vrednotijo urejenost domačega kraja z vidika različnih potreb ljudi, varovanja okolja ter naravne in kulturne dediščine.

Naš projekt se je začel s pojmovno mapo o kraju Šentjur. Učenci so nizali ideje in dejstva o njihovem kraju. Pripovedovali so o svojem domu in počutju v kraju, kjer živijo, o stvareh, ki jih pogrešajo, so jim všeč itd. S pomočjo Google zemljevida so na interaktivni tabli pokazali svoj dom. Hitro smo ugotovili, da kljub temu da vsi živijo v isti občini, ne poznajo vseh vasi, ulic in zaselkov. Ker je bilo njihovih idej in zgodb o njihovem kraju preveč, smo se odločili, da bo vsak o svojem kraju, o svojem zaselku napisal zgodbo, ki jo bo potem predstavil svojim sošolcem. Idejo zasnove zgodbe smo medpredmetno povezali še z ostalimi predmeti. Učenci so si lahko izmislili kakšno pesem, rimo na temo njihovega kraja in jo kot zvočni posnetek vstavili v njihovo predstavitev. Lahko so posneli okoliš in video vpeli v stran v knjigi, pri likovni umetnosti pa so lahko kaj poustvarili na temo njihovega kraja in v knjigo dodali ilustracijo ipd. Ideje so bile skupne, končni izdelek pa je bil izviren in na podlagi zamisli vsakega posameznika. Projekt je potekal tri tedne, pri vseh urah družbe in tudi doma, saj so si učenci šolske tablice izposodili tudi za domov.

Na koncu so svojo knjigo predstavili najprej svojim sošolcem, nato so svoje različice še natisnili in jih odnesli v knjižnico na razstavo, najprej šolsko, nato pa še v mestno knjižnico. Izvedli smo natečaj za najboljšo napisano knjigo in jo ob občinskem prazniku poslali županu občine Šentjur.

3 PREDNOSTI IN SLABOSTI APLIKACIJE

Poleg tega da je aplikacija preprosta za uporabo, učitelju omogoča povratno informacijo o samem učenčevem izdelku. Izdelek si lahko ogledamo v samem orodju, izvozimo v PDF obliki in natisnemo. Izdelke lahko tudi posredujemo v e-obliki, jih objavimo, za kar pa je potrebna prijava z e-pošto. Oblikovanje je zelo enostavno in ponuja veliko funkcij, izbiramo lahko tudi med različnimi vrstami oblik podlage. Aplikacija tako omogoča učenčevo ustvarjalnost in domišljijo, navsezadnje pa tudi socialno povezanost, ko se izdelek zaključi, saj ga lahko deli s širšo množico.

Vse izdelke si lahko ogledamo v samem orodju ali pa jih iz orodja izvozimo v PDF obliki ali v obliki videoposnetka. PDF oblika omogoča, da izdelke natisnemo ali posredujemo v e-obliki. Prav tako lahko učitelj izdelke objavi (potrebna prijava z e-pošto). Orodje ponuja veliko funkcij (fotoaparat, risanje, snemanje zvoka, videoposnetek) in kombinacijo vsega. Lahko se izbira tudi med različnimi vrstami oblik podlag.

Orodje ima več prednosti kot slabosti. Kot učiteljica, ki spodbuja sodelovalno delo, pri aplikaciji pogrešam, da bi lahko skupno knjigo oblikovalo več učencev hkrati, da bi svoje zapise delili in ustvarili sodelovalno delo. Še ena pomanjkljivost, ki smo jo zaznali, je ta, da lahko z brezplačno različico izdelamo le eno knjigo z več stranmi. Možno je tudi, da vsak učenec izdela po

eno stran, učitelj fotografira izdelke in sestavi eno knjigo z več stranmi različnih avtorjev.

4 ZAKLJUČEK

Popestritev vsakodnevnih dejavnosti v razredu je zelo dobrodošla, tako za učitelja kot učence. Vsekakor lahko to drugačnost v veliko primerih dosežemo z digitalno pismenostjo. Vsako vsebino, ki jo učencem ponudimo, moramo dobro preučiti, kritično analizirati in spoznati pravilen pristop do tega. Na koncu lahko pridobimo veliko več, kot smo na začetku upali in želeli. Eden ključnih razlogov, zakaj razvijati digitalno pismenost in drugačnost pouka, je zagotovo ta, da so učenci veliko bolj motivirani in kreativni pri pouku. Poleg tega se učijo spretnosti uporabe IKT za celo življenje. Učna ura, ki smo jo izpeljali s pomočjo aplikacije BookCreator, je pokazala pozitiven vpliv vključevanja IKT v pouk. Pri učencih je spodbudila motivacijo, idejo za razvoj in uporabo aplikacije tudi pri drugih predmetih, učinkovita pa je bila za razvoj pomnjenja, pridobivanja osnovnih in specifičnih znanj ter razvoj socialnih veščin.

LITERATURA IN VIRI

[1] Avsec, S. in Sajdera, J. (2019). Factors influencing pre-services preschool teachers' engineering thinking: model development and test. International journal of technology and design education, doi: 10.1007/s10798-018-9486-8.

[2] BookCreator (b. d.). Pridobljeno dne 8. 8. 2022 s https://itunes.apple.com/us/app/book-creator-for-ipad/id442378070?mt=8.

[3] Garmire, E. in Pearson, G. (2006). Tech Tally: Approaches to Assessing Technological Literacy. Washington. V The National Academy Press. Dostopna na: https://www.nap.edu/read/11691/chapter/4.

[4] Novak, L., Velianje, E. in Kranjc, R. (2013). Ali vemo, kaj zmorejo učenci 1. ViO na področju računalništva? V Kreuh, N., Trestenjak, B., Blagus, K., Kosta, M. in Lenarčič, A. (ur). V Mednarodna konferenca Splet izobraževanja in raziskovanja z IKT – SIRikt 2013. (Str. 149–153). Kranjska Gora: Miška d. o. o.

Spodbujanje in razvijanje bralnega razumevanja pri pouku angleščine s tehnologijo

Encouraging and Developing Reading Comprehension in English Classes With Technology

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POVZETEK

Branje pri dijakih pogosto povzroči slabo voljo, saj sami ne želijo brati daljših besedil in odgovarjati na vprašanja v fizični obliki. Odločili smo se jim približati in obogatiti njihovo bralno razumevanje. Pouk smo popestrili z uporabo telefonov, tablic ali računalnikov. Poleg tega so dijaki za domačo nalogo na računalniku izdelali bralni zvezek, iz katerega so bili kasneje ocenjeni. Cilj drugačnih pristopov k bralnemu razumevanju je bil predvsem popestriti razvijanje bralne kompetence z vključitvijo tehnologije in večjega števila nalog za bralno razumevanje med in po branju, kot tudi za uvodno motivacijo pred branjem. Pri izbiri orodja za popestritev bralnega razumevanja je potrebno upoštevati tudi dostopnost brezplačnih orodij, zaradi česar smo se pri tem osredotočili na Google Forms, Microsoftov program OneNote in spletno stran Liveworksheets. Nov način dela v šoli in doma je popestril pouk in dobro vplival na delovno motivacijo dijakov, hkrati pa je nov način preverjanja bralnega razumevanja omogočal dodatno individualno delo tistim, ki so to želeli ali potrebovali.

KLJUČNE BESEDE

Angleščina, srednja šola, branje, bralno razumevanje, OneNote, motivacija

ABSTRACT

Reading in class often puts students to a bad mood since they do not enjoy reading long passages of texts and answer numerous questions on paper. Due to the constant and annoying presence of phones in class, we have decided to use them for the purpose of education. Phones have made the reading experience more diverse and easier and whenever we had a chance, we resorted to the computers and tablets as well. In addition, the students had to compile a reading notebook on the computer and were graded from it. The goal of such different teaching and learning approaches was mainly to diversify reading comprehension by including technology and a bigger scope of tasks during and after reading, as well as tasks for before reading. While the number of tools is big, one needs to consider the accessibility of free tools that will enhance the reading comprenshion for students. That is why we focused our tasks on Google Forms, Microsoft software OneNote and a website called Liveworksheets. A new method of teaching and working at home has enhanced the classes and increased the students' motivation and at the same time, the new way of tackling reading comprehension has enabled all students, especially those who want or need to, to do reading comprehension tasks at their own leasure.

KEYWORDS

English, secondary school, reading, reading comprehension, OneNote, motivation

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1 UVOD

Tehnologija je postala tako dostopna, da jo učitelj zelo enostavno vključi v didaktični proces in z različnimi metodami poučevanja vpliva na motivacijo in učinek učenja v šoli ali doma. Bralno razumevanje v izobraževanju tujih jezikov ostaja ena izmed štirih glavnih jezikovnih spretnosti, poleg slušnega razumevanja, govornega in pisnega sporočanja. Od vseh štirih spretnosti je branje pri mlajših generacijah izgubilo svojo priljubljenost, saj v prostem času ni več tako popularno, kot je bilo v preteklosti. Vseeno pa je branje pri tujem jeziku še vedno izjemnega pomena, saj širi bralni zaklad, hkrati pa se dijak utrjuje v poznavanju slovničnih struktur [1].

Poleg tega bralno razumevanje ostaja pomemben element zaključnih izpitov v srednješolskih programih, kot sta poklicna in splošna matura, in se ga povezuje ne le z razumevanjem sporočila besedila, vendar tudi z razumevanjem uporabe slovničnih struktur in besednih kolokacij. Pri poklicni maturi gre za tipe nalog, kot so dopolnjevanje besedila z besedami ali deli stavkov, odgovarjanje na vprašanja, povezovanje tem z deli besedila, izbira pravilnega odgovora. Podobno bralno razumevanje se preverja tudi na splošni maturi, vendar na višji ravni B2, poleg tega pa morajo dijaki poznati tudi vse osnove slovnice, besedotvorja in glagolskih oblik. Učitelji morajo v času srednješolskega izobraževanja dijake s tovrstnim bralnim razumevanjem ne le seznaniti, ampak jih na to tudi pripraviti in jim delo olajšati s posameznimi aktivnostmi.

2 MOTIVACIJA ZA BRANJE

Motivacija v učilnici je širok pojem, ker jo lahko razdelimo na notranjo ali zunanjo motivacijo. Hkrati lahko dijake motiviramo

na kratek rok, kasneje pa tudi na daljšega. Pri tem je najbolj učinkovit način, da učitelj motivira dijake postopoma – sprva na krajši način s pomočjo ugank, primerno hitrostjo, primerno tematiko, ki spodbuja komunikacijo dijakov in pritegne njihovo pozornost. Eden izmed pomembnih elementov pri vzpostavljanju pozitivne motivacije je ustvarjanje prijetnega vzdušja v razredu. [2]. Ker so dijaki močno navajeni uporabe mobilnih telefonov, lahko raba le-teh vzpostavi prijetnejše vzdušje pri pouku, pa tudi če le za kratek čas.

Drugi elementi, ki močno vplivajo na motivacijo dijakov pri branju so: izbira besedila oz. teme, namen branja, količina besedila, branje na glas ali po tiho, čas branja, razumevanje jezika in besedišča [3]. Besedila beremo z različnim namenom in od tega je odvisno tudi, kako jih preberemo.

Dijaki se branja hitro naveličajo, ker je besedilo predolgo ali pa se učiteljev način pristopa k branju ponavlja. Potrebno je načelo pestrosti, ki poskrbi, da način obravnave besedila in namen branja ne ostaja enak. Pomembna spretnost, ki jo dijaki morajo razviti, je hiter pregled besedila (ang. *skimming*) [3]. Pri tem dijaki ne preberejo celega besedila, vendar najdejo določene informacije. Dijaki nimajo celotnega besedila pred seboj, vendar ga lahko odprejo na tablici ali telefonu. S tem se osmisli uporaba mobilne naprave pri pouku in učna ura se popestri. Poleg pestrih in spreminjajočih učnih pripomočkov in tipov nalog je potrebno poskrbeti, da so besedila, ki jih dijaki analizirajo na poglobljen način, krajša, oz. jih ne obdelujejo prepogosto.

3 BRANJE S TEHNOLOGIJO

Branje smo poskušali vključiti v učni proces na več načinov. Bralnega razumevanja ni mogoče razviti v krajšem času, zato smo poskrbeli, da so dijaki v štiriletnem izobraževanju redno izpostavljeni branju. Tehnologija nam je omogočila, da smo bralno razumevanje popestrili in da so bili dijaki dodatno motivirani.

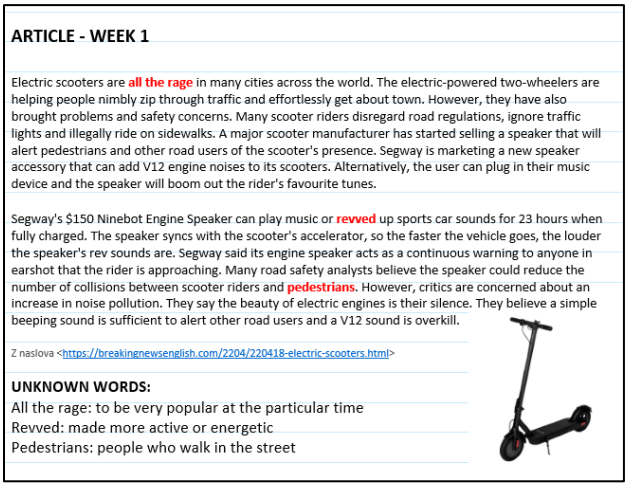
3.1 Bralni zvezek

Za redno spodbujanje branja so dijaki dobili domačo nalogo, kjer so v štirih mesecih izdelovali bralni zvezek. Bralni zvezek vsebuje več besedil, ki jih dijaki berejo postopoma. Za vsako besedilo, ki ga najdejo na internetu ali v revijah, napišejo vir, označijo nekaj neznanih besed in ga v petih povedih obnovijo. Vsak teden v prvi polovici šolskega leta preberejo besedilo, v drugi polovici šolskega leta pa učitelj bralni zvezek oceni. Tako je dijak hkrati ocenjen iz razumevanja besedil in poznavanja besedišča.

Metoda se je izkazala kot odlična pri spodbujanju branja, s katero ima dijak svobodo izbire besedila, v določenih primerih pa lahko izbira tudi tematiko. Ker se je bralni zvezek izkazal za uspešnega v papirnati obliki, smo se odločili, da dijak bralni zvezek pripravi tudi v elektronski obliki – najprej v obliki datoteke Microsoft Word, ko pa so dijaki usvojili rabo programa Microsoft OneNote, pa so bralne zvezke oddali v tej obliki.

Bralni zvezek se je izkazal kot dober način priprave na maturo, saj dijaki na poklicni maturi dobijo zelo podobno nalogo, kjer govorijo o članku iz strokovne tematike, podoben učinek pa ima ta način dela tudi na dijake gimnazijskih smeri, ki so tako bolj pripravljeni na branje krajših odsekov literarnih del, ki jih obravnavajo na splošni maturi.

Bralni zvezek je način, ki dijakom daje dovolj svobode za izbiro člankov, zato lahko vključijo tematike, ki jih zanimajo in o katerih želijo govoriti oz. brati. Z namenom, da bi popestrili vsebino bralnega zvezka, pa se morajo dijaki vseeno dotakniti vsaj pet poljubnih tematik. Izdelave bralnega zvezka do končnega datuma ne preverjamo, kar tudi povečuje motivacijo k delu in spodbudi dijake k samostojnemu delu ter razmišljanju. Slika 1 prikazuje primer dobro urejenega članka.



ARTICLE - WEEK 1

Electric scooters are **all the rage** in many cities across the world. The electric-powered two-wheelers are helping people nimbly zip through traffic and effortlessly get about town. However, they have also brought problems and safety concerns. Many scooter riders disregard road regulations, ignore traffic lights and illegally ride on sidewalks. A major scooter manufacturer has started selling a speaker that will alert pedestrians and other road users of the scooter's presence. Segway is marketing a new speaker accessory that can add V12 engine noises to its scooters. Alternatively, the user can plug in their music device and the speaker will boom out the rider's favourite tunes.

Segway's $150 Ninebot Engine Speaker can play music or **revved** up sports car sounds for 23 hours when fully charged. The speaker syncs with the scooter's accelerator, so the faster the vehicle goes, the louder the speaker's rev sounds are. Segway said its engine speaker acts as a continuous warning to anyone in earshot that the rider is approaching. Many road safety analysts believe the speaker could reduce the number of collisions between scooter riders and **pedestrians**. However, critics are concerned about an increase in noise pollution. They say the beauty of electric engines is their silence. They believe a simple beeping sound is sufficient to alert other road users and a V12 sound is overkill.

Z naslova <https://breakingnewsenglish.com/2204/220418-electric-scooters.html>

UNKNOWN WORDS:

All the rage: to be very popular at the particular time
Revved: made more active or energetic
Pedestrians: people who walk in the street

Slika 1: Primer članka iz bralnega zvezka.

3.2 Potopni bralnik

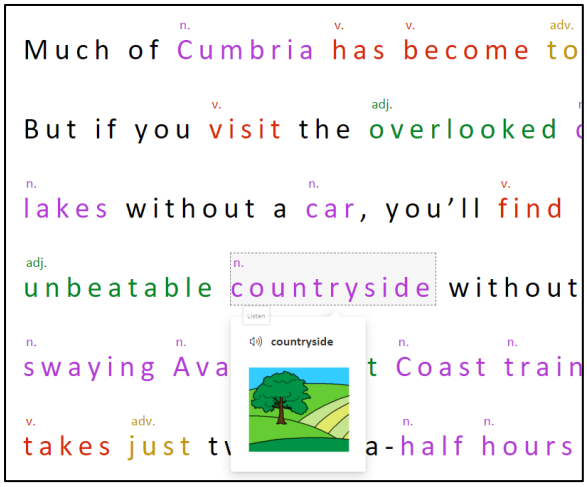
Pri natančnejši obravnavi besedila se pogosto pokažejo razlike med dijaki. Dijaki različno hitro berejo in rešujejo naloge bralnega razumevanja. Pojavili so se tudi primeri dijakov, ki zaradi disleksije ali ostalih težav niso tako dobro sledili pouku oz. so morali snov nadoknaditi doma. Besedilo na belem listu papirja je nespremenljivo in njegova velikost, pisava ali barva otežijo branje in bralno razumevanje določenim dijakom s posebnimi potrebami. Na učnih urah nižjih letnikov srednje poklicne in tehniške šole so se pokazale tudi razlike v razumevanje besed in nezmožnosti izgovorjave.

Orodje potopni bralnik (ang. *Immersive reader*) v orodjih Microsoft Word in OneNote omogoča ogled besedila z ustreznim razmikom črk in besed, ki olajša branje marsikaterim dijakom s posebnimi potrebami. Besedilo je dostopno v orodju OneNote, kar pomeni, da ga dijak lahko ponovno prebere doma in si spremeni velikost ali pisavo besedila. Vsi dijaki, ki imajo primanjkljaj v poznavanju besedišča, lahko s tem orodjem kliknejo na besedo, ki jo program prevede v slovenščino, za določene besede pa se pojavi tudi slika pomena.

Poznavanje besednih vrst v besedilu je ključnega pomena za učenje besedotvorja. Zgradba povedi in prepoznavanje glagola, samostalnika, pridevnika in prislova v povedi bo dijakom omogočila boljše razumevanje slovnične zgradbe stavka. Potopni bralnik je orodje, ki v vsakem besedilu samodejno označi besedne vrste, tako da lahko dijak sam utrjuje prepoznavanje besednih vrst s pomočjo tega orodja.

Ob obravnavi besedila v razredu pa smo potopni bralnik uporabili tudi za glasno branje besedila, iz katerega smo razvili več vrst aktivnosti. Na primer, dijakom smo predvajali narek besedila ob počasnejši ali hitrejši hitrosti, pri tem pa so imeli

različne naloge – zapis besed in prislovov, dokončanje stavka itd. Na sliki 2 so v besedilu besede različnih besednih vrst označene z različnimi barvami, možna pa je tudi podrobna razlaga besede s klikom nanjo.

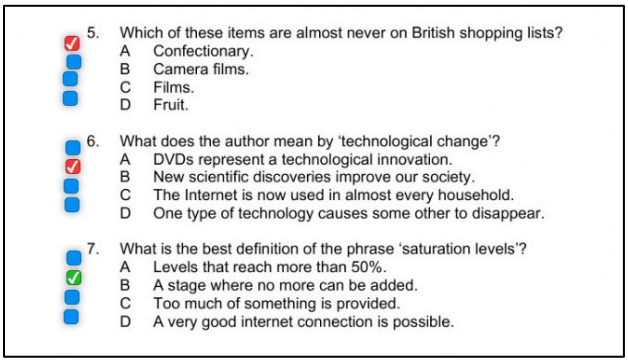


Slika 2: Primer besedila z označenimi besednimi vrstami.

3.3 Preverjanje bralnega razumevanja

Pri bralnem razumevanju je pogosto potrebno veliko vaje. Namesto ogromno učnih listov v fizični obliki lahko učitelj dijakom pripravi izročke v obliki spletnega kviza. Učitelji lahko besedila s spleta uvozijo v Google Obrazec, kjer označijo pravilne odgovore. Tako imajo lahko dijaki dostop do več nalog bralnega razumevanja. Mnogi učitelji radi uporabljajo tudi Microsoft Forms, podobno aplikacijo, vendar Google Obrazce uporabljamo predvsem zaradi večjih možnosti pri sestavljanju vprašanj in bolj primernega izgleda vprašanj.

Na podoben način deluje tudi spletna stran Liveworksheets. Po ustvarjenem profilu si lahko učitelj ustvari učni list, ki ga spletna stran prikaže v obliki PDF. V dokumentu je v za to označene prostore možno vpisati kratke odgovore ali številke, učitelj pa rešitve vnese že prej. Na enak način lahko dijak označi pravilne odgovore ali izbira med več možnostmi, tako da obkljuka pravilni odgovor. Ko dijak učni list pregleda in napiše svoje odgovore, jih orodje pregleda ter točkuje, učitelj pa takoj dobi povratno informacijo o številu točk. Slika 3 prikazuje primer treh vprašanj, kjer lahko dijaki preverijo pravilnost svojih odgovorov takoj po reševanju učnega lista na spletni strani.



Slika 3: Odsek učnega lista z izbiro odgovorov s spletne strani Liveworksheets.

4 ZAKLJUČEK

Branju se pri pouku tujega jezika v srednji šoli ne moremo izogniti. Orodij na spletu je dovolj, da si vsak učitelj najde način, ki mu olajša delo, dijakom pa popestri učne ure in domače delo. Zaradi uporabe telefona in računalnika pri bralnem razumevanju so dijaki lahko prebrali več besedil, si tako bolj razširili besedišče stroke. Vseeno pa moramo biti pozorni, da z uporabo tehnologije pri pouku učitelj ne pretirava. Kratka anketa je pokazala, da je nov način ocenjevanja bralnega zvezka ustreznejši 60 % dijakom, hkrati pa je 70 % dijakov odgovorilo, da jim preverjanje bralnega razumevanja v obliki spletnih učnih listov bolje ustreza kot na papirju. Kljub temu verjamemo, da je pri uporabi različnih metod poučevanja pomembna pestrost – tako kot je potrebno v pouk občasno vključiti tehnologijo, je za dijake in učitelja pomembna tudi vrnitev k tradicionalnemu načinu branja, ki ima druge pozitivne lastnosti.

LITERATURA IN VIRI

[1] Jermeny Harmer. 2007. The Practice of English Language Teaching (4th. ed.). Pearson Longman, Harlow, Essex.
[2] Henry D. Brown. 2007. Teaching by Principles: An Interactive Approach to Language Pedagogy (3rd. ed.). Allyn & Bacon, Boston, Massachusetts.
[3] David Cross, 1992. A practical handbook of Language Teaching. Cassell, London.

Izobraževanje šolskih knjižničarjev na daljavo v Narodni in univerzitetni knjižnici

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POVZETEK

Narodna in univerzitetna knjižnica ima med svojimi nalogami tudi izobraževalno dejavnost. Velik del programa je namenjen izobraževanju strokovnih knjižničarskih delavcev. Epidemija pa je posegla v sam proces izobraževanj, zato je bilo potrebno vsa izobraževanja preseliti v spletno okolje. V luči spremenjenih razmer dela in izobraževanja na daljavo so bile vse vsebine tečajnikom podane s pomočjo spletne platforme ZOOM. Narodna in univerzitetna knjižnica je torej v letu 2021 uspešno izpeljala izobraževanja na daljavo za šolske knjižničarje.

KLJUČNE BESEDE

Narodna in univerzitetna knjižnica, izobraževanje, ZOOM, epidemija, šolske knjižnice

ABSTRACT

National and University Library also has educational activities among its tasks. However, the epidemic has interfered with the training process itself, and it has been necessary to move all training to an online environment. In the light of the changed working and distance education situation, all content was delivered to the participants using the ZOOM online platform. National and University Library has therefore successfully delivered distance learning courses for school librarians in 2021.

KEYWORDS

National and University Library, education, ZOOM, epidemic, school libraries

1 UVOD

Narodna in univerzitetna knjižnica (dalje NUK) je nacionalna knjižnica Republike Slovenije, katere temeljno poslanstvo je zbiranje in varovanje ter zagotavljanje uporabe nacionalne zbirke knjižničnega gradiva, strokovna podpora knjižnicam pri izvajanju javne službe in nacionalnemu bibliografskemu sistemu ter vključevanje v mednarodne knjižnične povezave [1]. Skladno z zakonodajo izvaja knjižnično dejavnost kot javno službo [2] in skrbi za dediščino ter sodeluje v nacionalnem vzajemnem bibliografskem sistemu, opravlja pa tudi druge dejavnosti in naloge. Med drugim je za knjižničarsko stroko izjemno pomembna izobraževalna dejavnost, za katero v NUK skrbi Oddelek za izobraževanje, razvoj in svetovanje. Potencialni udeleženci izobraževanj so slovenski strokovni knjižničarski delavci, založniki ter uporabniki knjižnic. Izobraževalne vsebine so razdeljene po sklopih, ki so namenjeni knjižničarjem začetnikom, knjižničarjem, ki želijo izpopolniti svoje znanje in tistim, ki se želijo usposobiti za delo v sistemu vzajemne katalogizacije ter uporabnikom knjižnic (študentje, raziskovalci, občani …) [3]. Stalno izobraževanje je za vsakega posameznika nepogrešljivo ter pomembno, česar se NUK zaveda in temu vsako leto posveča veliko pozornosti.

2 IZOBRAŽEVANJE ŠOLSKIH KNJIŽNIČARJEV IN NUK

Kot že omenjeno med drugimi nalogami NUK zagotavlja tudi izobraževalne vsebine. Vsako koledarsko leto objavi program izobraževanja (dostopen na spletni strani NUK) ter izvede strokovna spopolnjevanja in permanentno izobraževanje za zaposlene v knjižnični dejavnosti [4], saj je strokovno izobraževanje izjemnega pomena za vsakega strokovnega knjižničarskega delavca. Kot je zapisano tudi v Etičnem kodeksu slovenskih knjižničarjev, mora vsak knjižničar znova in znova izpopolnjevati svoje strokovno znanje ter ustvarjalno prispevati k razvoju knjižničarske stroke in njene dejavnosti [5]. NUK zato organizira ter izvaja različne oblike izobraževanj za knjižničarje, založnike in usposabljanja za uporabnike knjižnic [6]. Svoj izobraževalni progam NUK izvaja na dveh lokacijah: v računalniški učilnici NUK na Turjaški ulici 1 ter v učilnici na Leskoškovi cesti 12. Od leta 2020, ko se je zaradi epidemije COVID-19 vse spremenilo, pa izobraževanja izvaja tudi na spletu.

Ob nastopu epidemije je bilo treba izvajanje izobraževanj prilagoditi razmeram, kar je pomenilo vzpostavitev različnih možnosti izobraževanja prek spleta oziroma na daljavo [7]. Kot eno izmed optimalnih izobraževalnih izkušenj smo v NUK izbrali ZOOM (ZOOM je spletna platforma za avdio in video komunikacijo, ki se uporablja za organiziranje sestankov, izobraževanj, delavnic in drugih oblik sodelovanja) [8]. Za dostopnost vsebin ter gradiv pa je bilo potrebno pripraviti tudi

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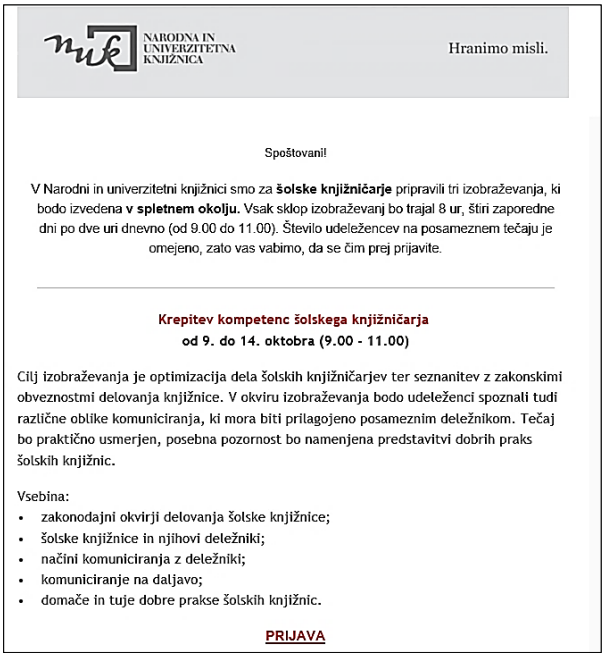
spletno učilnico, ki je osnovna aplikacija za uporabo pri izobraževalnem procesu na daljavo [9].
Tudi izobraževalne vsebine za šolske knjižnice so se preselile na splet. Načrtovana so bila naslednja izobraževanja:

- Krepitev kompetenc šolskega knjižničarja,
- Izločanje, odpis in inventura v šolski knjižnici,
- Spletna orodja in aplikacije za šolske knjižnice.

Potencialni udeleženci izobraževanj, ki so zaposleni v šolskih knjižnicah, so prejeli e-pošto z vsemi podatki ter informacijami, na voljo je bila tudi prijava na izobraževanja prek spletnega obrazca. Obveščeni so bili, da bodo za udeležbo potrebovali ustrezno tehnično opremo (računalnik s kamero, zvočnikom in mikrofonom ter čim boljšo internetno povezavo). Na Sliki 1 je prvo vabilo na izobraževanje za šolske knjižnice.


NARODNA IN UNIVERZITETNA KNJIŽNICA

Hranimo misli.

Spoštovani!

V Narodni in univerzitetni knjižnici smo za **šolske knjižničarje** pripravili tri izobraževanja, ki bodo izvedena **v spletnem okolju.** Vsak sklop izobraževanj bo trajal 8 ur, štiri zaporedne dni po dve uri dnevno (od 9.00 do 11.00). Število udeležencev na posameznem tečaju je omejeno, zato vas vabimo, da se čim prej prijavite.

Krepitev kompetenc šolskega knjižničarja
od 9. do 14. oktobra (9.00 - 11.00)

Cilj izobraževanja je optimizacija dela šolskih knjižničarjev ter seznanitev z zakonskimi obveznostmi delovanja knjižnice. V okviru izobraževanja bodo udeleženci spoznali tudi različne oblike komuniciranja, ki mora biti prilagojeno posameznim deležnikom. Tečaj bo praktično usmerjen, posebna pozornost bo namenjena predstavitvi dobrih praks šolskih knjižnic.

Vsebina:

- zakonodajni okvirji delovanja šolske knjižnice;
- šolske knjižnice in njihovi deležniki;
- načini komuniciranja z deležniki;
- komuniciranje na daljavo;
- domače in tuje dobre prakse šolskih knjižnic.

PRIJAVA

Slika 1: Prvo vabilo ter povezave do spletne prijave na izobraževanja za šolske knjižnice.

3 IZPELJAVA IZOBRAŽEVANJ ZA ŠOLSKE KNJIŽNIČARJE NA DALJAVO

V spletno okolje je bilo potrebno preseliti vsa tri (v nadaljevanju omenjena) izobraževanja, ki so bila posebej namenjena šolskim knjižničarjem. Večjih težav pri predpripravi ni bilo, saj smo v NUK že izvajali izobraževanja v spletnem okolju. Vsa tri izobraževanja smo razdelili na štiri zaporedne dni po dve uri. Naklonjenost takemu načinu izvedbe so izrazili sami šolski knjižničarji, ki so predhodno izpolnili anketni vprašalnik. Na anketno vprašanje 'V kolikšni meri vam ustrezajo spodaj navedene oblike izobraževanja?', kjer so bile na voljo tri možnosti: spletna izobraževanja, kombinirana izobraževanja in klasična izobraževanja v živo, je odgovorilo 207 anketirancev. Prvo možnost (spletna izobraževanja) je izbralo kar 157 anketirancev, kar je 76 % vseh anketirancev. Za drugo možnost (kombinirana izobraževanja) se je odločilo 34 anketirancev, kar je 16 % in za zadnjo možnost (v živo) se je odločilo le 16 anketirancev (8 %).

3.1 Krepitev kompetenc šolskega knjižničarja

Izobraževanje je potekalo od 11. do 14. oktobra 2021, vsak dan od 9.00 do 11.00 ure, z uporabo aplikacije ZOOM.

Vsebina:

- zakonodajni okvirji delovanja šolske knjižnice,
- šolske knjižnice in njihovi deležniki,
- načini komuniciranja z deležniki,
- komuniciranje na daljavo,
- domače in tuje dobre prakse šolskih knjižnic.

Cilj izobraževanja je bil optimizacija dela šolskih knjižničarjev ter seznanitev z zakonskimi obveznostmi delovanja knjižnice. V okviru izobraževanja so udeleženci spoznali različne oblike komuniciranja, ki mora biti prilagojeno posameznim deležnikom.

3.2 Izločanje, odpis in inventura v šolski knjižnici

Izobraževanje je potekalo od 8. do 11. novembra 2021, vsak dan od 9.00 do 11.00 ure, z uporabo aplikacije ZOOM.

Vsebina:

- zakonodajni okvirji za izločanje, odpis in inventuro,
- izločanje in odpis knjižničnega gradiva,
- inventura v šolski knjižnici,
- primeri iz prakse in čas za vprašanja.

Cilj izobraževanja je bil razrešitev dilem, s katerimi se šolski knjižničarji soočajo pri izločanju, odpisu in inventuri knjižničnega gradiva.

3.3 Spletna orodja in aplikacije za šolske knjižnice

Izobraževanje je potekalo od 30. novembra do 3. decembra 2021, vsak dan od 9.00 do 11.00 ure, z uporabo aplikacije ZOOM.

Vsebina:

- digitalna pismenost,
- digitalne kompetence,
- uporaba brezplačnih aplikacij ter spletnih orodij v šolski knjižnici,
- izobraževanje s pomočjo aplikacij in spletnih orodij,
- prikaz praktičnih primerov.

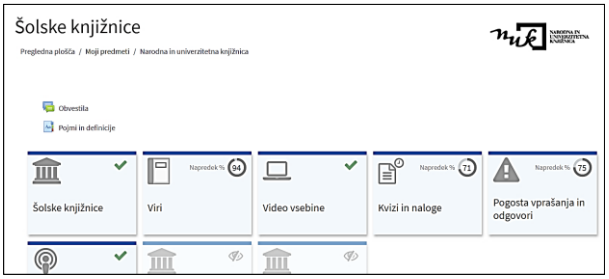
Cilj izobraževanja je bil usposobiti šolske knjižničarje za izobraževalce na področju informacijske pismenosti in digitalnih kompetenc. Udeleženci so se seznanili s koristmi aplikacijami in spletnimi orodij za delo v šolski knjižnici.

Po spletni prijavi je vsak udeleženec prejel povratne informacije, gradiva in napotke za delo ter vedenje v času trajanja izobraževanja (navodila glede poimenovanja, kamere, načina sodelovanja ter druge informacije). Za vsako izobraževanje so udeleženci prejeli natančen opis, urnik ter časovnico. Povezavo za vstop v spletno okolje so dobili nekaj dni pred začetkom izobraževanja.

Vsebine izobraževanj so bile pripravljene posebej za potrebe in naravo dela v šolskih knjižnicah. Šolske knjižnice namreč izvajajo knjižnično dejavnost, potrebno za izvajanje javne službe na področju vzgoje in izobraževanja [10].

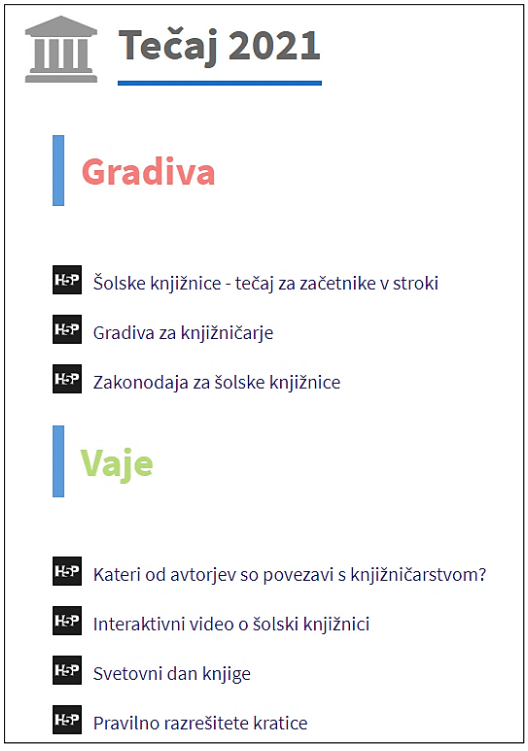
Vsak dan vsake izvedbe izobraževanja je bil časovno ravno dovolj obširen, da so udeleženci pred zasloni obdržali motivacijo za sodelovanje ter zbrano sledili vsem vsebinam. Izkazalo se je

tudi, da je bilo dovolj časa za vprašanja ter reševanje zastavljenih vaj in nalog. Poleg vseh uporabnih virov, dejavnosti in funkcij je bil uporaben tudi klepet v ZOOM-u, kjer je potekala komunikacija med udeleženci in izvajalci izobraževanj (vsi namreč niso imeli možnosti video in avdio vklopa). Tako so postavljali vprašanja ter komunicirali preko klepeta. Slika 2 prikazuje NUK učilnico za šolske knjižnice ter vsebine.



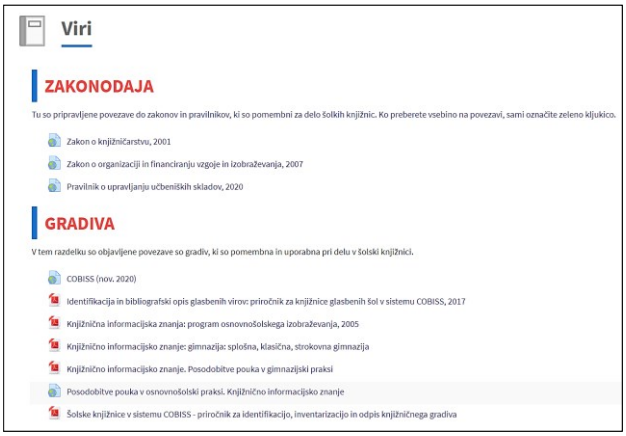
Slika 2: Vpogled v NUK učilnico za šolske knjižnice. Vsebine v učilnici so vezane na delovanje šolskih knjižnic. Posebej za določeno izvedbo je bilo pripravljano poglavje z vsebinami ter vajami (zelo uporabno pri tečaju o aplikacijah).

Na Sliki 3 je viden pogled v spletno učilnico, kjer so za udeležence (skladno z zastavljenimi cilji) pripravljeni posamezni sklopi, vsebine in gradiva posameznega izobraževanja.



Slika 3: Vpogled v spletno učilnico Spletna orodja in aplikacije za šolske knjižnice, v kateri so bile pripravljene interaktivne naloge (udeleženci so jih reševali tekom izobraževanja), napotki za delo z aplikacijami ter primeri že pripravljenih dejavnosti. V kolikor kdo ni uspel rešiti ter pregledati pripravljenih vaj med samim izobraževanjem, je imel nato še 14 dni časa, da je vaje lahko rešil sam.

Na Sliki 4 prikazujemo vsebino oziroma poglavje spletne učilnice za izobraževanje Krepitev kompetenc šolskega knjižničarja. Na enem mestu so zbrani vsi za šolske knjižnice pomembni dokumenti, povezave ter gradiva.



Slika 4: Zaslonska slika določenega poglavja v spletni učilnici.

4 ZAKLJUČEK

V besedilu smo na kratko predstavili in opisali izobraževalno dejavnost NUK za šolske knjižnice v letu 2021, ko je bilo potrebno izobraževanje zaradi epidemije prenesti v spletno okolje.

V poučevanje na daljavo smo se v letu 2020 podali čez noč, saj so z razglasitvijo epidemije ustavili tako rekoč celotno državo. V tako imenovani novi realnosti je bilo potrebno prilagoditi tudi izobraževanje, ki ga za knjižničarje, založnike in uporabnike izvaja NUK. Izobraževanja na daljavo se je izvedlo s pomočjo spletne aplikacije ZOOM in spletnih učilnic, kar so z odobravanjem sprejeli tudi udeleženci. Čas in trajanje posamezne izvedbe izobraževanj ter sama komunikacija so bili prilagojeni udeležencem. Udeleženci so pridobili in nadgradili sposobnosti sodelovanja, komuniciranja, reševanja in uporabe spletnih orodji (tudi spletne učilnice) ter krepili posamezne stopnje digitalnih kompetenc (digitalne kompetence segajo na področja informacijske pismenosti, komuniciranja in sodelovanja, izdelovanja digitalnih vsebin in drugo) [11]. Še posebno pa so znanja na področju informacijske tehnologije nadgradili udeleženci izobraževanja Spletna orodja in aplikacije za šolske knjižnice. Vse tri izvedbe izobraževanj so nekako zaokrožile delo v šolski knjižnici.

Zagotovo lahko trdimo, da je nov način izvajanja izobraževanj na daljavo s svojo prilagodljivostjo, funkcionalnostjo prispeval k novim izobraževalnim potem. S tem, da je NUK izvajal izobraževanja na daljavo, so se v strokovni prostor vpeljale nove strategije, novi načini dela in podajanja vsebin ter so se ob tem razvijale nekatere strokovne kompetence. Kar pa je še bolj pomembno, vsebine ter izobraževanja so bila dostopna širšemu krogu potencialnih udeležencev, kar so v anketnem vprašalniku potrdili ter zapisali njihovi udeleženci. Lažje in rajši so se udeležili izobraževanja na daljavo kot v živo (različni razlogi – od stroškov, prevoza, časovne zamude …).

Nekateri pa so celo zapisali, da se izobraževanja v živo sploh ne bi udeležili.

LITERATURA IN VIRI

[1] Naloge, vizija, poslanstvo in vrednote NUK. Dostopno na naslovu: https://www.nuk.uni-lj.si/nuk/poslanstvo# (3. 8. 2022)

[2] Zakon o knjižničarstvu. 2015. Dostopno na naslovu: http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO2442 (3. 8. 2022)

[3] Marinšek, P. 2020. Mnenje knjižničarjev o e-izobraževanju. V Knjižničarske novice. Dostopno na naslovu: http://www.dlib.si/stream/URN:NBN:SI:DOC-7FVZ2H9N/15cb3bc3-43bd-4711-94d9-d548fc595b94/PDF (9. 8. 2022)

[4] Škrlj, G. 2006. Management kadrovskih virov v knjižnici: izobraževanje in usposabljanje kadrov v visokošolskih knjižnicah Univerze v Ljubljani. G. Škrlj, Ljubljana

[5] Etični kodeks slovenskih knjižničarjev. 1995. Dostopno na: https://www.zbds-zveza.si/daljsa-6/ (3. 8. 2022)

[6] Uredba o osnovnih storitvah knjižnic. Dostopno na naslovu: http://www.pisrs.si/Pis.web/pregledPredpisa?id=URED2851 (3. 8. 2022)

[7] Izobraževanje na daljavo NUK. Dostopno na naslovu: https://www.nuk.uni-lj.si/izpostavljamo/izobrazevanje-na-daljavo (3. 8. 2022)

[8] Uporaba aplikacije ZOOM. Dostopno na naslovu: https://www.nuk.uni-lj.si/sites/default/files/dokumenti/2020/ZOOM.pdf (3. 8. 2022)

[9] Spletna učilnica. Dostopno na naslovu: https://www.knjiznice.si/knjiznicarji/izobrazevanje/spletna-ucilnica/ (4. 8. 2022)

[10] Zakon o knjižničarstvu. 2015. Dostopno na naslovu: http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO2442 (4. 8. 2022)

[11] Posodobitve pouka v osnovnošolski praksi. Knjižnično informacijsko znanje. 2014. Zavod RS za šolstvo, Ljubljana, Dostopno na naslovu: http://www.dlib.si/details/URN:NBN:SI:DOC-ABAUB0ON (10. 8. 2022)

Airnominal

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POVZETEK

Problem onesnaženosti zraka je eden izmed najbolj akutno nevarnih ekoloških problemov, s katerimi se danes soočamo. Glede na študije Svetovne zdravstvene organizacije skoraj vsi prebivalci sveta dihajo zrak, ki presega priporočene vrednosti WHO in vsebuje visoke ravni onesnaževal. Čeprav so senzorji in druga merilna oprema že dolgo na voljo, podatki, ki jih uporabljajo raziskovalci, običajno prihajajo z dveh do treh postaj na nekem območju, velike zbirke podatkov z visoko prostorsko ločljivostjo pa niso na voljo. Da bi raziskovalci lahko preverili, ali je katera koli rešitev, ki obravnava kakovost zraka, dejansko učinkovita, morajo imeti možnost pridobiti veliko podatkov višje kakovosti v standardizirani obliki. Da bi rešili to težavo, smo se odločili, da zgradimo odprto platformo merilnih postaj za kakovost zraka, ki ljudem omogoča povezovanje in izmenjavo meritev kakovosti zraka. Prav tako smo želeli zagotoviti zasnovo odprte merilne postaje, ki jo lahko vsakdo zgradi in poveže s platformo. Na ta način bi državljani prispevali dragocene informacije za lokalne raziskave zraka in razkrili glavne vire/vzroke visokih koncentracij onesnaževal v zraku; med delom na našem projektu je bilo enostavno priti le do senzorjev PM (kriza Covid-19 je ovirala pošiljke po vsem svetu). V prihodnosti bodo dodani senzorji dušikovih oksidov in ozona, ko bodo na trgu spet na voljo cenovno sprejemljivi senzorji sprejemljive kakovosti.

KLJUČNE BESEDE

Onesnaženost zraka, spremljanje zraka, PM (trdi delci), javno zdravje, podnebne spremembe, ekologija

ABSTRACT

The problem of air pollution is one of the most acutely dangerous ecological problems we face today. According to studies made by World Health Organization, almost all of the global population breathe air that exceeds WHO guideline limits containing high levels of pollutants. Even though sensors and other measurement equipment is already available, data that researchers use usually comes from two to three stations in an area, and large datasets of high spatial resolution are not available. To test if any solution addressing air quality is in fact effective, researchers need to be able to obtain many higher quality data in a standardized format. To address this problem, we decided to build an open platform of air quality measuring stations, which enables people to connect and exchange air quality measurements. We also wanted to provide a design of an open measuring station that anyone could build and connect to the platform. In this way, citizens would be contributing valuable information for local air research, revealing the main sources/causes of high air pollutants concentrations; when working on our project, only PM sensors were easy to get to (Covid-19 crisis interfered with the shipments all over the world). In future, nitrous oxides and ozone sensors will be added, when reasonable price sensors of acceptable quality will be available on the market again.

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KEYWORDS

Air pollution, air monitoring, PM (particulate matter), public health, climate change, ecology

1 UVOD

Med vsemi ekološkimi problemi, s katerimi se danes soočamo, je le malo takšnih, ki so bolj nevarni kot problem onesnaženosti zraka. Glede na študije Svetovne zdravstvene organizacije skoraj vsi prebivalci sveta dihajo zrak, ki presega priporočene vrednosti WHO in vsebuje visoke ravni onesnaževal. Onesnaženost zraka je priznana kot dejavnik tveganja za številne bolezni, vključno z ishemično boleznijo srca, možgansko kapjo, kronično obstruktivno pljučno boleznijo, astmo in rakom. Ocenjuje se, da so bolezni, ki jih pripisujejo onesnaženosti zraka, zdaj enakovredne drugim zdravstvenim tveganjem, kot sta nezdrava prehrana in kajenje tobaka, ter da je samo ta težava vzrok za več kot 7 milijonov smrti na leto (to je več ljudi, kot je prebivalcev 12 držav članic EU). [1, p. 7] [2]

Problem je znan že vrsto let, senzorji in druga merilna oprema pa so poceni in lahko dostopni. Za veliko mladih, tudi za naju, je bilo zbiranje podatkov o meritvah zraka morda prvi projekt z Arduinom. Kljub temu podatki, ki jih uporabljajo raziskovalci, še vedno običajno prihajajo z dveh ali treh postaj na nekem območju, velike zbirke podatkov z visoko prostorsko ločljivostjo pa niso na voljo. Da bi lahko preizkusili, ali je katera koli rešitev, ki obravnava kakovost zraka, dejansko učinkovita, morajo imeti raziskovalci možnost pridobiti veliko podatkov višje kakovosti v standardizirani obliki.

Glede na to težavo smo se odločili, da bomo vzpostavili odprto platformo za zbiranje podatkov z merilnih postaj za merjenje kakovosti zraka; ta platforma bi ljudem omogočila

povezovanje in izmenjavo meritev kakovosti zraka, vključno z vlago, temperaturo, koncentracijo delcev PM, dušikovimi oksidi (NOx) in koncentracijo ozona. Delimo tudi našo zasnovo odprte merilne postaje, ki jo lahko vsakdo zgradi in poveže s platformo ter tako zagotovi dragocene informacije za raziskave ter razkrije glavne vire/vzroke visokih koncentracij delcev PM.

Poleg tega ta projekt mladim omogoča, da se naučijo programiranja, spajkanja in konstrukcijskih spretnosti ter izboljšajo svoje znanje o meritvah onesnaženosti in kakovosti zraka.

2 PREGLED LITERATURE

Onesnaženost zraka je eden izmed najbolj nevarnih okoljskih problemov. Večina svetovnega prebivalstva diha zrak, ki presega mejne vrednosti, ki jih priporoča Svetovna zdravstvena organizacija, pri čemer so najbolj prizadete države z nizkimi in srednjimi dohodki. Znano je, da je onesnaženje zraka pomemben vir obolevnosti in umrljivosti ter prispeva kot dejavnik tveganja za številne bolezni, vključno z boleznimi srca, kroničnimi obstruktivnimi pljučnimi boleznimi in akutnimi okužbami dihal. Ocenjuje se, da onesnaženost zraka v zaprtih prostorih in okolice skupaj povzroči približno 8 milijonov prezgodnjih smrti na svetu letno. [3] [4]

Onesnaževanje zraka povzročajo vsi kemični, fizikalni ali biološki dejavniki, ki spreminjajo lastnosti zraka. Glavni viri onesnaževanja zraka so domače kurilne naprave, industrijski obrati in motorna vozila. Glavna onesnaževala so trdni delci (PM), ogljikov monoksid (CO), dušikov dioksid (NO_2), žveplov dioksid (SO_2) in ozon (O_3).

Trdni delci (PM) so pogost kazalnik onesnaženosti zraka in prizadenejo več ljudi kot katero koli drugo onesnaževalo. Sestavljajo ga predvsem sulfati, nitrati, amonijak, natrijev klorid, črni ogljik, mineralni prah in voda, kompleksna mešanica trdnih in tekočih delcev, suspendiranih v zraku. Običajno se razvršča v različne kategorije PM_x , kjer "x" določa največji premer delcev v µm. Najpogostejši kategoriji sta PM_{10} in $PM_{2.5}$. Delci PM_{10} najpogosteje vplivajo na oči in grlo, delci $PM_{2.5}$ pa so še nevarnejši, saj lahko skozi pljuča potujejo v krvni sistem. Ko so na voljo občutljivejša merilna orodja, se delci običajno razdelijo v dodatne kategorije, kar omogoča boljšo analizo delcev. Manjši kot so, globlje v dihala in krvni sistem lahko prodrejo, kar povzroča vedno večje tveganje. Kronična izpostavljenost delcem prispeva k boleznim srca in ožilja ter dihal in pljučnemu raku. [4] [5]

3 REZULTATI

3.1 Delovanje platforme

Naše merilne postaje so trenutno sestavljene iz mikrokrmilnikov Arduino in ESP, na katere je mogoče priključiti senzorje temperature, vlage, PM in druge senzorje ter modul GPS za določanje lokacije postaje. Postaja zbira meritve iz senzorjev in modula GPS ter jih s pomočjo naše knjižnice pošilja v naš strežnik. Uporabniki lahko merilne postaje izdelajo tudi iz drugih krmilnikov, kompatibilnih z Arduino sistemom, ter nanje priključijo poljubne senzorje in jih povežejo na platformo s pomočjo programske knjižnice.

Knjižnica prek omrežja Wi-Fi ali drugih komunikacijskih protokolov podatke pošlje na centralen strežnik, kjer se shranijo. Vsi podatki so brezplačni in javno dostopni prek http programskega vmesnika ter posebne spletne strani za prikazovanje podatkov.

Podatke si je mogoče ogledati tudi prek spletne strani, kjer so na voljo tudi navodila za nastavitev lastnih merilnih naprav in njihovo registracijo na strežnik. Po registraciji naprave uporabniki dobijo posebno konfiguracijo, ki jo morajo nato nastaviti na njivi merilni napravi. V prihodnosti nameravamo na spletno stran dodati še več funkcionalnosti, povezanih z upravljanjem podatkov in merilnih naprav.

Uporabniki si lahko ogledajo zemljevid vseh trenutno aktivnih postaj ali izberejo določeno postajo in si ogledajo vse pretekle podatke. Na strani za posamezno postajo so prikazane tudi trenutne meritve, pretekli podatki s pomočjo razumljivih grafov ter trenutne in vse pretekle lokacije na zemljevidu. Izberete lahko tudi več postaj in primerjate njihove podatke.

Raziskovalci, ki morajo analizirati veliko količino podatkov, lahko prek vmesnika API neposredno prenesejo pretekle podatke. Strežnik omogoča tudi omejitev podatkov na določeno datumsko območje, postajo ali vrsto meritev, tako da jim ni treba skrbeti za filtriranje podatkov in se lahko osredotočijo na svoje raziskave. Ta funkcionalnost je lahko zelo uporabna za raziskovalce ali druge posameznike ali organizacije, ki morajo lokalno izvajati naprednejše analize.

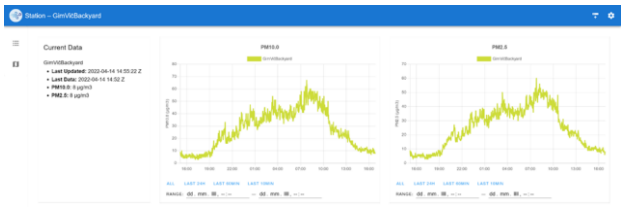
Projekt je odprtokoden in na voljo na spletnem mestu GitHub: https://github.com/ChristofferNorgaard/Airnominal

Uradna instanca je trenutno nameščena na strežnikih šole: https://zrak.gimvic.org/

3.2 Analiza podatkov

Želeli smo vključiti in analizirati podatke, pridobljene na nekaj lokacijah v Sloveniji (slika 1). Žal zaradi nepredvidljivih razmer pri pošiljanju senzorjev s Kitajske nismo mogli izvesti vseh želenih vrst meritev, vendar nam je uspelo pridobiti vsaj meritve temperature, vlage in PM z nekaj postaj.

Naša šola se nahaja tik ob Tržaški cesti, eni glavnih ljubljanskih prometnic. Da bi analizirali, kako promet vpliva na kakovost zraka v kraju, smo se odločili, da na naši šoli postavimo dve postaji, eno obrnjeno proti ulici in eno proti dvorišču.



Slika 1: Meritve s šolske postaje, obrnjene na šolsko dvorišče (od 2022-04-13 do 2022-04-14)

Opažamo, da se koncentracija delcev PM10 in PM2.5 prvič poveča okoli 21.00, kar je zelo verjetno posledica zaprtja bližnjega nakupovalnega središča, ponoči se pojavi nekaj skokov, zjutraj pa tudi velik skok, ki ga povzročijo ljudje, ki se vozijo na delo. Čez dan je bila koncentracija večinoma nizka. Žal nam zaradi nedostopnih senzorjev še ni uspelo postaviti postaje,

obrnjene proti ulici, vendar jo nameravamo postaviti, ko jih bomo pridobili.

Vzpostavili smo tudi uvoz urnih meritev, ki jih zagotavlja Agencija Republike Slovenije za okolje (ARSO), tako da je mogoče naše postaje primerjati z uradnimi in strokovnimi meritvami (slika 2). Postaje ARSO se nahajajo na različnih lokacijah v Sloveniji, zato je mogoče njihove meritve neposredno primerjati z našimi.

Slika 2: Primerjava med šolsko postajo in postajo ARSO na istem območju (od 2022-04-13 do 2022-04-14)

Naše meritve večinoma kažejo višje koncentracije, vendar še vedno sledijo enakim trendom kot uradna postaja. Razlog za to je, da je postaja ARSO precej bolj oddaljena od ulice (približno 1 km), medtem ko je naša postaja oddaljena le eno stavbo. Iz naših grafov je tudi razvidno, da na delce PM2.5 veliko bolj vpliva oddaljenost od vira (ulice) kot na delce PM10 .

Vse meritve z vseh postaj so na voljo tudi na naši spletni strani (https://zrak.gimvic.org/).

4 ZAKLJUČEK

Glavni edinstveni vidik našega projekta je, da uporabnikov ne omejuje na nobeno določeno merilno postajo in jim omogoča, da opremo popolnoma prilagodijo svojim potrebam. Poleg tega odprtost naše platforme s podporo za postaje po meri spodbuja ljudi, da oblikujejo svoje izdelke, se učijo o pomembnih temah ter izboljšujejo svoje spretnosti programiranja, spajkanja, konstruiranja in fine motorike. Naš projekt omogoča šolam in drugim izobraževalnim ustanovam, da si aktivno prizadevajo za izboljšanje teh spretnosti, hkrati pa pripomorejo k zbiranju znanstvenih podatkov.

Na začetku bo naš izdelek namenjen posameznikom in izobraževalnim ter drugim javnim ustanovam. Z razvojem platforme bo raziskovalcem na voljo vedno več podatkov, kar bo povečalo znanstveno in tržno vrednost projekta. Pridobivanje povratnih informacij od posameznikov in raziskovalnih organizacij nam bo omogočilo nenehno izboljševanje naše platforme, da bo boljša in še bolj uporabna za različne uporabnike.

Povezali se bomo z lokalnimi skupnostmi in klubi, ki nam bodo pomagali pri promociji projekta, ter na oddaljenih lokacijah namestili merilne naprave in tako povečali pokritost s podatki

ZAHVALA

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LITERATURA IN VIRI

[1] World Health Organization, "WHO global air quality guidelines," 2021. [Online]. Available: https://apps.who.int/iris/rest/bitstreams/1371692/retrieve.

[2] World Health Organization, "Air pollution," [Online]. Available: https://www.who.int/health-topics/air-pollution.

[3] World Health Organization, "Household air pollution and health," 22 09 2021. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/household-air-pollution-and-health.

[4] World Health Organization, "Ambient (outdoor) air pollution," 22 09 2021. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.

[5] L. Lattanzio, "Particulate Matter Sensing for Air Quality Measurements," 27 12 2018. [Online]. Available: https://www.fierceelectronics.com/components/particulate-matter-sensing-for-air-quality-measurements.

Vpliv osebnostnih lastnosti starejših ljudi na zadovoljstvo uporabe ADC sistema za mobilno upravljanje senčil

The Influence of Personality Characteristics of Elderly People on the Satisfaction of Using the ADC System for Mobile Blind Control

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POVZETEK

V prispevku bomo obravnavali problem starejših ljudi na 50 let in njihovo zadovoljstvo uporabe ADC sistema za mobilno upravljanje senčil. Podjetje ADC sistemi d.o.o. je slovensko podjetje, specializirano za mobilno upravljanje električnih senčil. Podjetje razvija inovativne rešitve na področju senčil, pergol, garažnih vrat, ramp, kontrole pristopa itd... Razvoj programske in strojne opreme so v celoti ustvarili slovenski inženirji, proizvedena pa je s pomočjo partnerskih podjetij v Sloveniji. Rezultat so tehnološko dovršeni in zanesljivi produkti, razviti v skladu s predpisi Evropske unije. Vizija podjetja je razvoj opreme za upravljanje vseh vrst senčil (rolete, žaluzije, screen senčila, tende, komarniki, pergole) in upravljanje različnih vrat (garažna vrata, vhodna vrata, rampe,…). V prispevku smo predstavili rezultate zadovoljstva uporabe ADC sistema, ki je zanesljiv, varen in enostaven in je prilagojen starejšim ljudem.

Namen prispevka je raziskati, enostavno opisati ter predstaviti osebnostne lastnosti starejših uporabnikov po modelu »velikih pet faktorjev osebnosti« in njihovo zadovoljstvu ob uporabi ADC sistema. V današnjem času večina ljudi misli, da se starejši ljudje ne morejo navaditi na novo tehnologijo in jo ne bodo sprejeli. Cilj prispevka je analizirati ter teoretično in praktično utemeljiti, da vsi starejši ljudje zelo dobro sprejmejo ADC sistem za mobilno upravljanje senčil.

Pri pisanju smo se osredotočili na analizo primarnih in sekundarnih virov, s primerjalno analizo in študijo primera smo na podlagi kritične analize zbranih podatkov podali končno oceno.

V prispevku smo predstavili 5 ključnih osebnosti človeka (nad 50 let) in korelacijo teh osebnosti na sprejemanje nove tehnologije ADC sistema za mobilno upravljanje senčil. Starejši ljudje so tehnologijo sprejeli zelo dobro in jo bodo v nadaljevanju uporabljali, tako da lahko trdimo, da starost in osebnostne lastnosti ne vplivajo na sprejemanje in uporabljanje novih tehnologij.

KLJUČNE BESEDE

Osebnostne lastnosti, velikih 5 faktorjev osebnosti, krmilnik, uporabniška izkušnja

ABSTRACT

In this article, we will discuss the problems and satisfaction of using the ADC system for mobile control of blinds in persons over the age of 50. The company ADC sistemi d.o.o. is a Slovenian company specializing in mobile control of electric blinds. The company is developing innovative solutions in the fields of window blinds, pergolas, garage doors, ramps, access control, etc... The software and hardware are completely developed by Slovenian engineers and produced with the help of Slovenian partner companies. The result is technologically complete and reliable products, developed in accordance with the regulations of the European Union. The company's vision is the development of products for managing all types of blinds (roller shutters, venetian blinds, textile screens, awnings, insect screens, pergolas) and doors (garage doors, entrance doors, ramps, ...). In the article, we present results about the satisfaction of using the ADC system, which is reliable, safe, easy to use, and adapted for use by older persons.

The purpose of this article is to research, describe simply, and present the personality traits of older users with the use of the "big five personality traits" model as well as their satisfaction with using the ADC system. Nowadays most people think that older people cannot get used to new technology and will not adopt it. The goal of this article is to analyze and theoretically and practically show that the ADC system for mobile control of blinds is very well received by older persons.

During the writing of this article, we focused on the analysis of primary and secondary sources, and with comparative analysis and example study we gave based on critical analysis of collected data a final score.

In the article, we present the 5 key human traits (of persons over the age of 50) and the correlation between personality and how the new technology of the ADC system for mobile control of

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blinds is received. The technology was received by older persons very well and they will continue to use it in the future, as such, we can conclude that age and personality traits do not affect the reception and usage of new technologies.

KEYWORDS

Personality traits, big 5 personality factors, controller, user experience

1 UVOD

Tehnologija se danes hitro menja. To je razlog, da so podjetja inovativna, podajajo ideje, stremijo k izobraževanju, izboljšujejo svoje produkte ter stremijo k medsebojnemu sodelovanju in zaupanju med uporabniki. Tehnologija z omenjenimi lastnostmi je bolj produktivna in zanesljiva, kar vodi v vse večjo uspešnost organizacije. Za uporabnike in podjetja so pomemben osebne značilnosti, saj z značilnostmi, ki jih imamo in ki jih od nas zahteva tehnologija, bomo lahko preživeli in ostali v koraku z časom.

Od osebnih značilnosti uporabnika je odvisno, ali stremimo k izobraževanju, ali sodelujemo s podjetjem, kako se odzovemo v stresnih situacijah in kako bomo sprejeli novo tehnologijo. Nekatere osebne značilnosti so prirojene, druge pa pridobljene skozi različna življenjska obdobja. Na osebnost močno vpliva družina, družba okolje, vzgoja, saj je osebnost posameznika sestavljena iz celote telesnih, vedenjskih in duševnih značilnosti, zato lahko rečemo, da je celota trajna, kompleksna in individualna. Osebne lastnosti izvirajo od vsakega posameznika v dani situaciji ter iz interakcije med posameznikom in situacijo [1].

1.1 Predstavitev problema

Vsak človek ima značilne osebnostne lastnosti. Te lastnosti pogojujejo vedenje v vsakdanjem življenju in v različnih situacijah. Obstaja veliko dejavnikov, ki vplivajo na vedenje posameznika, kombinacije teh dejavnikov in osebnostnih lastnosti pa ustvarjajo razlike med ljudmi. Prav zato ob upoštevanju dejstva, da se tehnološki dosežki razvijajo z veliko hitrostjo, pojavila se je ideja, da bi bilo treba tehnologijo uporabiti za izboljšanje kakovosti življenja starejših ljudi. Vendar, kot je bilo že omenjeno, ljudje na različne načine pristopajo in sprejemajo nove stvari in situacije, še posebej ko gre za starejšo populacijo. Zaradi tega razloga, pomembno je preučiti vpliv osebnostnih lastnosti na uporabo pametnih sistemov oz. v nadaljevanju ADC sistema za mobilno upravljanje senčil. Na podlagi pregledane literature nismo zasledili študije, ki bi se ukvarjale s tem vprašanjem.

Primerjava spola oziroma med moškim in žensko kaže vpliv na osebnostne značilnosti in sicer pri ženskah je veliko bolj izražena ekstravertnost in sprejemljivost [2]. Kot ugotavlja MacDonald da so razlike med moško in žensko populacijo v splošnem minimalne oziroma zanemarljive [3]. Avtorja Phares in Chaplin pa sta mnenja, da se moški in ženske razlikujejo v vseh osebnostnih dimenzijah razen pri dimenziji odprtosti [4].

1.2 Cilj

Z nastankom našega prispevka želimo doseči tri cilje. Prvi cilj prispevka je preučiti psihologijo osebnosti po modelu »*velikih pet faktorjev osebnosti*« ter seznaniti bralce z psihološkimi elementi, ki bi jim pomagali pri razumevanju tega prispevka. Drugi cilj našega prispevka je predstaviti vpliv osebnostnih lastnosti starejše populacije nad starostjo 50 let glede na model »*velikih pet faktorjev osebnosti*« o uporabi ADC sistema za mobilno upravljanje senčil, ki bo olajšala krmiljenje senčil starejšim ljudem. Tretji cilj našega prispevka je starejšim ljudem predstaviti in jim dati na uporabo ADC sistem za mobilno upravljanje senčil, ter odkriti prednosti in slabosti ADC sistema ter odkriti napake in grožnje, s katerimi se soočajo starejši ljudje pri uporabi le teh.

1.3 Predpostavke in omejitve

V prispevku kot predpostavko navajamo zlorabo varstva osebnih podatkov. Predpostavimo lahko, da na podlagi prejšnjih ugotovitev psiholoških osebnostnih lastnosti ter njihov vpliv na uporabo ADC sistemov postavimo model, da bo čim bolj enostaven za starejšo populacijo in primeren za proizvajalce senčil.

Glavna omejitev našega prispevka bo najti starejše ljudi nad starostjo 50 let, ki bo želelo sodelovati in odgovarjati na vprašanja, ki jih večina ljudi ne želi razkriti. Kot omejitev pa lahko izpostavimo obseg ter zapletenost preučevanja psiholoških osebnostnih lastnosti in njihov vpliv na uporabo ADC sistemov.

1.4 Metodologija

Pregledali bomo literaturo po različnih svetovnih bazah, kot so Web of Science, Scopus, Google Scholar in Research Gate. Literaturo bomo iskali z ključnimi besedami: personality traits, big five, IoT, blinds.

Anketa je bila zaprtega tipa, kar pomeni, da anketiranci ne vpisujejo lastnih mnenj ampak za vsako trditev obkrožijo odgovor, ki opisuje njegovo strinjanje oz. nestrinjanje (1 – popolnoma se ne strinja, 2 – delno se ne strinjam, 3 – nisem prepričan, 4 - delno se strinjam, 5 – popolnoma se strinjam). Vzorec v tej raziskavi vključuje 58 ljudi, starih od 50 do 70 let, ki uporabljajo ADC sistem za mobilno upravljanje električnih senčil. Anketni vprašalnik je bil izveden s pomočjo spletne ankete preko Google Forms. Povezavo smo poslali po elektronski pošti vsem uporabnikom ADC sistemov, ki so starejši od 50 let. Vsi anketiranci so se strinjali, da bo prostovoljno sodelujejo v tej raziskavi, pri čemer so se strinjali, da je njihova zasebnost varovana in da bodo njihovi podatki uporabljeni izključno v znanstveno-raziskovalne namene. Raziskava je potekala v obdobju od junija do avgusta 2022.

Ob zaključku ankete smo samodejno beležili podatke o rešenih anketah, ki smo jih izvozili v program za statistično analizo IBM SPSS in pa v Microsoft Excel.

V prispevku bomo analizirali in predstavili podatke, ki smo jih dobili z pomočjo ankete, ki bo sestavljena iz dveh delov. V prvem delu ankete je bila za ocenjevanje uporabljena skrajšana verzija različice vprašalnika »*Big Five Plus Two*« [5]. V drugem delu ankete so vprašanja, ki so vezana na zadovoljstvo uporabe ADC sistema.

Delovna hipoteza je: Starejša populacija sprejema uporabo ADC sistema za mobilno upravljanje senčil.

2 PREGLED LITERATURE

2.1 Velikih pet faktorjev osebnosti

Costa in McCraejev model velikih pet faktorjev osebnosti je eden od najbolj znanih modelov osebnosti in velja za najbolj sprejemljivo teorijo osebnosti v znanstveni skupnosti. Njihova raziskava temelji na predhodnih empiričnih in teoretičnih raziskavah, kjer jim je z raziskavo uspelo v svojem modelu predstaviti veliko število osebnostnih lastnosti [6,7].

Model velikih pet faktorjev osebnostnih lastnosti se je izkazal za doslednega in stabilnega. Posameznike so namreč spremljali skozi leto, da bi pokazali in dokazali stabilnost osebnostnih lastnosti oziroma kako se lastnosti osebnosti ne spreminjajo, niti nanje ne vplivajo zunanji dejavniki [7]. Nadalje, Jensen pravi, da lahko vsako osebnostno lastnost obravnavamo kot kontinuum, tj. posamezniki so lahko visoko ali nizko na vsaki ravni od petih faktorjev. Vsaka oseba se nahaja v določenem delu kontinuuma za vsak faktor in tako tvori kompleksno sestavo kombinacij, ki so značilne za osebnost določenega posameznika. Posameznik ima lahko prevladujočo osebnostno lastnost in lahko imam osebnostno lastnost, ki je v središču kontinuuma in v tem primeru ta osebnostna lastnost nima posebej izrazitega vpliva na posameznika. Ta model je sestavljen iz naslednjih faktorjev:

1. Sprejemljivost,
2. Ekstravertnost,
3. Vestnost,
4. Odprtost,
5. Nevroticizem.

Vsak faktor modela velikih pet faktorjev osebnosti velja za večplasten konstrukt, torej vključuje dve oz. več faset nižjega reda [8,9]. Fasete predstavljajo skupino značilnosti (pridevniki), ki opisujejo človekovo osebnost in so združene v širši, večdimenzionalni dejavnik, ki jih logično povezuje in pojasnjuje ter kaže na širšo sliko določene dimenzije osebnosti.

Sprejemljivost je dimenzija, ki jo imajo izjemno skromni ljudje, katerih življenjska gonila in glavna motivacija je nesebičnost in usmerjenost k drugim ljudem. Ljudje, ki imajo izraženo to osebnostno lastnost so kooperativni in prijazni. Empatija omogoča, da vidijo situacijo iz perspektive nekoga drugega, kar spodbuja k razumevanje in prosocialnemu način postopanja. Ti ljudje so pošteni in prilagodljivi . Ljudje, ki imajo nizko oceno na tej dimenziji, so pogosto obrnjeni proti sebi, skeptični do namer drugih ljudi, neprilagodljivi, egocentrični, trmasti in pogosto so nesramni in sovražno nastrojeni. S svojim pristopom odbijajo druge od sebe [5].

Ekstravertnost je opredeljena kot dimenzija, po kateri se ljudje razlikujejo glede na število medosebnih odnosev, ob katerih se dobro počutijo [5]. Za osebe z visoko oceno ekstravertnosti je značilno veliko število medosebnih odnosov in večja verjetnost preživljanja časa z drugimi, pri nizki oceni pa je ravno obratno. Take osebe poimenujejo intraverti. Ekstraverti so odprti, energični, družabni ljudje z izraženimi komunikacijskimi sposobnostmi in so radi v središču pozornosti. Poleg teh pozitivnih strani obstajajo tudi negativne, to je, da so ti ljudje precej čustveni in impulzivni, in pogosto jim je zanemarjena tudi vzročno-posledična zveza določenih postopkov.

Vestnost se nanaša na število ciljev, na katere smo osredotočeni. Ti ljudje upoštevajo pravila in roki, in so zelo odgovorni. Odlikujeta jih izjemna disciplina in perfekcionizem. Vestnost kot osebnostna lastnost ima tudi svoje negativne strani. Pretiravanje včasih vodi v obsedenost. Pretirana predanost delu in deloholičnost vodita v zanemarjanje drugih vidikov življenja, dolžnosti, oseb in potrebe. Ljudje z nizko oceno na tej dimenziji ponavadi hitro obupajo in imajo manjša pričakovanja do sebe in do drugih[5].

Odprtost se nanaša na sprejemanje novih idej, pristopov in izkušenj ter je povezana z ustvarjalnostjo. To so ljudje, ki imajo sposobnost videti realnost iz širše perspektive. Visoka ocena je pokazatelj ustvarjalnosti, radovednosti, širokih interesov, izvirnosti in domišljije. Takšni ljudje so navdušeni nad inovativnostjo. Po drugi strani pa ljudje z nizkimi rezultati na tej dimenzije imajo ozke interese, so bolj konzervativni in se počutijo bolj udobno z znanimi stvari [5].

Nevroticizem: čustvena stabilnost je dimenzija, ki jo imajo uravnoteženi ljudje, katerih čustva ne vplivajo na vedenje. Takšni ljudje se znajo upreti lastnim nagonom in prenagljenim odločitvam, saj jih pri odločanju in na splošno v življenju vodi razum. Posledica odsotnost čustvene stabilnosti je nevroticizem. Nevroticizem je značilen za ljudi, ki so nagnjeni k močnemu čustvenemu doživljanju ter težkemu prenašanje in prilagajanje na življenjske spremembe. Pomembno je poudariti, da ta dimenzija ni patocentrična in da ljudje z visokimi fasetami v tej dimenziji ne rabijo imeti kakršno koli psihiatrično motnjo [5].

2.2 VPRAŠALNIK VELIKIH 5 PLUS 2

Vprašalnik Velikih pet plus dva (ang. *Big Five Plus Two*) je bil zgrajen na podlagi leksikalnih opisov osebnosti v srbskem jeziku. Druga psiholeksikalna študija v srbskem jeziku, iz katere je izpeljan vprašalnik temelji na primeru po Telegenovi in Wallerjevi neomejevalni metodologiji za izbiro opisa osebnosti [10]. Vprašalnik je namenjen za ocenjevanje sedem dimenzij osebnosti na najvišjem hierarhičnem nivodju, od tega vsaka vključuje dve ali tri ožje dimenzije. V skladu s tem ima vsaka od sedmih lestvic vprašalnika ma dve ali tri podlestvice. Lestvica nevroticizem vključuje podlestvico anksioznost, depresija in negativni efekt, lestvica ekstravertnost vsebuje podlestvico toplina, družabnost in pozitiven učinek, odprtost vsebuje intelekt in iskanje novih stvari, vestnost ima podlestvico vztrajnost, premišljenost in samodisciplina, agresivnost ima podlestvico jeza, nepopustljivost in trdoživost, pozitivna valenca ima speriornost in pozitivna samopodoba in negativna valenca ima manipulativnost in negativna samopodoba. Vprašalnik vsebuje 184 postavk s petstopenjsko Likertovo lestvico [5].

2.3 ADC SISTEMI

Podjetje ADC sistemi d.o.o. je prvo in edino slovensko podjetje, specializirano za mobilno upravljanje električnih senčil. ADC je eden od vodilnih svetovnih proizvajalcev visokokakovostnih izdelkov za avtomatizacijo poslovnih in zasebnih objektov.

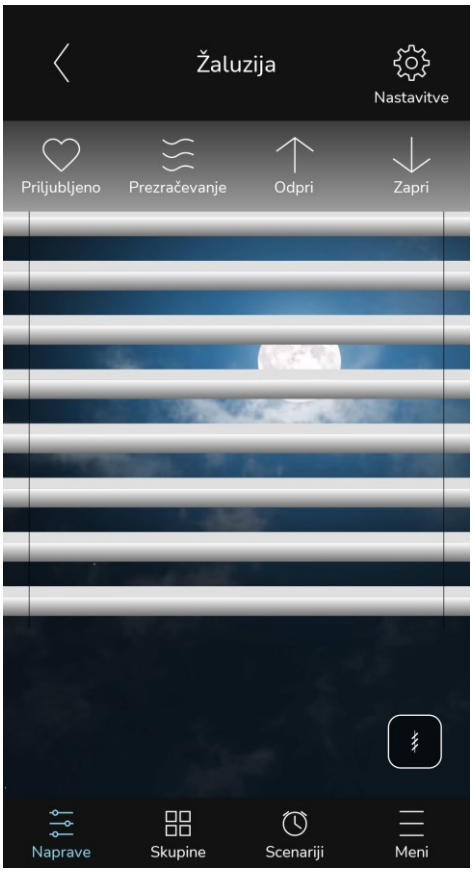
Podjetje ADC sistem je ustanovljeno leta 2020 in se je v 2 letih razvilo v mednarodno podjetje, ki ponuja inovativne rešitve v vseh državah Evropske unije. Razvoj temelji na interdisciplinarnem pristopu in skupinskih metodah dela, in sicer v skladu s sodobnimi spoznanji različnih strok. Razvoj programske in strojne opreme smo v celoti ustvarili slovenski inženirji, proizvedena pa je s pomočjo partnerskih podjetij v Sloveniji. Rezultat so tehnološko dovršeni in zanesljivi produkti, razviti v skladu s predpisi Evropske unije. Varnost in zanesljivost

ADC produktov postavljamo na prvo mesto, zato so vsi produkti testirani v naših raziskovalnih laboratorijih.

Podpiramo upravljanje vseh vrst senčil (rolete, žaluzije, screen senčila, tende, komarniki, pergole ...) s telefonom, tabličnim računalnikom, spletnim portalom glasovnim upravljanjem ali s stikalom/tipalom. ADC omogoča širok nabor funkcionalnosti, zato je primeren za vsakega posameznika od povprečnih uporabnikov pa vse do naprednih. S pomočjo glasovnega upravljanja (Google Assistant, Alexa, Siri) lahko senčila upravljamo z govornimi ukazi. Poleg osnovnih funkcionalnosti lahko izbiramo med velikim naborom senzorjev, ki se uporabljajo za nadzor senčil.

ADC aplikacija (sliki 1 in 2) omogoča priročen uporabniški vmesnik, kar pomeni da je preprosta in enostavna za uporabo. Na voljo je v Google Play, App Store, AppGallery in je brezplačna. Aplikacija je visoko zmogljiva, tako da se vsi procesi na aplikaciji hitro naložijo. Varnost je naše vodilo, zato so uporabniški podatki dobro zaščiteni in šifrirani. Naši strokovnjaki redno posodabljajo aplikacijo in jo nadgrajujejo z novimi funkcionalnostmi. Aplikacija je prilagojena vsem uporabnikom in jo lahko povežemo tudi z drugimi sistemi. ADC aplikacija je zaradi svojega dizajna, odzivnosti, preprostosti, zanesljivosti, varnosti, učinkovitosti najbolj priljubljena aplikacija za mobilno upravljanje električnih senčil. Aplikacija je na voljo v slovenskem jeziku, prav tako pa tudi v angleškem, nemškem italijanskem, hrvaškem, bosanskem in srbskem jeziku.

Slika 1: ADC aplikacija seznam naprav



Slika 2: Prikaz upravljanja žaluzij

ADC krmilnik (slika 3) je naprava, zasnovana za brezžično upravljanje električnih senčil z uporabo mobilnega telefona, tabličnega računalnika, spletnega portala, glasovnega upravljanja ali pa stikala/tipala. Krmilnik je sodobna in edinstvena rešitev, saj za svoje delovanje potrebuje le električno in domače Wi-Fi omrežje. Namestitev krmilnika je enostavna.

Slika 3: ADC krmilnik

3 REZULTATI

3.1 Značilnosti anketirancev

Med 58 anketiranci je bilo 35 moških, kar predstavlja 60 % vseh anketirancev in 23 žensk, kar predstavlja 40 % celotne populacije (Tabela 1).

Tabela 1: Struktura anketirancev po spolu

Spol	N	Delež v %
Moški	35	60%
Ženski	23	40%
Skupaj	58	100%

Starostna struktura anketirancev je prikazana v tabeli 2. Največ anketirancev, ki uporabljajo ADC sistem je bilo od 50 do 59 let, kar predstavlja 48 % vseh anketirancev. V naslednji starostni skupini od 60 do 69 let je bilo 20 anketirancev, kar znaša 34 % celotne populacije. Med 70 in 79 leti je bilo samo 8 anketirancev oziroma 14 % od celotne populacije. Na koncu smo imeli srečo, da smo imeli predstavnike nad 80 let in sicer 2 osebi oziroma 3 % celotne populacije.

Tabela 2: Struktura anketirancev po starosti

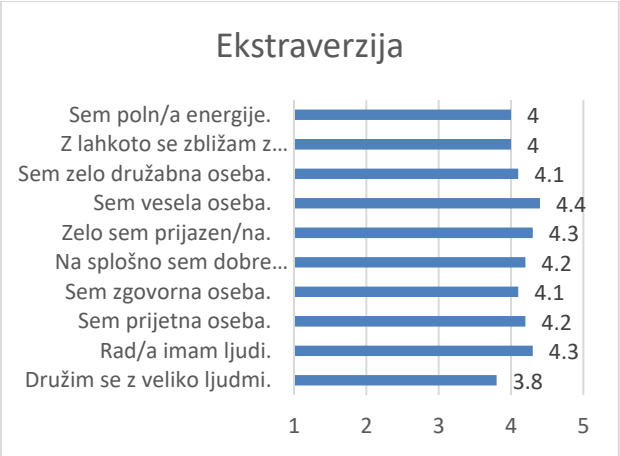
Starost	N	Delež v %
od 50 do 59	28	48%
od 60 do 69	20	34%
od 70 do 79	8	14%
nad 80	2	3%
Skupaj	58	100%

3.2 Osebnostne značilnosti anketirancev

Sprejemljivost smo merili z 10 trditvami. Na sliki 4 so prikazani rezultati povprečja dimenzije sprejemljivosti. Merili smo naslednje trditve:

1. Pogosto se prepiram z drugimi ljudmi – 1,9.
2. Sem vzkipljiv/a - 2,4.
3. Pogosto nasprotujem mnenju drugih – 2,3.
4. Zlahka se razjezim – 2,6.
5. Pogosto se jezim – 2,5.
6. Pogosto nasprotujem drugim ljudem – 2,2.
7. Sem blage narave – 2,9.
8. Rad/a ukazujem – 2,5.
9. Sem "težka" oseba – 2,2.
10. Lahko rečem, da sem čemerna oseba – 2,1.

Slika 4: Sprejemljivost s povprečno oceno



Slika 5: Ekstraverzija s povprečno oceno

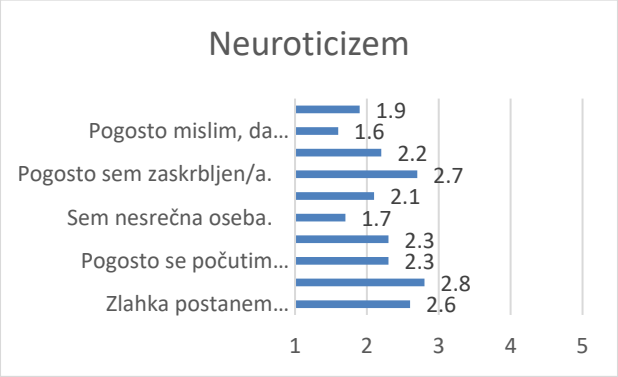
Na sliki 5 je prikazana dimenzija **ekstraverzija**, ki smo jo merili z 10 trditvami in sicer:

1. Družim se z veliko ljudmi – 3,8.
2. Rad/a imam ljudi – 4,3.
3. Sem prijetna oseba – 4,2.
4. Sem zgovorna oseba – 4,1.
5. Na splošno sem dobre volje – 4,2.
6. Zelo sem prijazen/na – 4,3.
7. Sem vesela oseba – 4,4.
8. Sem zelo družabna oseba – 4,1.
9. Z lahko se zbližam z ljudmi – 4.
10. Sem poln/a energije – 4.

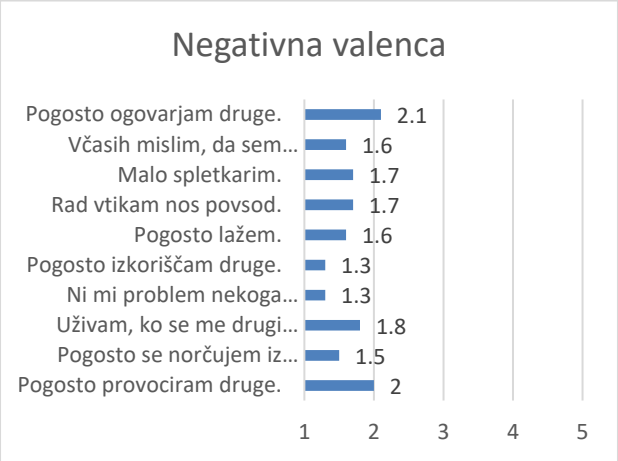
Podobno smo z 10 trditvami merili dimenzijo **neuroticizma** (slika 6). Trditve so urejene po padajočih rezultatih:

1. Pogosto sem zaskrbljen/a – 2,7.
2. Nimam veliko sreče – 2,8.
3. Zlahka postanem maloduešn – 2,6.
4. Pogosto se počutim ogorčeno – 2,3.
5. Čutim, da je življenje krivično do mene – 2,3.
6. Pogosto se počutim krivega – 2,2.

7. Pogosto imam morje žalostnih misli – 2,1.
8. Pogosto čutim tesnobo - 1,9.
9. Sem nesrečna oseba – 1,7.
10. Pogosto mislim, da življenje nima smisla – 1,6.



Slika 6: Neuroticizem s povprečno oceno



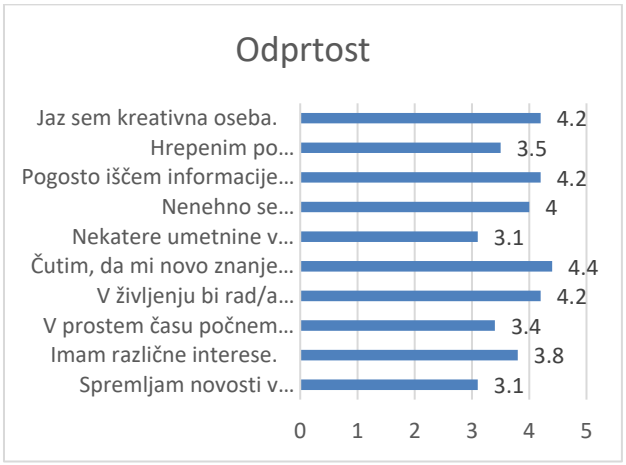
Slika 7: Negativna valenca s povprečno oceno

Slika 7 prikazuje 10 trditev za **negativno valenco** in sicer:

1. Pogosto provociram druge – 2.
2. Pogosto se norčujem iz drugih – 1,5.
3. Uživam, ko se me drugi bojijo – 1,8.
4. Ni mi problem nekoga prevarati – 1,3.
5. Pogosto izkoriščam druge – 1,3.
6. Pogosto lažem – 1,6.
7. Rad vtikam nos povsod – 1,7.
8. Malo spletkarim – 1,7.
9. Včasih mislim, da sem grozljiva oseba – 1,6.
10. Pogosto ogovarjam druge – 2,1.

Na sliki 8 vidimo trditve za dimenzijo **odprtosti** in sicer te so:

- Spremljam novosti v umetnosti (glasba, film, literatura...) – 3,1.
- Imam različne interese 3,8.
- V prostem času počnem veliko zanimivih stvari 3,4.
- V življenju bi rad/a poizkusil/a čim več stvari 4,2.
- Čutim, da mi novo znanje bogati življenje 4,4.
- Nekatere umetnine v meni zbudijo močna čustva 3,1.
- Nenehno se izpopolnjujem in napredujem 4.
- Pogosto iščem informacije o stvareh, ki me zanimajo 4,2.
- Hrepenim po razburljivosti in novostih 3,5.
- Jaz sem kreativna oseba 4,2.



Slika 8: Odprtost s povprečno oceno

Slika 9: Pozitivna valenca s povprečno oceno

Trditve, namenjene za **pozitivno valenco** so prikazane na sliki 9. Te trditve so:

- Jaz sem rojeni zmagovalec - 3,7.
- Sem očarljiva oseba – 3,5.
- Jaz sem modra oseba – 3,7.
- Mislim, da sem zelo nadarjen - 3,6.
- Ustvarjen sem bil za velika dela – 3,5.
- Mislim, da imam nekaj posebnih lastnosti – 3,8.
- Sem pomembna oseba - 2,5.
- Sem močna oseba – 4,1.
- Sem vplivna oseba – 2,5.
- O sebi imam zelo visoko mnenje – 3,3.

Dimenzija **vestnosti** (slika 10) se je obravnavala z naslednjimi trditvami:

- Zelo sem vztrajen – 3,7.

- Zame velja: kaj lahko narediš danes, ne pusti za jutri – 2,2.
- Sem zelo pridna in delovna oseba – 1,7.
- Vedno izpolnim vse svoje obveznosti – 2,3.
- Vse kar začnem, to končam - 4.
- V tem kar počnem, sem zelo temeljit/a – 3,9.
- Nagnjen/a sem k odlašanju - 4.
- Pri obveznostih sem malomaren – 4,2.
- Sem lena oseba – 3,7.
- Pogosto najdem delo – 4,3.

Slika 10: Vestnost s povprečno oceno

3.3 Zadovoljstvo uporabe ADC sistema

Vsi anketiranci so uporabljali ADC sistem za mobilno upravljanje senčil in so podali mnenja na naslednje trditve (slika 11).

1. Zelo pogosto uporabljam telefon - 5.
2. Za premikanje senčil uporabljam stikala/tipkala – 4,2.
3. Aplikacija je enostavna za uporabo - 5.
4. ADC aplikacijo uporabljam tudi na tabličnem računalniku – 2,8.
5. Stroški implementacije ADC sistema so nizki – 4,6.
6. Všeč mi je, da ne potrebujem dodatne centralne enote - 5.
7. Namestitev celotnega ADC sistema je enostavna in nezahtevna - 5.
8. Odzivnost aplikacije je zelo visoka - 5.
9. Vse moje zahteve in potrebe so vključene v ADC sistem – 4,3.
10. Počutim se varnega z ADC sistemom – 4,8.
11. Uporabljam pametne vremenske scenarije brez dodatnih senzorjev – 4,5.
12. Pametni vremenski scenariji so enostavni za uporabo – 4,8.
13. Všeč mi je, da se krmilniki povezujejo na domače Wi-Fi omrežje (router) - 5.
14. Verjamem, da se ADC sistemi nenehno izpopolnjujejo in skrbijo za sistem – 4,3.
15. Stroški gretja in hlajenja so manjši z ADC sistemom – 4,4.
16. Povezava med ADC sistemi in domačim omrežjem je zanesljiva in varna – 5.
17. Grafični vmesnik aplikacije je pregleden in prilagodljiv – 5.
18. Za upravljanje senčil bi rajši izbral/a ADC aplikacijo kot pa daljinec – 5.
19. ADC sistem mi je olajšal/a življenje.
20. ADC sistem bi priporočil/a vsakemu.

Slika 11: Zadovoljstvo uporabe ADC sistema s povprečno oceno

4 DISKUSIJA

V prispevku smo postavili hipotezo »*Starejša populacija sprejema uporabo ADC sistema za mobilno upravljanje senčil*«, ki smo jo preverjali v empiričnem delu naloge. Na podlagi rezultatov hipotezo potrdimo, saj so starejši ljudje pozitivno sprejeli novo tehnologijo ADC sistemi in jo tudi zelo hitro sprejeli kot del vsakdanja.

Pravijo da med starostjo in sposobnostjo sprejemanja novih tehnologij ni korelacije oziroma starejša populacija težko sprejema nove stvari. Na podlagi raziskave lahko rečemo, da so bili starejši ljudje zadovoljni z ADC sistemom in so ga zelo hitro sprejeli. V primerjavi z starejšo tehnologijo daljincev, so se starejši ljudje odločili, da bi rajši uporabljali ADC sistem kot pa daljinec.

Med moškim in ženskim spolom ni razlik v osebnostnih lastnostih po modelu velikih pet faktorjev osebnosti. Moški in ženske so si po želenih osebnostnih lastnostih zelo podobni, torej spol nima nobenega vpliva na osebnost posameznika.

Rezultati so pokazali, da v povprečju osebnostne lastnosti pozitivno vplivajo na sprejemanje uporabe ADC sistema. Nekatere dimenzije se malo težje prilagodijo, nekatere pa zelo

hitro. Da bi dobili še bolj natančne rezultate, moramo vsako dimenzijo še razdeliti v pod dimenzije, nato določiti osebnost posameznika in mu dati na uporabo ADC sistem. Šele po določenem številu istih vzorcev bi videli, katera dimenzija se lažje prilagodi na novo tehnologijo, katera se pa težje. S tem bi lahko še podrobneje preverili, katere dimenzije imajo velik vpliv in katere dimenzije imajo majhen vpliv na sprejemanje uporabe ADC sistema.

V nadaljnje raziskave bi lahko vključili tudi vprašalnik BFQ, ki prav tako meri osebnostne značilnosti. BFQ vprašalnik vsebuje 132 trditev. Tako bi lahko med seboj primerjali pridobljene rezultate obeh vprašalnikov in jih med seboj primerjali. Vprašalnik BFQ omogoča bolj poglobljene rezultate, saj poleg pet dimenzij modela velikih pet vključuje tudi deset podrejenih dimenzij.

Raziskave o osebnih značilnostih starejših ljudi in njihovo sprejemanje ADC sistema med pisanjem prispevka nismo zasledili ne v slovenski ne v tuji literaturi.

5 ZAKLJUČEK

Temeljni cilj prispevka je preveriti povezanost osebnostnih značilnosti v povezavi z zadovoljstvom uporabe ADC sistema za mobilno upravljanje senčil. Da smo cilj dosegli smo najprej preučili opredelitev osebnosti po modelu velikih pet faktorjev osebnosti. Model velikih pet sestavlja pet dimenzij mi smo pa uporabili zadnjo verzijo anketnega vprašalnika velikih pet plus dve, kjer smo ugotavljali naslednje dimenzije: ekstravertnost, nevroticizem, vestnost, sprejemljivost, odprtost, pozitivna valenca in negativna valenca, s katerimi smo ugotavljali osebnostne značilnosti, razlike med posameznimi dimenzijami in razlike me spolom.

Tehnologija hitro napreduje in danes imamo kar nekaj sistemov za mobilno upravljanje senčil, ki delujejo preko Wi-Fi signala ali pa radijskega signala, ki se preko centralne enote pretvori v Wi-Fi signal. Vsi sistemi se med seboj razlikujejo po ceni, velikosti, zmogljivosti, varnosti, prilagodljivosti, uporabnosti itd…

ADC sistem je postavljen sodobno in poleg interneta za delovanje ne potrebuje ničesar. ADC sistemi so v Sloveniji najbolj priljubljeni sistemi za mobilno upravljanje senčil. Veliko je bilo govora o tem, kako bo starejša populacija sprejela novo tehnologijo ADC sistem, kjer so predpostavljali lastniki podjetij, da se bodo starejši ljudje zelo težko oz. se ne bodo navadili na novo tehnologijo. V prispevku lahko potrdimo da je starejša populacija sprejela uporabo ADC sistema za mobilno upravljanje električnih senčil.

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LITERATURA IN VIRI

[1] Musek, J., 2002. Dimenzije in meje osebnosti. Dialogi, 38(9/10), 23-35.
[2] Cecić Erpić, S., Boben, D., Zabukovec, V., Škof, B., 2002. Dejanske in želene osebnostne lastnosti športnih pedagogov. Psihološka obzorja, 11(4), 81-102.
[3] MacDonald, K., 1995. Evolution, the five-factor model, and levels of personality. Journal of Personality, 63(3), 525-567.
[4] Phares, E. J., Chaplin, W. F., 1997. Introduction to personality. New York: Longman.
[5] Smederevac, S., Mitrović, D., 2006. Ličnost-metode i modeli. Beograd: Centar za primenjenu psihologiju.
[6] Costa, P. T., McCrae, R. R. (1992). Four ways five factors are basic. Personality and Individual Differences, 13, 653-665.
[7] Jensen, M., 2015. Personality Traits, Learning and Academic Achievements. Journal of Education and Learning, 4(4), 91-118.
[8] Digma, J M., 1990. Personality structure: Emergence of the five-factor model. Annual Rewiev of Psychology, 41(1), 417-440.
[9] Varvodić, I., 2016. Kupovno ponašanje i model »velikih pet« faktora ličnosti. Diplomsko delo. Dostopno na naslovu https://repozitorij.efst.unist.hr/islandora/object/efst:896 (1.8.2022).
[10] Waller, N. G., 1999. Evaluating the structure of personality. In C. R. Cloninger (Ed.), Personality and psychopathology. Washington, DC; American Psychiatric Press, 155-197.

Igrifikacija v visokošolskem izobraževanju: primer visokošolskih učiteljev in sodelavcev

Gamification in Higher Education: The Case of Higher Education Teachers and Colleagues

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POVZETEK

Igrifiakcijo lahko opredelimo kot uporabo elementov igrifikacije v neigranih kontekstih. Najbolj poznani elementi igrifikacije so točke, lestvice, nagrade in drugo. Izobraževanje je področje, kjer se je igrifikacija zelo uveljavila. Igrifikacija v izobraževanju se najpogosteje omenja in uporablja pri študentih z namenom doseganja večje motiviranosti, angažiranosti in učinkovitosti. Manj poznana in analizirana pa je igrifikacija, ki se uporablja pri visokošolskih učiteljih in sodelavcih. Članek obravnava igrifikacjio na področju visokega šolstva, natančneje njene aplikacije pri visokošolskih učiteljih in sodelavcih. Slednji so v primerjavi z ostalimi javnimi uslužbenci najbolj izpostavljeni elementom igrifikacije. Ugotavljamo, da so elementi igrifikacije pri visokošolskih učiteljih in sodelavcih, tako formalne kot neformalne narave. Najpomembnejši in najbolj znani izmed njih so predstavljeni v nadaljevanju. Elementi igrifikacije imajo v visokem šolstvu velik vpliv. Nekateri elementi vplivajo na osebni dohodek zaposlenega, napredovanje, status zaposlenega in drugo.

KLJUČNE BESEDE

Visokošolsko izobraževanje, visokošolski učitelji, visokošolski sodelavci, igrifikacija, elementi igrifikacije

ABSTRACT

Gamification can be defined as the use of gamification elements in non-game contexts. The most familiar gamification elements are points, leaderboards, prizes, rankings and more. Education is an area where gamification has become very popular. Gamification in education is usualy used for students in order to achieve greater motivation, engagement and efficiency. Less known and analyzed is gamification, which is used for higher education teachers and colleagues. The article deals with gamification in the field of higher education, more precisely its applications for higher education teachers and colleagues. Compared to other civil servants, the higher education teachers and colleagues are most exposed to gamification elements. We find that the gamification elements in higher education teachers and colleagues are both formal and informal in nature. The most important of them are presented in detail below. The gamification elements have a great influence in higher education. Some elements have an impact on the employee's personal income, promotion, employee status and more.

KEYWORDS

Higher education, higher education teachers, higher education colleagues, gamification, gamification elements

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1 UVOD

Ljudje so se in se srečujemo z igrami skozi vso svojo zgodovino. Igre najpogosteje povezujemo z zabavo, sprostitvijo, prostovoljno udeležbo in otroštvom. Igre so pomembne za otroke kot tudi za odrasle, saj vplivajo na razvoj in počutje posameznika in skupnosti ter predstavljajo pomembno psihološko in fiziološko potrebo [1]. Igro lahko opredelimo kot "oblika igranja neke igre s cilji in strukturo" [2]. Najbolj poznane in prisotne sledeče igre [3]: športne igre, namizne igre, igranje vlog, simulacije, poslovne igre in video igre (offline in online). Z razvojem informacijsko-komunikacijske tehnologije (IKT) so se spreminjale tudi igre. Prav zaradi IKT so se najbolj razvile video igre. Na njihovo splošno razširjenost pa so vplivale številne nove tehnologij, kot so igralne konzole, igralne platforme, mobilna telefonija, tablice in tehnologije za igranje [4]. IKT v igrah je omogočila zbiranje velike količine podatkov. V industriji iger se tako zbrani podatki analizirajo z namenom prilagajanja igre oz. njenega izboljšanja. Glavni namen video iger je zadržati igralca čim dlje časa v igri. Zato mora biti igra zanimiva in zabavna. V industriji iger v ta namen uporabljajo tako imenovane elemente igrifikacije. Najbolj poznani elementi igrifikacije so razni sistemi točk, značke, trofeje, lestvice, ravni, ugled, skupine naloge, časovni pritisk, naloge, avatarji, virtualni svetovi in virtualna trgovanja [5]. Uporabo teh elementov lahko označimo kot igrifikacijo (angl. gamification). Z igrifikacijo želimo vplivati na posameznikovo obnašanje in vedenje. Zaradi pozitivnih vplivov omenjenih elementov so se začela spoznanja ter elementi igrifikacije iz industrije igre prenašati tudi na druga področja in industrije. Danes lahko najdemo elemente igrifikacije skoraj v vseh industrijah in panogah.

Eno izmed bolj zanimivih področij za uporabo igrifikacije je zagotovo izobraževanje in visokošolsko izobraževanje pri tem ni

izjema. Najbolj znana je uporaba igrifikacije pri študentih, kjer je njen glavni namen povečati motivacijo, angažiranost in učinkovitosti študentov pri študiju. Manj poznana ter znanstveno in strokovno analizirana pa je uporaba igrifikacije pri zaposlenih v visokošolskem izobraževanju, ki sodelujejo v pedagoškem procesu. Zaposleni v visokošolske izobraževanju so na tak ali drugačen način izpostavljeni elementom igrifikacije. V članku je v nadaljevanju predstavljeno področij visokega šolstva, igrafikacije in elementi igrifikacije. Sledi pregled najpomembnejših elementov igrifikacije s katerim se srečujejo visokošolski učitelj in sodelavci. Ti elementi imajo lahko velik vpliv na posameznikovo aktivnost, kariero, dohodek kot tudi na počutje in posameznikova občutja. Na visokošolske učitelje in sodelavce imajo takšni elementi lahko pozitivne kot tudi negativne vplive.

2 VISOKOŠOLSKO IZOBRAŽEVANJE

Izobraževanje ima pomembno vlogo v življenju vsakega posameznika. Temeljne cilje izobraževalnega sistema lahko hierarhično delimo na [6]: izobraževalne cilje, ki jih izobraževalnemu sistemu postavlja družba; izobraževalne cilje posameznih izobraževalnih programov, ki jih navadno opredeljujejo posamezne stroke, seveda ob upoštevanju prejšnjih; izobraževalne cilje v učnih načrtih predmetov, ki tvorijo posamezen izobraževalni program, s pomočjo katerih skušamo uresničiti izobraževalne cilje, postavljene na prejšnjih dveh nivojih.

Na spletnem portalu gov.si [7] lahko zasledimo, da je cilji visokošolskega izobraževanja v Sloveniji sledeč: »Osnovni cilji slovenskega visokošolskega prostora so kakovost in odličnost, raznovrstnost ter dostopnost. Kakovost bo vsem omogočala mednarodno primerljivo in priznano visokošolsko izobrazbo, s tem pa večje zaposlitvene možnosti ter mobilnost v evropskem prostoru in svetu. Pri tem je pomembna socialna razsežnost, ki omogoča širok dostop do visokega šolstva in zagotavlja pogoje za uspešno dokončanje študija.«. Na omenjenem spletnem portalu [7] lahko zasledimo tudi opredelitev visokošolskega sistema v Sloveniji, ki se glasi: »Visokošolski zavodi v slovenskem visokošolskem prostoru so univerze, fakultete, umetniške akademije in visoke strokovne šole. Zagotavljajo razvoj znanosti, strokovnosti in umetnosti ter v izobraževalnem procesu posredujejo spoznanja z znanstvenih, strokovnih, raziskovalnih in umetniških področij. Fakultete, umetniške akademije in visoke strokovne šole so lahko ustanovljene tudi kot samostojni visokošolski zavodi zunaj univerz.«. Spletna stran spot.gov [8] navaja, da so za izvajanje visokošolskega izobraževanja v Sloveniji zadolžene univerze, fakultete, umetniške akademije in visoke strokovne šole. Na omenjeni spletni strani spot.gov [8] lahko najdemo tudi opredelitev univerze, fakultete, umetniške akademije in visoke strokovne šole, ki se glasi: »Univerza zagotavlja razvoj znanosti, strokovnosti in umetnosti in prek fakultet, umetniških akademij ali visokih strokovnih šol v izobraževalnem procesu posreduje spoznanja z več znanstvenih oziroma umetniških področij ali disciplin. Univerza lahko neposredno organizira izvajanje znanstveno-raziskovalnih in študijskih interdisciplinarnih programov. Fakulteta opravlja pretežno znanstveno-raziskovalno in izobraževalno dejavnost s področij ene ali več sorodnih oziroma med seboj povezanih znanstvenih disciplin in skrbi za njihov razvoj. Umetniška akademija opravlja pretežno umetniško in izobraževalno dejavnost s področij ene ali več sorodnih oziroma med seboj povezanih umetniških disciplin in skrbi za njihov razvoj. Visoka strokovna šola opravlja izobraževalno dejavnost s področja ene ali več sorodnih oziroma med seboj povezanih strok in skrbi za njihov razvoj.«

Pri delu s študenti oz. pedagoškem delu v visokem šolstvu zasledimo različne akterje. Najbolj poznani nazivi so redni profesor, izredni profesor, docent, višji predavatelj, predavatelj in lektor. Omenjene uvrščamo med tako imenovane visokošolske učitelje. Osebe oz. nazive kot so asistent, bibliotekar, strokovni svetnik, višji strokovni sodelavec, strokovni sodelavec in učitelj veščin pa uvrščamo med tako imenovane visokošolske sodelavce. Visokošolski učitelji in sodelavci so glavni nosilci pedagoškega in raziskovalnega dela na univerzah oz. fakultetah. Kot bo prikazano v nadaljevanju so prav ti zaposleni podvrženi velikemu številu ocenjevanj, rangiranju, tekmovanju, razvrščanju ter drugimi elementi, ki jih lahko opredelimo kot elemente igrifikacije v visokošolskem izobraževanju.

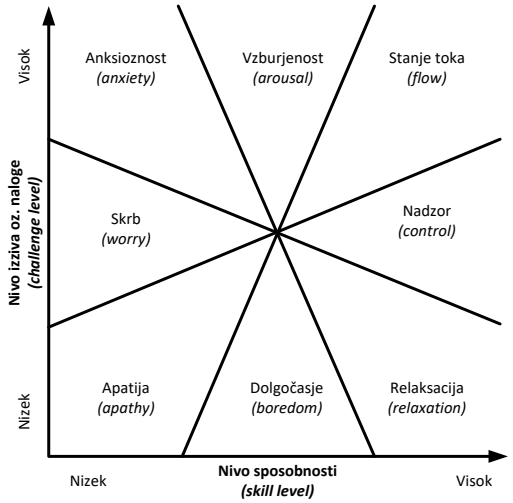
3 IGRIFIKACIJA

Igrifikacija se začne resneje uvajati in proučevati šele od druge polovice leta 2010 [9]. Opredelitev igrifikacije lahko označimo kot aktivnost z značilnostim iger, ki so vključene v dejavnosti, ki same niso igre [10]. Igrifikacija ima lastnosti značilne iger, ki so zabavne in privlačne ter so uporabljene za izboljšanje uporabniške izkušnje igralca v okolju brez iger (na delovnem mestu, šoli, aplikacijah ali spletnih straneh) [11]. Igre so najpogosteje zasnovane tako (predvsem video igre), da skušajo igralca čim hitreje vpelje v igro in ga obdržati v navidezni povratni zanki sestavljeni iz akcije, povratne informacije in refleksije [12]. Namen igrifikacije je povečati določene aktivnost ljudi in spodbujati določena vedenja [13]. Igrifikacijo lahko razumemo tudi kot zbirko orodij, ki se lahko uporablja za doseganje želenega vedenja [14].

Z igrifikacijo nekega področja ali procesa lahko dosežemo drugačno obnašanje udeležencev v tem procesu. Številne raziskave na različnih področjih, ki so podprta z elementi igrifikacije, poročajo o višji stopnji motiviranosti, angažiranosti in učinkovitosti udeležencev. Čas preživet v takšni aktivnosti je daljši in uporabnik je bolj zadovoljen. Če je neka naloga (ali igra) zasnovana na način, da sta zahtevnost naloge in veščina udeleženca usklajeni lahko govorimo o tako imenovanem stanju toka (angl. flow). Stanj toka se definira kot optimalna izkušnja, za katero sta značilna popolna osredotočenost in angažiranost na neko aktivnost v kateri je nek udeleženec [15]. Na Sliki 1 je prikazan model oz. stanje udeleženca glede na nivo sposobnosti/znanja in izziva oz. naloge. Glede na nivo sposobnosti/znanja in nivo izziva se pri udeležencu pojavljajo določeni občutki in stanja prikazana na Sliki 1.

Obstaja devet značilnosti med stanjem toka in izkušnjo uporabnika in sicer kot: uravnoteženost med zahtevnostjo naloge in sposobnostjo posameznika, samodejno opravljanje neke aktivnosti, jasno postavljeni cilji, jasne povratne informacije, osredotočenost na nalogo, občutek nadzora aktivnosti, izguba samozavedanja, občutek za čas postane izkrivljen in avtentična izkušnja (dejavnost je sama po sebi razlog opravljanja) [15]. V tem stanju se pogosto zgodi, da izgubimo občutek za čas in dogajanje v oklici. Udeleženec, ki je v stanju

toka je popolnoma osredotočen na nalogo. Izvajanje takšne naloge je pogosto najučinkovitejše in najuspešnejše.



Slika 1: Prikaz mentalnega stanja igralca glede na nivo sposobnosti in izziva [16].

4 ELEMENTI IGRIFIKACIJE

Glavni cilj igrifikacije v izobraževanju je narediti izobraževanje prijetno, kot je to značilno za video igre [13]. Ko je govora o igrifikaciji nikakor ne moremo mimo njenih glavnih gradnikov, ki so elementi igrifikacije. Seznam elementov igrifikacije s kratkim pojasnilom (po abecednem vrstnem redu) [10]:

- avatar: vizualna predstavitev igralčevega značaja,
- boj z močnejšim: značilno težka naloga v okviru določene stopnje,
- boj: ničelni seštevek vsote točk ali financ med igralci, ki se borijo za isti cilj,
- dosežki: specifično definirana naloga v igri,
- lestvice: primerjanje z drugimi igralci, ki temelji na sposobnostih,
- naloge: predhodno določeni izzivi,
- nivoji: težavnostno merilo, ki temelji na igralčevih kompetencah,
- obdarovanje: zagotavljanje pomoči drugim igralcem,
- odklepanje vsebin: zagotavljanje novih vsebin, ki so posledica osvojitve delnega cilja,
- skupine: skupina igralcev, ki sodeluje z namenom dosege nekega cilja,
- točke: numerični zapisi o igralčevi aktivnosti,
- virtualne dobrine: sredstva z določeno vrednostjo v okviru igre.
- zbirke: zbirka določenih značk in
- značke: vizualna predstavitev dosežka.

Elementi igrifiakcije imajo svoje značilnosti. Namenjeni so specifičnim uporabnikom v specifičnih situacijah. Zgolj uvedba elementov igrifikacije v nek proces še ne zagotavlja, da bo proces oz. njegovi uporabniki zadovoljni. Pri uporabnikih obstajajo številne posebnosti kot so kultura, rasa, veroizpoved, starost, spol, osebnostne lastnosti in drugo, ki vplivajo na dojemanje in sprejemanje elementov igrifikacije.

V nadaljevanju so predstavljeni elementi igrifikacije v visokem šolstvu s poudarkom na visokošolskih učiteljih in sodelavcih.

5 ELEMENTI IGRIFIKACIJE V VISOKOŠOLSKEM IZOBRAŽEVANJU

Uporaba elementov igrifikacije v izobraževanju ima številne prednosti, njihova uporaba v izobraževalnih okoljih pa se je izkazala za uspešno [17]. Pri tem moramo poudariti, da je velika večina raziskav s področja igrifikacije v izobraževanju narejena na učencih, dijakih in študentih. Elementi igrificikaje, ki jih lahko najpogosteje zasledimo v izobraževanju in so uporabljeni na študentih so (po abecednem vrstnem redu) [3]: časovna omejitev (naloga, izpit), delo z virtualnimi karakterji in problemi, dobra ocena, dodatne točke, doseči čim več točk na izpitu, vajah, finančne nagrade, hitre povratne informacije, individualno delo, javna podelitev priznanj, javna pohvala profesorja, kazen za neaktivnost, materialne nagrade, naloge, ki imajo velik družben pomen, negativne točke za napačen odgovor, objava med najboljšimi študenti, pisno priznanje, predčasno dokončanje nalog in skupinsko delo, strah pred neuspehom, tekmovanje/primerjanje s sošolci, ustna pohvala profesorja, vizualni prikaz in statusa napredka. Zelo malo pa je bilo izvedenih raziskav o igrifikaciji, elementih igrifikacije ter njihovem vplivu na visokošolske učitelje in sodelavce. V primerjavi z drugimi javnimi uslužbenci, kamor štejmo tudi visokošolske učitelje in sodelavce, lahko trdimo, da so prav omenjeni najbolj izpostavljeni elementom igrifikacije.

Visokošolski učitelji in sodelavci v Sloveniji najpogosteje delujejo oz. so zaposleni na univerzah (fakultetah). Omenjene ustanove so podvržene številnim medsebojnim primerjavam, ki so javno dostopne. Na spletni strani Univerze v Ljubljani pod poglavjem kakovost lahko najdemo nekatere mednarodne lestvice po katerih lahko medsebojno primerjamo posamezne univerze [18]: (1) Academic Ranking of World Universities (Shanghai Ranking); (2) QS World University Ranking; (3) Times Higher Education (THE) World Universities Ranking; (4) Times Higher Education Emerging Economies University Rankings in (5) Center for World University Rankings (CWUR).

Omenjene lestvice omogočajo medsebojno primerjanje univerz. V Sloveniji sta vodilni in najbolj poznani Univerza v Ljubljani in Univerza v Mariboru, ki sta tudi največji tekmeci za študente in ugled. Številni kriteriji, ki so zajeti v rangiranju univerz upoštevajo znanstvene objave visokošolskih učiteljev in sodelavce. Zato je pomembno, da so visokošolski učitelji in sodelavci aktivni v svojem znanstveno-raziskovalnem in strokovnem delu oz. da imajo kvalitetne objave v priznanih revijah. Visokošolske učitelje in sodelavce se najpogosteje ocenjuje in vrednoti po sledečih elementih: (1) znanstveno-raziskovalna dejavnost; (2) strokovna dejavnost; (3) umetniška dejavnost in (4) pedagoška dejavnost. Visokošolski učitelji in sodelavci morajo za svoj obstoj oz. zaposlitev izpolnjevati določene pogoje. Eden izmed teh pogojev je aktivno znanstveno-raziskovalno in strokovno delo, ki se odraža v znanstvenih in drugih objavah. Med omenjenimi zaposleni je ta proces znan pod imenom habilitacija. Habilitacija se mora opraviti vsakih nekaj let (najpogosteje za dobo petih let). Za številne zaposlene predstavlja habilitacija velik napor in stres. Za razliko od večine javnih uslužbencev pa so rezultati dela visokošolskih učiteljev in

sodelavcev, ki so v obliki znanstvenih objav, javno dostopni na raznih spletnih straneh. Ena izmed pomembnejših spletnih strani, kjer so objavljena dela visokošolskih učiteljev in sodelavcev je SICRIS. Na področju visokega šolstva ima spletna stran SICRIS zelo pomembno vlogo, kjer lahko najdemo različne podatke o raziskovalcih, raziskovalnih skupinah, projektih in drugo. Na spletni strani Wikipdija [19] lahko zasledimo opredelitev SICRIS-a, ki se glasi: »Informacijski sistem o raziskovalni dejavnosti v Sloveniji (kratica SICRIS - Slovenian Current Research Information System) je namenjen javnemu spletnemu prikazu podatkov iz zbirke oziroma evidence izvajalcev raziskovalne in razvojne dejavnosti, ki jo vodi Javna agencija za raziskovalno dejavnost Republike Slovenije (ARRS), ter podatkov o raziskovalnih projektih in raziskovalnih programih, ki jih financira ARRS iz sredstev državnega proračuna. Evidenca izvajalcev raziskovalne in razvojne dejavnosti vsebuje podatke o raziskovalnih organizacijah, o raziskovalnih skupinah in o raziskovalcih oziroma o raziskovalnem kadru. Informacijski sistem vzdržujeta Institut informacijskih znanosti in Javna agencija za raziskovalno dejavnost Republike Slovenije.« Na SICRIS-u lahko vidimo kakšne rezultate dosega nek visokošolski učitelja ali sodelavec. Pregled informacijskega sistema o raziskovalni dejavnosti v Sloveniji (SICRIS) pokaže, da lahko visokošolske učitelje in sodelavce rangiramo in primerjamo po številnih kriterijih kot so na primer [20]: A" - Izjemni dosežki; A' Zelo kvalitetni dosežki; A 1/2 - pomembni dosežki; Ocena A1 - objave; Ocena A3 - sredstva izven ARRS; CI10 - število čistih citatov znanstvenih del v zadnjih desetih letih; CImax - najodmevnejše delo; h-indeks; Scopus - povezani zapisi; Scopus - citati (TC); Scopus - čisti citati (CI); Scopus - povprečje čisti citatov (CIAu); WoS - povezani zapisi; WoS - citati (TC); WoS - čisti citati (CI) in WoS - povprečje čistih citatov (CIAu).

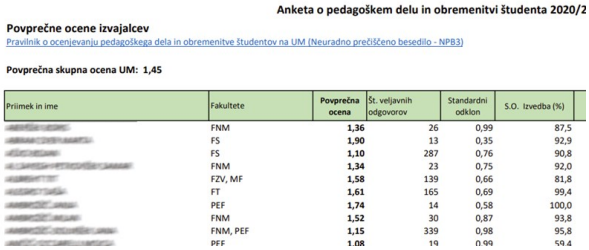
Na spletni strani SICRIS najpogosteje zasledimo elemente igrifikacije kot so točke in lestvice. Na omenjeni spletni strani lahko zasledimo številne izvedbe pojava, ki ga imenujemo igrifikacija in se kaže v obliki [20]: vrednotenja skupin izbranih raziskovalcev; prikaza najuspešnejših raziskovalcev; prikaza najuspešnejših skupin; objav v najuglednejših publikacijah in biografskih kazalcev uspešnosti za izvolitve v naziv.

Na področju izobraževanja je v Sloveniji zelo poznana tudi spletna stran COBISS. »COBISS (Co-operative Online Bibliographic System & Services, slovensko Kooperativni online bibliografski sistem in servisi) je slovenski knjižnični informacijski sistem, ki ga je razvil mariborski Institut informacijskih znanosti (IZUM). COBISS je organizacijski model povezovanja knjižnic v nacionalni knjižnični informacijski sistem z vzajemno katalogizacijo, vzajemno bibliografsko-kataložno bazo podatkov COBIB in lokalnimi bazami podatkov sodelujočih knjižnic, bazo podatkov o knjižnicah COLIB, normativno bazo podatkov CONOR ter s številnimi drugimi viri in funkcijami.« [21]. Po podatkih spletne strani Similarweb [22], spletno stran COBISS-a mesečno obišče 106.600 obiskovalcev, ki si v povprečju ogledajo 1,68 strani in ostanejo na spletni strani minuto in 45 sekund. Spletna stran COBISS-a se v primerjavi z ostalimi spletnimi stranmi v Sloveniji po obisku nahaja na 783 mestu. Navedeni podatki pričajo, da je spletna stran COBISS-a zelo priljubljena v Sloveniji in pomembna za področje izobraževanja. Na omenjeni spletni strani lahko med drugim zasledimo tudi objave v najugodnejših revijah in njihove avtorje (Slika 2). Omenjen objave lahko kot element igrifikacije opredelimo kot status, ki avtorjem objav v najuglednejših revijah veliko pomeni. Objava na tako pomembni spletni strani kot je COBISS pri javno objavljenih avtorjih vzbuja pozitivne občutke, kot so ponos, pomembnost, motiviranost za nadaljnje delo in drugo.

Slika 2: Objavljeni naslovi in avtorji člankov, ki so objavljeni v najuglednejših publikacijah [23].

Na spletni strani COBISS lahko najdemo tudi številna dela, mentorstva, somentorstva in druga dela pri katerih so sodelovali visokošolski učitelji in sodelavci. Spletni strani COBISS in SICRIS ponujata javni vpogled na rezultate dela posameznega visokošolskega učitelja in sodelavca. V Sloveniji je zelo malo spletnih strani, kjer bi lahko na tako raznolik, kritičen in javen način medsebojno primerjali rezultate dela posameznih javnih uslužbencev (npr. upravne delavce, zdravnike, policiste, …).

Poleg elementov igrifikacije, ki prikazujejo znanstveno-raziskovalno delo visokošolskih učiteljev in sodelavcev moramo na tem mestu omeniti še druga področja, ki so izpostavljena igrifikaciji. Eno izmed teh je pedagoško delo visokošolskih učiteljev in sodelavcev. Omenjeni zaposleni so glavni nosilci pedagoškega dela oz. dela s študenti, ki se najpogosteje odraža v obliki predavanj in vaj. Študenti imajo možnost preko anket oceniti delo visokošolskih učiteljev in sodelavcev. Ocena je najpogosteje v obliki ocenjevalne lestvice (točk). Slaba ocena, ki jo dobi nek učitelj ali sodelavec ima lahko resne posledice. Kot primer takšne ankete lahko omenimo anketo (Slika 3), ki se izvaja na Univerzi v Mariboru že od študijskega leta 2009/2010 do danes (opomba: imena in priimki so zaradi diskretnosti zamegljeni). Na spletni strani Univerze v Mariboru [24] lahko najdemo opredelitev študentske ankete, ki se glasi: "Študentska anketa je mnenjska anketa, s katero študenti izražajo svoje mnenje o pedagoškem delu na vseh članicah Univerze v Mariboru. O anketiranju, njegovem namenu in vprašalniku, dekan obvesti vse študente in visokošolske učitelje in sodelavce na začetku študijskega leta."


Anketa o pedagoškem delu in obremenitvi študenta 2020/2

Povprečne ocene izvajalcev

Pravilnik o ocenjevanju pedagoškega dela in obremenitve študentov na UM (Neuradno prečiščeno besedilo - NPB3)

Povprečna skupna ocena UM: 1,45

Priimek in ime	Fakultete	Povprečna ocena	Št. veljavnih odgovorov	Standardni odklon	S.O. Izvedba (%)
[redacted]	FNM	1,36	26	0,99	87,5
[redacted]	FS	1,90	13	0,35	92,9
[redacted]	FS	1,10	287	0,76	90,8
[redacted]	FNM	1,34	23	0,75	92,0
[redacted]	FZV, MF	1,58	139	0,66	81,8
[redacted]	FT	1,61	165	0,69	99,4
[redacted]	PEF	1,74	14	0,58	100,0
[redacted]	FNM	1,52	30	0,87	93,8
[redacted]	FNM, PEF	1,15	339	0,98	95,8
[redacted]	PEF	1,08	19	0,99	59,4

Slika 3: Ocene visokošolskih učiteljev in sodelavcev kot rezultati ankete o pedagoškem delu in obremenitvi študenta 2020/2021 [25].

Omeniti moramo tudi dejstvo, da je dostop do rezultatov ankete javen in da si rezultate lahko ogleda pravzaprav vsak, ki

le ima dostop do svetovnega spleta. Študentska anketa je v veliki meri pokazatelj oz. posledica odnosa visokošolskega učitelja ali sodelavca do študentov. Če je nek študent zadovoljen bo ocena višja in obratno. Zato je cilj vsakega zaposlenega imeti kar najboljši pristop do študentov. Na tem mestu moramo opomniti na dejstvo, da se visokošolski učitelji in sodelavci uvrščajo med javne uslužbence v Sloveniji. Zelo malo je področij in zaposlenih, ki so tako javno izpostavljeni elementov igrifikacije kot ravno visokošolski učitelji in sodelavci. Nikjer na spletu ne moremo na primer najdi ocene nekega zdravnika splošne medicine, ki so jo podali pacienti glede zadovoljstva ali obravnave. Prav tako nikjer ni mogoče najti javno prikazanih ocen (v točkah) zaposlenih na upravnih enotah glede prijaznosti. Iz omenjenega lahko sklepamo, da so visokošolski učitelji in sodelavci najbolj izpostavljeni igrifikaciji med vsemi javni uslužbenci glede odnosa do svojih strank (v tem primeru so to študenti). Poleg anket o pedagoškem delu s študenti na ravni univerz obstajajo tudi ankete na ravni fakultet, ki prav tako ocenjujejo pedagoško delo visokošolskih učiteljev in sodelavcev.

Mnenja študentov o delu visokošolskih učiteljev in sodelavcev imajo tudi druge učinke in posledice (pozitivne in negativne). Na nekaterih slovenskih fakultetah obstajajo t.i. dekanove nagrade oz. dekanove liste. Omenjene liste so predvsem namenjene podelitvi nagrad ali priznanj najboljšim študentov. V sklopu takšnih prireditev pa se pogosto podeli tudi nagrada za najboljšega profesorja in asistenta. Nagrade in priznanja namenjena visokošolskim učiteljem in sodelavcem se podeljujejo tudi na nivoju univerz. Kot primer navajamo seznam nagrad in priznanj, ki jih podeljuje Univerza v Mariboru [26]: (1) Nagrada Univerze v Mariboru za znanstvenoraziskovalno, umetniško in izobraževalno delo; (2) Nagrada Univerze v Mariboru za sodelovanje z gospodarstvom in prenos znanja; (3) Priznanje Univerze v Mariboru za znanstvenoraziskovalno, umetniško in izobraževalno delo; (4) Nagrada Univerze v Mariboru za strokovno delo; (5) Priznanje Univerze v Mariboru za strokovno delo in (6) Svečana listina Univerze v Mariboru. Podeljena nagrada ali priznanje je posledica dela, ki ga zaposleni opravlja. Nagrada ali priznanje pomeni za posameznika pozitivno povratno informacijo za nadaljnje delo. V kontekstu igrifikacije se nagrade uporabljajo kot motivacija za krepitev zaželenega obnašanja posameznika v neki aktivnosti. Nasprotno nagradi se v igrifikaciji uporablja element kazni ali sankcije.

Poleg formalnih oblik igrifikacije v visokem šolstvu obstajajo tudi neformalne oblike igrifikacije dela in rezultatov visokošolskih učiteljev in sodelavcev. V svetu raziskovalcev obstajajo spletne strani, ki omogočajo objavo člankov, medsebojno povezovanje, komuniciranje in medsebojno primerjanje. Ena izmed bolj znanih spletnih strani je ResearchGate (https://www.researchgate.net/). Registracija na omenjeni spletni strani je brezplačna in prostovoljna. Vrednotenje aktivnosti in objav je izvedena s posameznimi elementi igrifikacije, kjer prevladujejo točke. Na omenjeni spletni strani lahko pri vsakem raziskovalcu najdemo naslednje elemente igrifikacije, ki kažejo na posameznikovo aktivnost in objave [27]: (1) Research Interest Score, (2) Citations in (3) h-index. Na osnovi vrednotenja del, ki so prikazane v obliki točk je omogočeno medsebojno primerjanje raziskovalcev z vsega sveta. Podobne spletne strani kot ResearchGate so še Inkpath, MyScienceWork, Academia.edu, Mendeley, AD Scientific Index in druge. Kot zanimivost naj omenimo, da na spletni strani AD Scientific Index (https://www.adscientificindex.com/) lahko najdemo številne primerjave med državami, univerzami, najboljše uvrščenimi znanstveniki, največkrat citirane posameznike in drugo.

Našteti in opisani so bili samo najpomembnejši in najbolj znani elementi igrifikacije, ki jih lahko zasledimo na področju visokošolskega izobraževanja in so uporabljeni na visokošolskih učiteljih in sodelavcih. Iz prikazanega lahko zaključimo, da so visokošolski učitelji in sodelavci izpostavljeni številnim elementov igrifikacije s katerimi naj bi zaposlene ocenjevali, motivirali in angažirali za delo.

6 ZAKLJUČEK

Kljub temu, da se je igrifikacija začela relativno pozno znanstveno in strokovno proučevati lahko zasledimo njeno hitro uvajanje na različna druga področja. Eno takšnih je zagotovo izobraževanje, kjer igrifikacije pridobiva vse večjo veljavo. Kot je bilo že omenjeno je namen igrifikacije vlivati na vedenje uporabnikov v neki dejavnosti ali aktivnosti. Večina igifikacije v izobraževanju se uvaja za namen povečevanja motiviranosti, angažiranosti in učinkovitosti učencev ali študentov. Bistveno manj pa je znanstvenih in strokovnih raziskav na področju igrifikacije v izobraževanju glede administrativnih delavcev, učiteljev in profesorjev oz. visokošolskih učiteljev in sodelavcev. Slednji so največkrat zaposleni na fakultetah oz. univerzah. Njihova glavna dejavnost se lahko razdeli in se vrednosti kot znanstveno-raziskovalna dejavnost, strokovna dejavnost, umetniška dejavnost in pedagoška dejavnost. Kot je bilo predstavljeno so visokošolski učitelji in sodelavci podvrženi številnim elementom igrifikacije, katerih namen je vplivati na aktivnost in obnašanje zaposlenih.

Visokošolski učitelji in sodelavci so eni izmed najbolj točkovalnih, rangiranih, ocenjevanih in javno izpostavljenih oseb med vsemi javnimi uslužbenci. Spletne strani kot so SICRIS in COBISS nudijo vpogled v rezultate znanstveno-raziskovalnega in strokovnega dela visokošolskih učiteljev in sodelavcev. V Sloveniji praktično ni spletni strani, ki bi na tako natančen, sistematičen in javen način spremljala delo ostalih javnih uslužbencev (recimo zdravnikov, zaposlenih na upravnih enotah, sodnikov in drugih) kot je to v primeru visokošolskih učiteljev in sodelavcev.

Pedagoška dejavnost visokošolskih učiteljev in sodelavcev je tako kot znanstveno-raziskovalna in strokovna dejavnost podvržena elementom igrifikacije. Osnova za vrednotenje pedagoškega dela so številne ankete, ki se redno izvajajo na nivoju univerz in fakultet. Nekatere univerze javno objavljajo rezultate anket. Ocena nekega zaposlenega je izražena v točkah zato lahko na enostaven način medsebojno primerjamo sebi podobne zaposlene na univerzi ali fakulteti. Ovrednoteni rezultati (največkrat v točah) znanstveno-raziskovalne, strokovne in pedagoške dejavnosti vplivajo na številne karakteristike. Ena izmed teh je delovna uspešnost zaposlenega. Delovna uspešnost se vrednosti po različnih kriterijih. Na številnih fakultetah se v končni oceni delovne uspešnosti upoštevajo vpisane objave v sistem SICRIS, pedagoška ocena študentke ankete in drugo. Ocena delovne uspešnosti pa se posledično odraža tudi v osebnem dohodku oz. plači.

V članku so prikazani samo nekateri najbolj poznani in pomembni elementi igrifikacije uporabljeni na visokošolskih

učiteljih in sodelavcih. Obstajajo tudi drugi, vendar manj pomembni elementi, ki pa vseeno vplivajo na delo, obnašanje in počutje visokošolskih učiteljev in sodelavcev. V znanstveni in strokovni literaturi pa je zelo malo dokazov, da so uporabljeni elementi igrifikacije optimalno uporabljeni oz. najboljši za doseganje motiviranosti, angažiranosti in učinkovitosti visokošolskih učiteljev in sodelavcev. Omenjeni zaposleni imajo svoje značilnosti in specifičnosti. Raziskava, ki so jo opravili Urh, Jereb, Šprajc, Jerebic in Rakovec (2022) ugotavlja, da imajo različni elementi igrifikacije različen vpliv na posameznike (v tem primeru na študente) glede na njihove osebnostne lastnosti - velikih pet faktorjev osebnosti (angl. Big Five personality traits). Tudi visokošolski učitelji in sodelavci imajo različne osebnostne lastnosti. Vsesplošna uporaba elementov igrifikacije v visokošolskem izobraževanju zato zagotovo ni optimalna. Takšna uporaba elementov igrifikacije ne prinaša najboljših rezultatov. Še več, nekateri zaposleni se zaradi takšne uporabe igfirikacije lahko (in se) počutijo neprijetno, prestrašeno, osramočeno in drugo. V prihodnosti bi bilo smiselno podrobno in natančno proučiti uporabljene elemente igrifikacije in njihov vpliv na visokošolske učitelje in sodelavce. Spoznanja bi lahko prispevala k boljši sprejetosti omenjenih in predstavljenih elementov in večji motiviranosti zaposlenih. Zanimivo bi bilo uvesti igrifikacijo v obliki javnega vrednotenja in ocenjevanja tudi ostalih javnih uslužbencev, kar bi lahko prineslo določena izboljšanja in dvig kakovosti na področjih, ki ga pokriva javni servis storitev (zdravstvo, sodstvo, osnovno in srednješolsko izobraževanje, storitve upravnih enot in drugo).

LITERATURA IN VIRI

[1] Playwork Scrutiny Group. 2005. The Playwork Principles. Dostopno na naslovu http://www.playwales.org.uk/login/uploaded/documents/Playwork%20Principles/playwork%20principles.pdf (16. 3. 2015).

[2] Maroney, K. 2001. My entire waking life. Dostopno na naslovu http://www.thegamesjournal.com/articles/ MyEntireWakingLife.shtml (11. 2. 2013).

[3] Urh, M. in Jereb, E. 2017 Igrifikacija v izobraževanju. BERNIK, Mojca (ur.), 2017, Kadrovski management v sodobni organizaciji [na spletu]. Univerzitetna založba Univerze v Mariboru. ISBN 978-961-286-102-5. Dostopno na naslovu https://dk.um.si/IzpisGradiva.php?lang=slv&id=68990

[4] Connolly, T. M., Boyle E. A., MacArthur E., Hainey T., in Boyle J. M. 2012. A systematic literature review of empirical evidence on computer games and serious games, Computers & Education 59, 661–686.

[5] Blohm, I., in Leimeister, J. M. 2013. Gamification: Design of IT-based enhancing services for motivational support and behavioral change. Bus. Inf. Syst. Eng. 5, 275–278. http://dx.doi.org/10.1007/s12599-013-0273-5.

[6] Jereb, J. 1998. Teoretične osnove izobraževanja. Založba Moderna organizacija, Kranj.

[7] Gov.si. 2022. Visokošolsko izobraževanje. Dostopno na naslovu https://www.gov.si/podrocja/izobrazevanje-znanost-in-sport/visokosolsko-izobrazevanje/ (10. 8. 2022)

[8] Spot.gov. 2021. Visokošolsko izobraževanje. Dostopno na naslovu https://spot.gov.si/sl/dejavnosti-in-poklici/dejavnosti/visokosolsko-izobrazevanje/ (8. 8. 2022)

[9] Deterding, S. 2011. Situated motivational affordances of game elements: A conceptual model, in: Presented at Gamification: Using Game Design Elements in Non-Gaming Contexts, a workshop at CHI 2011. Dostopno na naslovu http://gamification-research.org/wp-content/uploads/2011/04/09-Deterding.pdf

[10] Werbach, K., in Hunter, D. 2012. For the Win: How Game Thinking Can Revolutionize Your Business. Wharton Digital Press, Philadelphia, PA.

[11] Pedreira O., García F., Brisaboa N. in Piattini M. (2015). Gamification in software engineering – A systematic mapping, Information and Software Technology 57, 157–168.

[12] Hickey, D. T., Ingram-Goble, A., in Jameson, E. M. 2009. Designing assessments and assessing designs in virtual educational environments. Journal of Science Education and Technology, 18(2), 187–208.

[13] Simões, J., Redondo, R. D., in Vilas, A. F. 2013. A social gamification framework for a K-6 learning platform, Computers in Human Behavior 29, 345–353.

[14] Buckley, P., in Doyle, E. 2017. Individualising gamification: An investigation of the impact of learning styles and personality traits on the efficacy of gamification using a prediction market, Computers & Education 106, 43−55.

[15] Csikszentmihályi, M. 1990. Flow: The psychology of optimal experience. New York: Harper and Row.

[16] Csikszentmihalyi, M. 1997. Finding flow: The psychology of engagement with everyday life. Basic Books.

[17] de-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., in Pages, C. 2014. An empirical study comparing gamification and social networking on e-learning. Computers & Education 75:82-91. DOI: 10.1016/j.compedu.2014.01.012

[18] Univerza v Ljubljani. 2022. Mednarodne rangirne lestvice. Dostopno na naslovu https://kakovost.uni-lj.si/mednarodne-rangirne-lestvice/ (8. 8. 2022)

[19] Wikipedija. 2018. SICRIS. Dostopno na naslovu https://sl.wikipedia.org/wiki/SICRIS (10. 8. 2022).

[20] SICRIS. 2022. Raziskovalci. Dostopno na naslovu https://cris.cobiss.net/ecris/si/sl/top/researcher (15. 8. 2022).

[21] Wikipedija. 2021. Vzajemni bibliografski sistem COBISS. Dostopno na naslovu https://sl.wikipedia.org/wiki/Vzajemni_bibliografski_sistem_COBISS (10. 8. 2022).

[22] Similarweb. (2022). cobiss.si. Dostopno na naslovu https://www.similarweb.com/website/cobiss.si/#overview (15. 8. 2022)

[23] COBISS. 2022. Objave v najuglednejših publikacijah. Dostopno na naslovu https://www.cobiss.si/raziskovalci.htm (11. 8. 2022)

[24] Univerza v Mariboru. 2022a. Študentska anketa. Dostopno na naslovu https://www.um.si/kakovost/studentska-anketa-2/ (8. 8. 2022)

[25] Univerza v Mariboru. 2022b Anketa o pedagoškem delu in obremenitvi študenta 2020/2021. Dostopno na naslovu https://www.um.si/wp-content/uploads/2021/12/Rezultati-studentske-ankete-za-studijsko-leto-2020-2021.pdf (10. 8. 2022).

[26] Univerza v Mariboru. 2022c. Nagrade in priznanja. Dostopno na naslovu https://www.um.si/o-univerzi/predstavitev/nagrade-in-priznanja/nagrade-in-priznanja/ (10. 8. 2022).

[27] Researchgate. 2022. Researchgate. Dostopno na naslovu (20. 8. 2022) https://www.researchgate.net/Tabela 1: Table caption (Slovene)

Pozitiven impulz IKT otroku s čustveno vedenjskimi težavami?

A Positive Impulse ICT for a Child With Emotional and Behavioural Problems?

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POVZETEK

Izzivi današnjega časa narekujejo vzgojiteljem, učiteljem in staršem prilagajanje vzgojnih in učnih prijemov nastalim situacijam. Znano je, da je za učence/dijake IKT močno motivacijsko sredstvo v šolah, manj raziskana pa je smiselna uporaba IKT pri vzgoji in izobraževanju v zavodih, kjer so nastanjeni otroci s čustveno vedenjskimi težavami. V prispevku so predstavljeni primeri dobre prakse uporabe IKT za dvig motivacije pri učenju in preusmerjanju vedenja, ki slonijo na teoretični podlagi s področij čustveno vedenjskih težav, (učne) motivacije in uporabne vrednosti IKT v šolskem prostoru, ter praktični podlagi dolgoletnih izkušenj pri delu z otroki/mladostniki.

KLJUČNE BESEDE

Čustveno vedednjske težave, učenje z IKT, motivacija z IKT, uravnavanje vedenja z IKT

ABSTRACT

Today's challenges require educators, teachers and parents to adapt their educational and learning approaches to the situations. It is known that ICT is a powerful motivational tool for pupils/students in schools, but the meaningful use of ICT in education in institutions housing children with emotional behavioural problems is less researched. The paper presents examples of good practice in the use of ICT for increasing motivation in learning and for behaviour regulation, which are based on a theoretical basis from the areas of emotional-behavioral problems, (learning) motivation and the useful value of ICT in the school environment, as well as on the practical basis of many years of experience in working with children/youths.

KEYWORDS

Emotional-behavioral problems, learning with ICT, motivation with ICT, behavior regulation with ICT

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1 UVOD

Mladinski dom Malči Beličeve je zavod, ki nudi otrokom/mladostnikom s čustveno vedenjskimi težavami celodnevno oskrbo po načelih družinske vzgoje. Otroci/mladostniki hodijo v eksterne šole, v Domu pa se izvaja vzgojni program, ki vključuje dejavnosti (preventivne socialno-varstvene, učno-vzgojne, kompenzacijske, osebnostno in socialno integrativne idr.) za dosego cilja, ki je vključitev otroka v običajno življenje.

V prispevku je predstavljen izkustveni primer uporabe IKT kot motivacijske metode pri učenju in prevzgoji oz. usmerjanju vedenja. Opira se na poznavanje čustveno vedenjskih težav, (učne) motivacije, uporabne vrednosti IKT v šolskem prostoru in na dolgoletne izkušnje učno-vzgojne pri delu z otroki/mladostniki.

Vzgojitelji moramo otroku ustvariti ljubeče in vzpodbudno okolje, pozorno moramo spremljati otrokove majhne dosežke, ki se dogajajo dan za dnem. Pohvaliti je potrebno vsako pozitivno dejanje in napredek. Pogoj za uspešno vzgojno delo so motivirani otroci, za uspešnost motivacije pa je odgovoren vzgojitelj, ki izbira najbolj učinkovito vzgojno sredstvo pri različnih oblikah in metodah dela [11].

2 MLADINSKI DOM MALČI BELIČEVE

Mladinski dom Malči Beličeve (v nadaljevanju MDMB) je od leta 2021 strokovni center, ki skrbi za otroke in mladostnike s čustvenimi in vedenjskimi težavami ter motnjami (v nadaljevanju ČVT/M). Je del ene od štirih skupin, v katero so vključeni trije zavodi (Mladinski dom Jarše in Vzgojno izobraževalni zavod Višnja Gora), ki pokrivajo oskrbo in obravnavo otrok in mladostnikov osrednjeslovenske, jugovzhodne, zasavske in spodnjeposavske regije.

Zavod MDMB je bil ustanovljen za opravljanje javne službe na področju vzgoje in izobraževanja otrok in mladostnikov s posebnimi potrebami (vzgoje in izobraževanja otrok in mladostnikov s čustvenimi in vedenjskimi motnjami) po javnoveljavnih vzgojno-izobraževalnih programih, ki jih v izvajanje določi pristojni šolski minister [8].

MDMB izvaja dejavnost socialnega varstva z nastanitvijo, ki obsega vse oblike pomoči v zavodu ali druge organizirane oblike, s katerimi se upravičencem nadomeščajo ali dopolnjujejo

funkcije doma ali lastne družine, zlasti pa bivanje, organizirana prehrana in varstvo [8].

Otroka oz. mladostnika se v strokovni center namesti (1) po izvedenem nujnem odvzemu s strani centra za socialno delo v skladu z zakonom, ki ureja družinska razmerja, ali (2) z odločbo o namestitvi v skladu z zakonom, ki ureja nepravdni postopek, in zakonom, ki ureja družinska razmerja, ali (3) z odločbo o izreku vzgojnega ukrepa oddaje v vzgojni zavod v skladu z zakonom, ki ureja obravnavanje mladoletnih storilcev kaznivih dejanj [16].

2.1 Vzgojni program

Osrednji cilj izvajanja veljavnega vzgojnega programa je ponovna uspešna vključitev otroka ali mladostnika s ČVT/M v običajno življenjsko sredino. Zato se v zavodu sledi naslednjim ciljem: (1) preventivnim socialno-varstvenim in zdravstvenim ciljem, (2) učno-vzgojnim ciljem (zagotavljanje šolske uspešnosti in celovite vzgoje), (3) kompenzacijski cilji - nadomestitev zamujenega, manjkajočega v razvoju otroka/mladostnika, (4) osebnostno in socialno integrativnim ciljem (spreminjanje/odpravljanje socialno nesprejemljivih navad, odnosov, vedenj, razbremenjevanje občutkov manjvrednosti, razvijanje zdravega samozaupanja, postopno vključevanje v običajno življenjsko okolje, usposobitev za družbeno sprejemljiv način življenja in delovanja ipd.), (5) vzgojno-izobraževalne dejavnosti, povezane s prehrano, in dejavnosti, s katerimi se vzpodbuja zdravo prehranjevanje in kulturo prehranjevanja [7].

MDMB je ustanova, ki razvojno, vzgojno in socialno ogroženim otrokom in mladostnikom z vedenjskimi in čustvenimi težavami nudi in zagotavlja celovito celodnevno oskrbo skozi vse leto. Poleg tega nudi še varstvo, zdravstveno nego, vzgojo in prevzgojo ter celotno pomoč pri izobraževanju osnovnošolski/srednješolski populaciji [8].

MDMB deluje po načelu družinske vzgoje. Otroci in mladostniki (izraz "mladostnik" po ZOOMTVI pomeni mladostnika, starega od 15 do 26 let) iz vzgojnih skupin se izobražujejo v eksternih šolah v rednih programih šol, lahko pa bi obiskovali interne izobraževalne programe, ki jih izvajata ostala dva strokovna centra v tej regiji.

Za izvajanje programa vzgojno izobraževalne in socialno varstvene dejavnosti so v zavodu MDMB organizirane skupine, in sicer: 6 vzgojnih skupin, 2 stanovanjski skupini, intenzivna skupina in mladinsko stanovanje. V zavodu je v času pisanja tega prispevka približno 70 osnovnošolcev in srednješolcev, za njih skrbi 37 strokovnih delavcev.

2.2 Individualizirani program

Za vsakega otroka/mladostnika strokovna skupina, ki jo vodi in usklajuje delavec strokovnega centra (v skupino je vključen tudi predstavnik pristojnega centra za socialno delo in predstavnik šole, v katero je otrok/mladostnik vključen, po potrebi tudi predstavnik pristojnega centra za duševno zdravje otrok in mladostnikov), pripravi individualiziran program, ki se ga s timskim pristopom izvaja in spremlja celotno šolsko leto. V individualiziranemu programu so določeni kratkoročni in celoletni cilji, oblike in metode dela z otrokom/mladostnikom, oblike sodelovanja s starši in nosilci posameznih dejavnosti. Vsak individualiziran program zajema več področij, med drugimi tudi naslednja: (1) socialni odnosi in veščine komuniciranja, (2) odnos do pravil in družbenih norm, (3) zdravstveno stanje, (4) interesne dejavnosti, (5) delovne navade, (6) šolsko področje idr.

Vzgojno delo zajema vse dejavnosti, ki stremijo k uresničevanju individualiziranih programov posameznih otrok/mladostnikov in hkrati sledijo osrednjemu cilju: vključitvi otroka/mladostnika s ČVT/M v običajno življenjsko okolje. V MDMB poteka vzgojno delo po okvirnem dnevnem urniku, ki vključuje tudi t. i. učne ure, med katerimi se uresničujejo predvsem učno-vzgojni cilji, in sicer [7]: ugodna psihosocialna klima, ki omogoča zadovoljitev potreb po varnosti in sprejetosti; dobri medosebni odnosi, zadovoljevanje naravne potrebe po uspešnosti in napredovanju, dvig otrokove samopodobe, približevanje učno-vzgojnih vsebin otrokovim psihofizičnim zmožnostim (pozitivno učenje).

3 OTROCI/MLADOSTNIKI S ČVT/M

Čustveno vedenjske težave oz. motnje različni avtorji opredeljujejo različno. V strokovni literaturi so navedeni številni pomembni avtorji s tega področja in njihova pojmovanja čustvenih, vedenjskih in socialnih težav: ČVT se kaže kot neprimerno, moteče, pasivno ali agresivno vedenje, nasprotovanje, iskanje pozornosti, ustrahovanje, samopoškodovalna tendenca, socialni umik, izolacija, jokavost, nepričakovan nemir, odsotnost, raztresenost, brezdelje, otročjost, defenzivnost, trma, težave s pomnjenjem in pozornostjo; delinkventnost ter nevodljivost oz. težja vodljivost [9]. Večina avtorjev poudarja tudi, da morajo biti omenjena vedenja kontinuirana in se pojavljati na več področjih otrokovega/mladostnikovega življenja, da lahko govorimo o kategoriji težav ali celo motnji.

Naj izpostavimo obširno klasifikacijo oz. shemo simptomov po Schraderju iz leta 1991 [6], ki deli vedenjske težave na: (1) funkcijske motnje: enureza, enkopreza, zaprtje, motnje prehranjevanja, splošen motorični nemir, tiki, govorne motnje, slabosti čutil ipd.; (2) motnje navad: sesanje palca, grizenje nohtov, puljenje las, škripanje z zobmi, ekscesivna masturbacija; (3) motnje občutkov jaza in temeljnega razpoloženja: občа bojazljivost, bojazen v določenih situacijah, bolehanje, samopomilovanje, tečnarjenje, depresija, jok, poskus samomora, evforičnost; (4) socialne motnje: trma, kljubovalnost, pretirano ljubosumje, čustveno šibka navezanost na ljudi, govorne motnje, samotarstvo, izostajanje iz šole, pobegi, potepanje, pretirana podrejenost, neznosno vedenje, brutalnost, mučenje živali in ljudi, zlobnost, zahrbtnost, škodoželjnost, nagnjenost k uničevanju, klovnovstvo, bahanje, nastopaštvo, goljufanje, tatvine; (5) motnje na področju dela in storilnosti: motnje pri igri ali pomanjkanje interesa, šolsko nazadovanje, neuspešnost, motnje zaznavanja, raztresenost, pozabljivost, motnje koncentracije, igrivost, sanjarjenje, počasnost, pomanjkanje pobud, lenoba, odpor do dela, prevelika pridnost, umazanost, netočnost, neurejenost, pretirana pedantnost, prevelika skrb za čistočo, pretirana skrbnost.

ČVT ima dve dimenziji: čustveno in vedenjsko, ki ju povezujemo z dvema kontekstoma, in sicer (1) notranji svet oz. njegov referenčni okvir in (2) socialni kontekst, na katerega se posameznik odziva na podlagi svojih izkušenj, pričakovanj, trenutne situacije in socialnega položaja, v katerem se znajde [9]. Pri nastajanju čustvenih in vedenjskih težav, ki se lahko

pojavljajo ločeno ali skupaj in so lahko pretežno internalizirane (čustvene težave), eksternalizirane (vedenjske težave) ali kombinirane (čustvene in vedenjske težave), gre za izrazito heterogenost pojavnih oblik in dejavnikov, ki vplivajo na njihovo nastajanje oz. utrjevanje. Gre za preplet bioloških, psiholoških in socialnih dejavnikov, ki delujejo interaktivno v procesu razvoja otroka/mladostnika [5].

Za razumevanje pojava je tako pomemben splet, kombinacija dogajanj, ki je pri vsakem otroku drugačna. Dejavniki lahko izhajajo iz družine, iz otroka samega, iz širšega okolja ali iz šole [10]. (1) Neugodne družinske razmere so pogosteje prisotne pri otrocih/mladostnikih s čustvenimi in vedenjskimi težavami kot pri tistih, ki teh težav nimajo. Družinski neugodni vplivi so predvsem dolgotrajna nesoglasja in prepiri med starši, čustveno prazni odnosi med otroki in starši, ravnodušnost staršev za otrokovo vzgojo, odsotnost nadzora otroka, alkoholizem, delinkventnost ali druge psihosocialne motnje pri starših, odsotnost ustreznega vzora za učenje moralnih norm in socialnega vedenja. (2) K pojavu težav lahko prispevajo nekatere odzivne in značajske lastnosti posameznika: nekatere lastnosti temperamenta, kot so: slabša sposobnost samoobvladovanja, manjša sposobnost premagovanja neuspehov in konfliktov, večja sprejemljivost za slabe vplive, večja občutljivost oz. ranljivost za neugodna doživetja, otrok ima lahko težave pri učenju vedenjskih norm zaradi nezrelosti. Med nemirnimi otroki je več otrok s težavami v vedenju kot med otroki, ki teh motenj nimajo. (3) Znano je, da se družbeni pritiski in krizne situacije lahko odražajo tudi s povečanjem števila vedenjskih težav med otroki in mladostniki. (4) Med dejavnike šole spadajo kakovost šole kot socialne organizacije in učinkovitost tehnik učiteljevega delovanja v razredu.

ČVT nastajajo dlje časa, ni pa nujno, da so trajne [14].

4 MOTIVACIJA

Motivacija je pojem, ki spremlja človeka na vseh ravneh njegovega življenja. Pojem motivacija izhaja iz latinske besede "movere", ki v prevodu pomeni premikati se oz. gibati se.

Motivacija je proces, ki vodi vedenje ljudi in jih usmerja k določenim ciljem, s pomočjo različnih motivov, npr. potreb, vrednot, želja, idealov idr. [1].

Motivacija je proces, ki uravnava obnašanje in ga poenoti v prizadevanju za dosego zadanih ciljev. Je kompleksen pojav, saj so dejanja usmerjena k določenemu cilju iz različnih razlogov. Obnašanje je vedno motivirano in se ne pojavlja kar samo od sebe, ker so vedno prisotni določeni cilji. Motivacija predstavlja kopičenje psihične energije pri človeku (pod vplivom notranjih in zunanjih dražljajev), ki jo človek izkoristi za svojo aktivnost - posledica je sproščena napetost, zaradi katere človek čuti spodbudo za to, da nekaj stori. Delovanje različnih motivov v človeku sproži motivacijo, na osnovi katere se človek nagiba ali odvrača od določenih predmetov, ki predstavljajo vsebino motivov. Motivacija je psihična funkcija, ki daje vsakemu človeku značilen pečat posebnosti in enkratnosti [11].

Proces motivacije vključuje čustveni in kognitivni vidik. Čustva imajo sama po sebi motivacijsko funkcijo, saj spodbujajo in usmerjajo obnašanje/vedenje - če motivi ne bi bili podprti z emocionalnim doživljanjem, sploh ne bi mogli delovati. Pomembnost kognitivnega vidika je v sodelovanju pri predstavljanju realnosti - potreba začne delovati šele, ko jo človek zazna [4].

V literaturi zasledimo tudi delitev na notranjo in zunanjo motivacijo. Intrinzična motivacija je povezana z željo po učenju zaradi želje same in s prirojeno radovednostjo v zvezi z neznanim; spodbuja pojmovno učenje in vodi k ustvarjalnemu učenju. Ekstrinzična motivacija pa je povezana s potrebo po učenju, učenec se uči zaradi zunanjega vzroka, npr. ocene, nagrade ipd. [13].

4.1 Učna motivacija

Učna motivacija psihološki proces, ki učenca spodbudi k učenju, ga pri učenju usmerja, določa intenzivnost učenja in učencu omogoči, da pri njem vztraja [12].

Skozi zgodovino so se spreminjala mnenja o tem, kateri so dejavniki, ki vplivajo na učno motivacijo otrok in mladostnikov. S časoma so kot pomembne dejavnike označili tudi učiteljeve osebnostne lastnosti, stil in strategijo vodenja ter šolsko klimo [3]. Če želimo torej povečati motivacijo pri otrocih, je ključno, da ustvarimo za to spodbudno okolje. Pomembno je, da so zadovoljene otrokove osnovne potrebe (fiziološke potrebe, potreba po varnosti, potreba po ljubezni in pripadnosti, potreba po spoštovanju, samospoštovanju, potreba po vrednotenju drugih, potreba po samouresničitvi). Vse to pa lahko dosežemo s pomočjo različnih strategij in predvsem odnosom, ki ga oblikujemo z otrokom/mladostnikom [14].

Učitelj mora razumeti, da se motivacija vedno dogaja v učencu in da je učenec sam osrednji vir lastnega motivacijskega delovanja. Učencu ne more dati motivacije, saj je že v njem. Z različnimi motivacijskimi spodbudami, ki jih učitelj nameni učencu, to "njegovo" motivacijo lahko samo spodbudi, neguje, dodatno krepi ali celo zavre. Motivacijske spodbude se lahko razdeli na dve skupini: (1) didaktične motivacijske spodbude: npr. organizacija učnega okolja in učenja, učne metode, didaktični material in (2) psihološke motivacijske spodbude: vodenje učenca med učenjem, povratne informacije o dosežkih, učna podpora, osredotočanje na območja učenčevega bližnjega razvoja [2].

4.2 Motivacija pri otrocih/mladostnikih s ČVT/M

Otroci/mladostniki, ki so vključeni v zavodsko okolje, se v življenju na različne načine spoprijemajo z novimi negotovostmi tveganji. Pogosto se v novih situacijah počutijo nemočni, socialno izolirani, njihovo samospoštovanje je nizko. Iz tega razloga se zatekajo v različne nesprejemljive oblike vedenja (pasivnost, agresija idr.). Zaradi nezaupanja pogosto težko vzpostavljajo stike, saj ljudi okrog sebe doživljajo kot sovražne in negativne. Še težje vzpostavljajo globlje stike z vrstniki, vsi njihovi odnosi so površinski in posledično v teh odnosih ni prostora za empatijo. Zanje značilni so tudi občutki dolgočasja in brezciljnosti v življenju. Primanjkuje jim motivacije za kakršnokoli delo [15].

Pri otrocih/mladostnikih s čustvenimi in vedenjskimi težavami se pogostoma opazi visoko raven demotiviranosti, ki se pojavlja na različnih področjih, od preprostih vsakodnevnih dejavnosti (pospravljanje, druženje) do učne motivacije.

Pogosto opažamo tudi motivacijske in učne primanjkljaje, ki so hkrati značilnosti naučene nemoči - motivacija danes je

odvisna od izkušenj v preteklosti. Neuspeh v preteklosti je torej ključen razlog za demotivirano vedenje danes in v prihodnosti. Otrok/mladostnik je prepričan, da je kakršenkoli odziv na trenutno stanje neučinkovit in da ni sposoben obvladovati trenutne situacije. Zaradi tovrstnega prepričanja ni pripravljen niti poskusiti [4].

Precej pogosteje se lahko v šolah/zavodih doseže, da so otroci zunanje motivirani, kar pomeni, da počnejo stvari zaradi zunanjih posledic. Zunanja motivacija ponavadi ni trajna, vztraja samo do trenutka, ko to zahteva okolje in je pa povezana s pritiski oz. zaskrbljenostjo, predvsem, kadar so cilji zastavljeni previsoko. Pri notranji motivaciji, ki se pri otrocih v zavodu običajno težko zazna, je cilj delovanja v želji/dejavnosti sami, vir podkrepitve pa je v posamezniku. Notranja motivacija običajno vztraja dlje, saj je povezana z notranjim zadovoljstvom, ki se ga čuti ob doseženem cilju. Notranjo motivacijo se povezuje s spontanostjo, ustvarjalnostjo in širjenjem interesov [11].

5 IKT

Uporabna vrednost IKT kot motivacijskega sredstva v šolskem prostoru je znana, vse več učiteljev ugotavlja, da je vse bolj pomembna. Vsak učitelj se je že znašel v situaciji, ko je ugotovil, da so učenci veliko bolj motivirani za delo, če imajo možnost aktivnega vključevanja z IKT.

IKT je "in". Danes se je raba IKT razmahnila do take mere, da vsak od nas uporablja dnevno vsaj eno digitalno napravo, od telefona, računalnika do tablice in drugih naprav. Nameni so zelo različni. Pri otrocih/mladostnikih je opaziti uporabo predvsem zaradi zabave oz. v družabne namene, po pandemiji Covid-19 pa pri njih narašča osveščenost, da je uporaba digitalnih naprav mogoča tudi za učenje.

6 IZKUSTVENI PRIMERI UPORABE IKT KOT MOTIVACIJSKE METODE V MDMB

Avtorja sva vzgojitelja v eni od vzgojnih skupin v MDMB. Vzgojna skupina vključuje otroke/mladostnike različnih starosti, najmlajši ima 10, najstarejša 16 let. Skupina (v času pisanja prispevka je 8 otrok in mladostnikov) je heterogena tako po starosti kot tudi po čustveno vedenjskih težavah.

Pri svojem delu se vzgojitelji vsakodnevno soočamo z velikimi izzivi spodbudnega okolja, vsakodnevno izbiramo najbolj učinkovita vzgojna sredstva, uporabljamo različne oblike in metode dela, hkrati pa preverjamo različne strategije (učno)vzgojnega dela za dosego različnih ciljev tako pri skupini v celoti, kot tudi pri posameznikih.

Vsak otrok/mladostnik dnevno v skupino prinese svojo energijo, razpoloženje, hotenja, želje. Pomembna naloga vzgojitelja je, da empatično poveže vse energije v celoto, a ohrani individualnost posameznika. Pri ustvarjanju vzpodbudnega okolja oz. ugodne psihosocialne klime je nujna tudi vzgojiteljeva korektivna vloga - da prepozna otrokovo/mladostnikovo sprejemljivo/nesprejemljivo vedenje in ga poskuša usmerjati k pravim ciljem. Načini so zelo različni, skupno vsem pa je, da otrok/mladostnik ozavesti svoja dejanja in za njih prevzame odgovornost. Uspešnost vzgojitelj pohvali in nagradi, za neuspešnost se dodeli postopen in sorazmeren vzgojni ukrep.

Otrokom/mladostnikom, ki so nameščeni v zavod in ki prihajajo iz socialno šibkih družin (ali pa jih sploh nimajo) prestavlja uporaba IKT potrebo, ki je v preteklosti zaradi različnih razlogov niso mogli zadovoljiti. Zato smo prišli do ideje, da bi z dostopnostjo/smiselno uporabo IKT lahko razvijali in usmerjali motivacijske procese, tako za učenje kot splošno obnašanje, pri naših otrocih/mladostnikih.

Primer 1: Otrok težje računa in ne mara matematike. Ve, da se mora učiti, a je ves čas nemiren, moti druge, glasno daje neprimerne pripombe o drugih, vstaja od svoje mize in hodi okoli, ne pripravi zvezka oz. učnih pripomočkov. Vzgojiteljeva naloga v takem primeru je večplastna, saj je potrebno pripraviti in vzdrževati spodbudno učno okolje tako za skupino (vsi otroci/mladostniki se učijo v istem prostoru) kot tudi za posameznika. Za to, da otroka umirimo in pripravimo za učenje, je potrebno uporabiti vzgojno motivacijsko metodo, ki je prilagojena posamezniku in hkrati deluje tudi na skupino. V našem primeru je bila to vzgojiteljeva vzpodbuda otroku v obliki kratkega nasveta: "Jaz vem, da ti to zmoreš. Vsak se lahko nauči računati, samo potruditi se je potrebno." in v obliki obljube, da bo dobil tablico za naloge računanja, če bo opravil vse "šolske domače" naloge. Vzpodbuda in obljuba sta delovali pozitivno v večino primerih, saj se je otrok umiril in začel učiti samostojno, tako da je bilo potrebno le preverjanje opravljenega, pohvala in večkratna vzpodbuda. Na koncu je sledila uporaba tablice, a pod določenimi pogoji – samo didaktične spletne naloge, ki so bile skrbno, premišljeno izbrane (primerne letom in težavnosti učne snovi) za ponavljanje/utrjevanje učne snovi. Ob tem se je otrok mimogrede naučil po principu učenja iz napak tudi "tehnične" uporabe IKT za učenje (prižgati/ugasniti tablico; "klik" oz. kratkotrajen dotik s prstom ali pisalom na zaslonu tablice (ali pametnega telefona); "dvoklik", uporaba gumbov (1) za glasnost, (2) na zaslonu/v aplikaciji; uporaba menijev v aplikacijah idr.). Epilog: uspešno usmerjena motivacija, zadovoljen otrok z novim znanjem in ustreznim obnašanjem, pozitivna učna klima, pozitivna izkušnja je povečala motivacijo za nadaljnje učenje. Naj pripomnimo še pomembno dejstvo, da na začetku, ko ni bilo vzpostavljenega osebnega odnosa otrok-vzgojitelj, tak način usmerjanja motivacije ni bil uspešen – predvidevamo da zato, ker otrok še ni imel zaupanja v vzgojitelja oz. se še ni vzpostavil konkretni pozitivni medosebni odnos otrok-vzgojitelj.

Primer 2: Mladostnik ne mara angleščine in ne zna nepravilnih glagolov. Uči se jih iz knjige, tako da jih bere. Po nasvetu vzgojitelja, jih prične izpisovati v zvezek – samo tiste, ki jih ne zna. Ko ne zmore več koncentracije, postane nemiren in nepozoren. Predlog vzgojitelja, da naj pri ponavljanju naučenega uporabi svoj telefon in vanj tipka nepravilne glagole, z začudenjem sprejme (predvidevamo da zato, ker so mladostniki navajeni uporabljati telefon in aplikacija po večini za družabne namene) – ko se uči na tak način, se vidi, da se je koncentracija za učenje in sama motivacija ponovno dvignila, saj je mirno osredotočen na delo. Po določenem času je opaziti ponoven padec učne moči (odsotnost, sanjarjenje, brezdelje), zato vzgojitelj vpraša (da se izogne nasprotovanju oz. odporu do dela), če bi morda delal naloge za nepravilne glagole prek prenosnika in ko mladostnik privoli, si sam prinese prenosnik, vzgojitelj pa ga samo usmerja, da najde primerno spletno didaktično orodje za učenje nepravilnih glagolov (naloge so bile večstopenjske, težavnost si je mladostnik izbiral sam, po nasvetu vzgojitelja od lažjih nalog do težjih: "Ko dobiš občutek, da znaš, in ti spletno

orodje pokaže, da imaš vse prav, nadaljuj z naslednjo stopnjo ali pa jo preskoči, izbira je tvoja."). Računalnik/prenosnik/telefon je bil tako priložnost za kratek odmor med učenjem in odlično motivacijsko sredstvo za nadaljevanje učenja, hkrati pa je v mladostniku povečal samostojnost in občutek uspešnosti ter napredovanja, s tem pa se je za mali drobec dvignila tudi njegova samopodoba, saj je ugotovil, da se je zmogel učno snov naučiti sam.

Primer 3: Mladostnici iz neznanih razlogov "gresta na beg" iz Doma ponoči v pižamah. Zjutraj, po vrnitvi sledi temeljit pogovor z vzgojiteljem o dejanjih in posledicah. Resno, brez posmehovanja, prevzameta krivdo za dejanje. Določen je bil vzgojni ukrep za kršitev Domskih pravil – do konca šolskega leta brez telefona. Vzgojni ukrep je pozitivno vplival na kasnejše vedenje obeh mladostnic, saj tega dejanja nista ponovili.

7 ZAKLJUČEK

Uporaba IKT se je v zadnjih letih zelo razmahnila na vseh področjih našega življenja. Namenov uporabe je več, najbolj zaželena pa je smiselna raba. Tudi v MDMB uporabljamo IKT v smiselne namene in preskušamo možnosti uporabe v učno-motivacijske in vzgojne namene. Prikazani primeri dobre rabe so lahko eden od možnih načinov pri iskanju vzgojnih in učnih prijemov za otroke/mladostnike s čustveno vedenjskimi motnjami. Morda bi veljalo v prihodnosti razmišljati tudi o, do sedaj pri nas neraziskani, drugačni rabi IKT: (1) usmerjenem in nadziranem skupinskem preskusu uporabe aplikacij za sproščanje/osredotočanje in (2) testiranju individualne uporabe aplikacij za krepitev izvršilnih funkcij/"trening možganov". Metode približevanja posamezniku, ob upoštevanju heterogene skupine, z različnimi motivacijskimi strategijami in oblikami dela, lahko lažje prinesejo pričakovane rezultate otrokom/mladostnikom in ne nazadnje tudi vzgojiteljem. Nekaj rezultatov pa že čutimo vsi, tako merljivih kot nemerljivih. In zato bomo zagotovo obdržali preskušene in razvijali nove učinkovite motivacijske prevzgojne in učne metode, tudi z IKT.

LITERATURA IN VIRI

[1] Barbara Benčina. 2016. Motiviranje zaposlenih. Vodenje v vzgoji in izobraževanju, 14(1), 27–47.

[2] Mojca Juriševič. 2012. Motiviranje učencev v šoli. Ljubljana: Pedagoška fakulteta.

[3] Mojca Juriševič. 2006. Učna motivacija in razlike med učenci. Ljubljana: Pedagoška fakulteta.

[4] Darja Kobal Grum, D. and Janez Musek. 2009. Perspektive motivacije. Ljubljana: Znanstvena založba Filozofske fakultete.

[5] Alenka Kobolt. 2011. Razumevanje in odzivanje na čustvene in vedenjske težave. Socialna pedagogika, 15(2), 153–175.

[6] Mitja Krajnčan. 2006. Na pragu novega doma: oddaja otrok v vzgojni zavod. Ljubljana: Pedagoška fakulteta.

[7] MDMB. (2021a). Letni delovni načrt SC MDMB za š. l. 2021-22.

[8] MDMB. (2021b). Pravila strokovnega centra Mladinskega doma Malči Beličeve Ljubljana.

[9] Uroš Metljak, Alenka Kobolt in Špela Potočnik. 2010. Narava čustvenih, vedenjskih in socialnih težav se izmika definicijam. V A. Kobolt (ur.), Izstopajoče vedenje in pedagoški odzivi (str. 87–113). Ljubljana: Pedagoška fakulteta.

[10] Anica Mikuš Kos. 1991. Šola in duševno zdravje. Murska Sobota: Pomurska založba.

[11] Vesna Podplatnik. 2011. Motivacija. V J. Erčulj in P. Peček (ur.), Sofinanciranje profesionalnega usposabljanja strokovnih delavcev v vzgoji in izobraževanju v letih 2008–2011 (str. 61–62). Brdo pri Kranju: Šola za ravnatelje.

[12] Melita Puklek Levpušček, M. and Maja Zupančič. 2009. Osebnostni, motivacijski in socialni dejavniki učne uspešnosti. Ljubljana: Znanstvena založba Filozofske fakultete.

[13] Phil Race. 1998. Teaching: Creating a Thirst for Learning? V S. Brown (ur.) Motivating Students (str. 47–58). London: Kogan Page.

[14] Edita Rihar Škoflek. 2018.. Otroci s čustveno vedenjskimi motnjami – ČVM. Dostopno na naslovu http://scvsi.splet.arnes.si/files/2019/04/Motnje-vedenja-in-%C4%8Dustvovanja.pdf (11. 8. 2022)

[15] Mirjana Ule. 2000. Temelji socialne psihologije. Ljubljana: Znanstveno in publicistično središče.

[16] Zakon o obravnavi otrok in mladostnikov s čustvenimi in vedenjskimi težavami in motnjami v vzgoji in izobraževanju (ZOOMTVI). 2020. Uradni list RS, št. 200/20. Dostopno na naslovu http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO8083 (12. 8. 2022)

Programski vzorci v rešitvah nalog iz uvodnega programiranja

Programming Patterns in Solutions to Introductory Programming Tasks

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POVZETEK

Znanje računalniškega programiranja omogoča razvijanje veščin za reševanje problemov, algoritmično, analitično in abstraktno razmišljanje ter logično sklepanje. Izkušnje kažejo, da imajo začetniki pri usvajanju tega znanja pogosto težave, ki so posledica pomanjkljivega strateškega znanja. Programski vzorci so od programskega jezika neodvisni strukturirani kognitivni delčki, ki predstavljajo konceptualne rešitve ponavljajočih algoritemskih problemov in jih je mogoče med seboj povezovati v kompleksne rešitve. Začetniku dajejo uvid v proces reševanja problemov in s tem v strategije reševanja, ki so značilne za izkušene programerje. V predstavljeni študiji smo analizirali rešitve nalog študentov uvodnega programiranja v sistemu Projekt Tomo, da bi ugotovili, kateri programski vzorci se pojavljajo v: 1) pravilnih, 2) pravilnih, ki vključujejo odvečno kodo in 3) nepravilnih rešitvah. Raziskovali smo, ali določene kombinacije programskih vzorcev uspešno napovedujejo pravilnost rešitve. Prav tako nas je zanimal proces gradnje rešitve s kombiniranjem programskih vzorcev, kar smo spremljali z analizo zaporednih oddaj. Rezultati študije so pokazali, da prisotnost pričakovanih programskih vzorcev v rešitvi dobro napove njeno pravilnost in je bolj natančna od avtomatskega vrednotenja v sistemu Projekt Tomo. Ugotovili smo, da analiza zaporednih oddaj daje vpogled v proces reševanja na konceptualnem nivoju, saj uporabljene kombinacije programskih vzorcev razkrijejo načine razmišljanja študenta. Menimo, da so rezultati raziskave uporabni na področju didaktike uvodnega programiranja, saj dokazujejo smotrnost uporabe programskih vzorcev. S programskimi vzorci si začetnik izgradi pomembno množico gradnikov, ki jih lahko uporabi v procesu snovanja rešitve in na ta način izboljša veščine pristopanja k reševanju problemov.

KLJUČNE BESEDE

Uvodno programiranje, programski vzorci, avtomatsko ocenjevanje rešitev programerskih nalog, didaktika programiranja, analiza programske kode

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ABSTRACT

Programming skills allow you to develop problem solving, algorithmic, analytical, abstract reasoning, and logical thinking skills. Experience shows that beginners often have difficulty acquiring these skills because they lack strategic knowledge. Programming patterns are structured cognitive building blocks, independent of the programming language, that represent conceptual solutions to recurring algorithmic problems and can be assembled into complex solutions. They provide novice programmers with insight into the problem-solving process and thus into the solution strategies that are typical of experienced programmers. In the present study, we analysed novice programmers' solutions to problems in Project Tomo to identify programming patterns that occur in 1) correct solutions, 2) correct solutions with redundant code, and 3) incorrect solutions. We investigated whether certain combinations of programming patterns successfully predict the correctness of a solution. We were also interested in the process of creating a solution by combining programming patterns, which was monitored by analysing sequential submissions. The results of the study showed that the presence of expected programming patterns in the solution predicts its correctness well and is more accurate than automatic evaluation in the Project Tomo system. We found that the analysis of sequential submissions provides insight into the solution process at the conceptual level, as the combinations of programming patterns used reveal the students' thinking. We believe that the results of the study are useful for the didactics of introductory programming as they reveal the rationality of using programming patterns. By using programming patterns, the novice builds an important set of building blocks to use in designing solutions, and in this way improves his ability to solve problems.

KEYWORDS

Introductory programming, programming patterns, automatic evaluation of solutions to programming tasks, programming didactics, code analysis

1 UVOD

Programiranje predstavlja eno od temeljnih veščin v sodobnem svetu, saj omogoča ustrezen razvoj veščin reševanja problemov, logičnega in kritičnega mišljenja [1]. Računalniški programi in algoritmi so vpeti v vsakdan, zato je pomembno, da imajo

posamezniki vsaj osnovno razumevanje temeljnih konceptov, na katerih so osnovani. Z učenjem programiranja učenci pridobijo znanja in veščine za ustvarjalno pristopanje k reševanju problemov. Programiranje je lahko zanimiva in izpolnjujoča izbira za njihov bodoči poklic [2].

Številne raziskave [3], **Error! Reference source not found.**, [4], [5], [6] so pokazale, da je za začetnike programiranje težko in kompleksno ter da imajo posledično težave pri pridobivanju tega znanja. Podrobnejši vpogled v njihove težave razkrije, da te ne temeljijo na razumevanju lastnosti, pravil in značilnosti določenega programskega jezika (sintaksa), prav tako nimajo težav z razumevanjem kako deluje posamezen programski konstrukt (semantika). Najbolj problematičen vidik predstavlja znanje o tem kako smiselno združiti posamezne programske konstrukte v pravilno rešitev in kako ustrezno uporabiti veščine reševanja problemov v procesu snovanja rešitve (strateško znanje) [6].

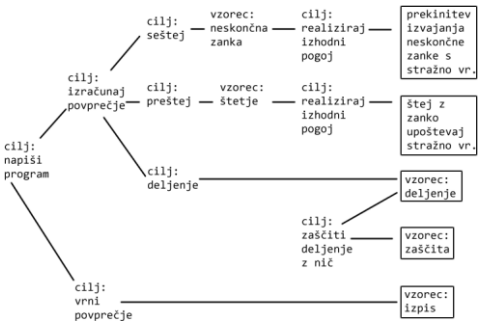
Začetniki programerji se srečujejo s številnimi omejitvami. Pogosto imajo neustrezne miselne modele, težave pri smiselnem deljenju kompleksnega problema na manjše, obvladljive podprobleme, njihovo predznanje pa je običajno neorganizirano in površno. Zaradi teh pomanjkljivosti pristopajo k razumevanju programske kode in snovanju rešitev na nivoju posamezne vrstice v kodi [7]. Izkušeni programerji se od njih pomembno razlikujejo, saj pri razumevanju oz. snovanju rešitve uporabljajo specializirane kognitivne sheme, urejene po funkcijah. To jim omogoča, da pristopajo k programiranju na višjem, konceptualnem nivoju, posledično pa so pri tem bolj učinkoviti in uspešni **Error! Reference source not found.**. To znanje je zajeto v programskih vzorcih.

Programski vzorci so od programskega jezika neodvisne rešitve algoritemskih problemov na konceptualnem nivoju, ki se pogosto pojavljajo pri reševanju problemov z računalnikom. Predstavljajo gradnike, ki ponazarjajo načine razmišljanja in sklepanja ter omogočajo pristopanje k snovanju programskih rešitev na abstraktnem nivoju. Uporaba programskih vzorcev programerju omogoča, da se najprej osredinja na višje nivojske oz. meta koncepte ter relacije med njimi, šele nato pa se ukvarja s tem kako bo rešitev zakodiral v izbranem programskem jeziku.

V članku bomo predstavili analizo programskih kod rešitev za dve nalogi iz uvodnega programiranja 50 visokošolskih študentov 1. letnika študijskega programa Praktična matematika, na Fakulteti za matematiko in fiziko, Univerze v Ljubljani v študijskem letu 2020/21, ki so jih oddali v sistem Projekt Tomo [10]. Projekt Tomo omogoča učiteljem sestavljanje nalog, študentom pa nalaganje rešitev, za katere pridobijo avtomatično povratno informacijo o pravilnosti. Cilj raziskave je ugotoviti ali začetniki programerji uporabljajo programske vzorce, ali je prisotnost/odsotnost pričakovanih programskih vzorcev pokazatelj njihove pravilnosti, kakšne so razlike v uporabi programskih vzorcev v nepravilnih rešitvah ter kako je iz zaporednih oddaj možno slediti razvoju rešitve iz vidika uporabe oz. kombiniranja programskih vzorcev.

2 PREGLED LITERATURE

Programski vzorci že desetletja predstavljajo aktivno in pomembno raziskovalno področje. Avtorji so preučevali različne vidike njihove uporabe v okviru uvodnega programiranja. Prvi, ki je vzorce preučeval v okviru uvodnega programiranja je bil Soloway [9], ki je ugotovil, da je ključna razlika med začetniki in izkušenimi programerji ravno v uporabi/neuporabi programskih vzorcev. Razvil je metodo »goal/plan analysis«, ki temelji na deljenju prvotnega problema na manjše podprobleme oz. »cilje«, za katerega pa ima programer v okviru svojega strateškega znanja programski vzorec, ki ga reši. Te pa nato združuje v rešitev problema. Slika prikazuje uporabo metode na primeru iskanja povprečne vrednosti vpisanih števil.



Slika1: Dekompozicija problema iskanja povprečne vrednosti vpisanih števil (povzeto po [9])

Trdil je, da z eksplicitnim poučevanjem programskih vzorcev pozitivno vplivamo na razvoj strateškega znanja pri začetnikih, ki je zanje najtežje dosegljivo. Pomembno raziskovalna smer na področju programskih vzorcev predstavlja njihovo identificiranje, opisovanje in klasificiranje [11], [12] [13] [14]. Cilj prizadevanj je znanje, ki je zajeto v programskih vzorcih, narediti eksplicitno. V tabeli 1 predstavljamo izbor programskih vzorcev iz literature [15], ki smo jih našli pri analizi predstavljenih nalog.

Programske vzorce so avtorji uspešno uporabili na različnih področjih poučevanja programiranja: kot modul v programskem okolju za učenje uvodnega programiranja [16], za izboljšanje rezultatov pri predmetu uvodnega programiranja [17], na področju učenja s pomočjo iger [18], za analizo napačnih razumevanj [5] in ugotavljanje kompleksnosti rešitev v programskem okolju Scratch [19].

Ključne prednosti uporabe programskih vzorcev pri učenju uvodnega programiranja so: zmožnost posredovanja splošnega programerskega znanja, ki je neodvisno od konkretnega programskega jezika [19]; učinkovitejše učenje splošnih visoko nivojskih strategij in konceptov za snovanje rešitev in strukturiranje programov [11] [19]; prepoznavanje situacij, v katerih je smiselno uporabiti vzorec [16]; neposredno prepoznavanje usvojenega konceptualnega znanja, ki se kaže v vzorcih v kodi začetnikov ter naslavljanje težav, ki jih imajo zaradi pomanjkanja strateškega znanja [13].

V raziskavi analiziramo programsko kodo študentov - začetnikov programerjev, ki so kodo oddali kot rešitev v sistem za avtomatično vrednotenje pravilnosti kode – Projekt Tomo. Sistem so razvili na Fakulteti za matematiko in fiziko, Univerze v Ljubljani leta 2010 in ga uporablja več kot 30 izobraževalnih inštitucij v Sloveniji. Podpira tri različne programske jezike: Python, Octave in R. Učiteljem omogoča ustvarjanje lastnih nalog, uporabo nalog, ki so jih ustvarili drugi in spremljanje napredka učencev. Njim nudi takojšno povratno informacijo o pravilnosti naloge in predstavlja okolje za samostojno učenje.

Pomembna lastnost sistema je, da hrani vse zaporedne oddaje posameznega učenca, tako da lahko spremljamo razvoj rešitve od začetne do končne oddaje [10].

Tabela 1: Opis izbranih programskih vzorcev (povzeto po [15])

Programski vzorec	Opis
Procesiraj vse elemente	Z zanko dostopimo do vseh vrednosti v zbirki in jih procesiramo
Posredno sklicevanje	Posredno sklicevanje v vseh oblikah (klici funkcij, vrednost v seznamu…)
Štetje	Štetje objektov, vrednosti, dogodkov, ki ustrezajo kriteriju
Nepovezana izbira	Zaporedno preverjanje več neodvisnih pogojev
Zanka in pol	Izstopni pogoj je v telesu zanke
Ekstremne vrednosti	Iskanje ekstremne vrednosti v zbirki z zanko glede na izbran kriterij
Ali pogoj velja ali ne	Pogojni stavek, ki ne določa kaj se zgodi, če pogoj ni resničen
Alternativna akcija	Pogojni stavek, ki določa kaj se zgodi, ko je oz. ni izpolnjen pogoj
Računanje vsote	Seštevanje vrednosti v zbirki z zanko
Filtriranje zbirke	Procesiramo elemente, ki ustrezajo pogoju
Prirejanje	Podatkovnemu objektu priredimo vrednost

Stalna povratna informacija je v procesu učenja programiranja izjemno pomembna za pridobivanje konceptualnih znanj in razvoju programerskih veščin. Običajno imajo učitelji v razredu veliko učencev, zato se težko posvetijo vsakemu učencu pri odkrivanju napak. Ročno iskanje napak je namreč težavno in zamudno. Avtomatizirani sistemi za ocenjevanje pomagajo učiteljem, da se hitreje odzovejo, učencem pa omogočijo, da se lahko učijo v lastnem tempu. Tovrstni sistemi pomagajo učiteljem pri ustvarjanju učnih gradiv, sledenju učnemu procesu in analizi rešitev, ki jih učenci nalagajo v sistem [10].

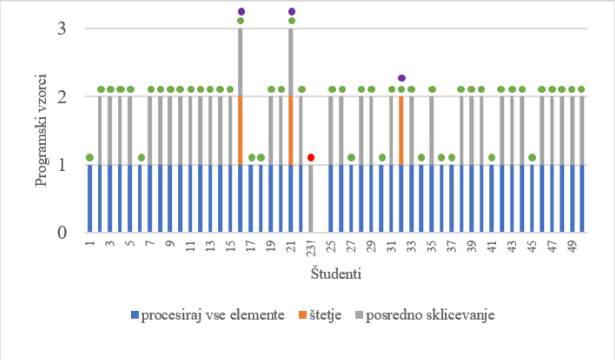
3 REZULTATI

V raziskavi smo analizirali 10 različnih nalog. V tekoči prispevek bomo analizirali rešitve dveh nalog, ki najbolj nazorno opiše pomen prisotnosti programskih vzorcev kodi študentov: »Pica« in »Iskanje lastnosti«. Raziskava je temeljila na neslučajnostnem priložnostnem vzorcu 50 študentov prvega letnika Fakultete za matematiko in fiziko, smeri Praktična matematika, v študijskem letu 2020/2021. Rešitve, ki so jih oddali v sistem Projekt Tomo smo ročno pregledali in v njih iskali vzorce.

3.1 Analiza končnih rešitev naloge – Pica

Definicija naloge: Napišite program, ki bo po vrsti izpisal sestavine za pico, naštete v seznamu *sestavine = ['testo', 'pelati', 'sir', 'olive', 'jajce'],* vsako v svojo vrstico.

Rešitev naloge je oddalo 49/50 študentov, ena od njih je bila napačna. Študenti so implementirali rešitev z uporabo *while* (35) in *for* zanke (14).



Slika 2: Programski vzorci vključeni v rešitve naloge »Pica«

Slika prikazuje, kateri programski vzorci so vključeni v pravilne (zelena pika), pravilne z odvečno kodo (zelena in vijolična pika) in nepravilne (rdeča pika) rešitve. V rešitvah so se pojavljali trije programski vzorci: *procesiraj vse elemente, posredno sklicevanje* in *štetje.* Vse pravilne rešitve so vključevale programski vzorec *procesiraj vse elemente* (48/48 = 100%), sledil je vzorec *posredno sklicevanje* (36/48 = 75%) in *štetje* (3/48 = 6%). Iz rezultatov lahko sklepamo, da pravilna rešitev naloge zahteva uporabo vzorca *procesiraj vse elemente*. Vzorec *posredno sklicevanje* pa so morali uporabiti tisti študenti, ki so se odločili za uporabo *while* zanke, saj je to edini način za sklicevanje na elemente v seznamu. V programskem jeziku Python lahko uporabimo zanko *for* kot iterator, takrat pa sklicevanja ne potrebujemo. Trije študenti (16, 21 in 32) so uporabili programski vzorec *štetje*, ki je odvečen, saj ne vpliva na pravilnost naloge.

Študent 1 - pravilna
Vzorec: *procesiraj vse elemente*

```
sestavine = ['testo', 'pelati',
'sir', 'olive', 'jajce']
for i in sestavine:
    print(i)
```

Študent 21 - pravilna
Vzorci: *procesiraj vse elemente*, *štetje* in *posredno sklicevanje*

```
sestavine = ['testo', 'pelati',
'sir', 'olive', 'jajce']
stevec = 0
element = 0
while stevec != len(sestavine):
    print(sestavine[element])
    stevec += 1
    element += 1
```

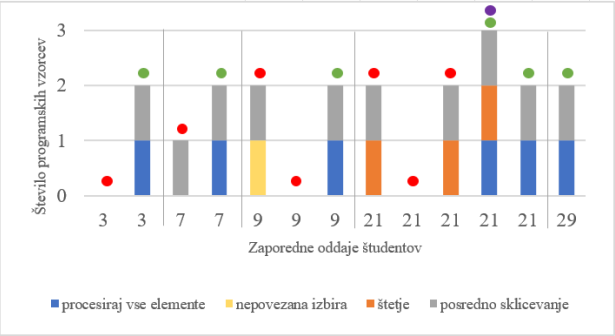
Slika 3: Programska koda z označenimi vzorci za rešitvi študentov 1 in 21 za nalogo »Pica«

Slika prikazuje kako sta študenta z oznako 1 in 21 implementirala programske vzorce. Študent 1 je uporabil zanko *for* v programskem jeziku Python kot iterator in je na ta način implementiral programski vzorec *procesiraj vse elemente*. Študent 21 pa je uporabil drugačen pristop in je ta vzorec implementiral z uporabo zanke *while*, pri čemer je uporabil spremenljivko *element* za sklicevanje na posamezne elemente ter funkcijo *len* v kombinaciji s spremenljivko *stevec*, da je ugotovil ali je dostopil do vseh elementov v seznamu. Za določanje konca bi lahko uporabil kar spremenljivko *element*, zato je uporaba

posebne spremenljivke, s katero je štel elemente v seznamu (programski vzorec *štetje*), odvečna.

3.2 Analiza zaporednih oddaj naloge – Pica

Z analizo zaporednih oddaj smo spremljali proces gradnje rešitve za nalogo »Pica« iz vidika uporabe programskih vzorcev pri študentih z identifikacijsko številko: 3, 7, 9, 21 in 29 (Slika).



Slika 4: Programski vzorci v zaporednih oddajah študentov 3, 7, 9, 21 in 29 za nalogo »Pica«

Študent 3 je rešitev oddal dvakrat. V prvi oddaji ni uporabil nobenega programskega vzorca, rešitev pa je bila nepravilna. Pri drugi oddaji je uporabil oba pričakovana vzorca, rešitev pa je bila pravilna.

Študent 7 je prav tako dvakrat oddal rešitev. V prvi je uporabil zanko *while* za dostopanje do vrednosti v seznamu, vendar se je zmotil v določanju pogoja za izstop iz zanke. Na ta način ni dosegel zadnjega elementa v seznamu in posledično ni pravilno implementiral vzorca *procesiraj vse elemente*. V drugi oddaji je napako popravil, na ta način implementiral oba pričakovana vzorca in njegova rešitev je postala pravilna.

Študent 9 je trikrat oddal rešitev. V prvi oddaji je uporabil programski vzorec *nepovezana izbira*, ki v kontekstu reševanje te naloge ni smiseln. Rešitev je bila nepravilna. V drugi oddaji je preverjal kako deluje *while* zanka v kombinaciji s funkcijo *len*, pri čemer ni implementiral nobenega vzorca, rešitev pa je bila nepravilna. V zadnji oddaji je vključil oba pričakovana vzorca, njegova rešitev pa je bila pravilna.

Študent 21 je petkrat oddal rešitev. V prvi in tretji oddaji je uporabil programski vzorec *štetje*, ki v kontekstu reševanja naloge ni smiseln, rešitev pa je bila v obeh primerih nepravilna. V drugi oddaji ni uporabil nobenega vzorca, rešitev pa je bila nepravilna. Zanimivi sta naslednji dve oddaji. V četrti je uporabil vzorce *procesiraj vse elemente, štetje* in *posredno sklicevanje*, rešitev je bila pravilna, vendar je vključevala odvečno kodo (tisto, ki je implementirala vzorec *štetje*). V zadnji oddaji je odstranil funkcionalnost programskega vzorca *štetje* in na ta način napisal pravilno rešitev brez odvečne kode.

Radi bi omenili še primer študenta 29, ki je oddal svojo rešitev v obliki funkcije. Sistem Projekt Tomo je njegovo rešitev ovrednotil kot nepravilno, čeprav je bila njegova rešitev konceptualno pravilna. Analiza s programskimi vzorci je pokazala, da je uporabil oba pričakovana vzorca in je bolje napovedala pravilnost rešitve.

3.3 Analiza končnih rešitev naloge – Iskanje lastnosti

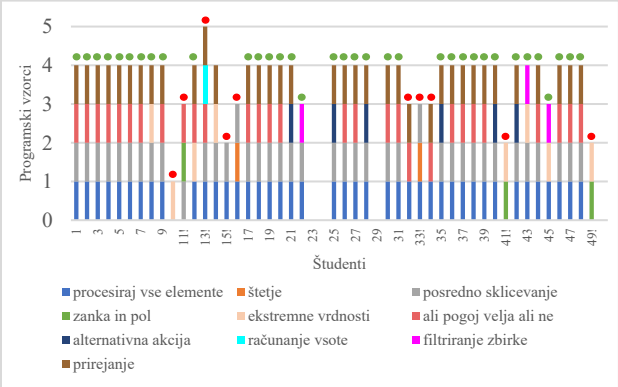
Definicija naloge: Izpiši število znakov najkrajšega niza v poljubnem seznamu.

Rešitev naloge je oddalo 46/50 študentov. Med oddanimi rešitvami bilo 37 pravilnih in 9 napačnih. Radi bi izpostavili, da smo med analizo ugotovili, da je 8 rešitev, ki so bile nepravilne, Projekt Tomo ovrednotil kot pravilne. Po našem mnenju gre za primere, ko so študenti vedeli za princip delovanja preverjanja pravilnosti in so ga namerno ukanili. Med pravilnimi rešitvami smo odkrili naslednje kombinacije programskih vzorcev, ki odražajo tipe reševanja: Tip-1 (24/37), Tip-2 (6/37), Tip-3 (2/37) in Tip-4 (3/37). Te so prikazane v tabeli 2.

Tabela 2: Kombinacije programskih vzorcev v različnih tipih pravilnih rešitev za nalogo "Iskanje lastnosti"

Programski vzorec	Tip-1	Tip-2	Tip-3	Tip-4
Procesiraj vse elemente	+	+	+	+
Ali pogoj velja ali ne	+	-	-	-
Alternativna akcija	-	+	-	-
Prirejanje	+	+	+	-
Posredno sklicevanje	+	+	+	+
Ekstremne vrednosti	-	-	+	+
Filtriranje zbirke	-	-	-	+

Slika grafično ponazarja, katere kombinacije programskih vzorcev so se pojavljale v posameznih rešitvah. Zelena pika nad stolpcem pomeni, da je rešitev pravilna, rdeča označuje nepravilno rešitev. Iz slike lahko vidimo, da se kombinacije programskih vzorcev ponavljajo (tipi reševanja), prav tako pa, da napačne rešitve ne vsebujejo ustrezne kombinacije vzorcev enega od tipov reševanja.



Slika 5: Programski vzorci v oddanih rešitvah za nalogo "Iskanje lastnosti"

Analiza je potrdila, da vse pravilne rešitve vsebujejo programska vzorca: *procesiraj vse elemente* in *posredno sklicevanje*. Nalogo je nemogoče v splošnem pravilno rešiti, če ne dostopimo vsakega niza v seznamu, zato je uporaba *procesiraj vse elemente* nujna. Vzorec *posredno sklicevanje* sicer ni nujen,

saj lahko do elementov v programskem jeziku Python dostopamo tudi preko iteratorja z uporabo zanke *for*. Študenti so v rešitvah večinoma uporabljali *while* zanko, ki pa zahteva uporabo tega vzorca. To lahko pripišemo temu, da je bil to učni sklop učenja uporabe zanke *while*. Najbolj pogosta rešitev je bila Tip-1. Pri tej rešitvi so študenti uporabili programski vzorec *ali pogoj velja ali ne*, da so z njim iskali lokalni minimum. Tega so uporabili v kombinaciji z vzorcem *prirejanje*, da so ga shranili. Podobna rešitev je Tip-2, pri kateri pa je funkcionalnost *ali pogoj velja ali ne* zamenjal vzorec *alternativna akcija*. V rešitvah Tip-3 je lokalni minimum realiziran preko vzorca *ekstremne vrednosti*. Študenti so v tem primeru minimalni element iskali s pomočjo funkcije *min*, ki pa dejansko implementira enega od prejšnjih tipov reševanja. Vseeno smo se odločili, da ga štejemo kot poseben tip, saj izkazuje, da študent pozna in zna uporabiti vgrajeno funkcijo *min*. Rešitve Tip-4 pa ponazarjajo manj pričakovan pristop k reševanju problema in sicer so študenti ustvarili nov seznam, v katerega so shranili dolžine nizov iz vhodnega seznama in nato uporabili funkcijo *min*.

Analiza s programskimi vzorci nam omogoči vpogled v rešitve na konceptualnem nivoju, ki je od programskega jezika neodvisen. Tako lahko hitro ugotovimo, da sta rešitvi konceptualno ekvivalentni, čeprav sta implementirani drugače. Slika prikazuje dve različni implementaciji konceptualno ekvivalentne rešitve (Tip-1).

Študent 2 - pravilna

Vzorci: *procesiraj vse elemente*, *ali pogoj velja ali ne*, *prirejanje* in *posredno sklicevanje*.

```
seznam = ['testo', 'pelati',
'sir', 'olive', 'jajce']
najmanjsa = len(seznam[0])
i = 1
while i < len(seznam):
    dolzina = len(seznam[i])
    if dolzina < najmanjsa:
        najmanjsa = dolzina
    i += 1
print(najmanjsa)
```

Študent 9 - pravilna

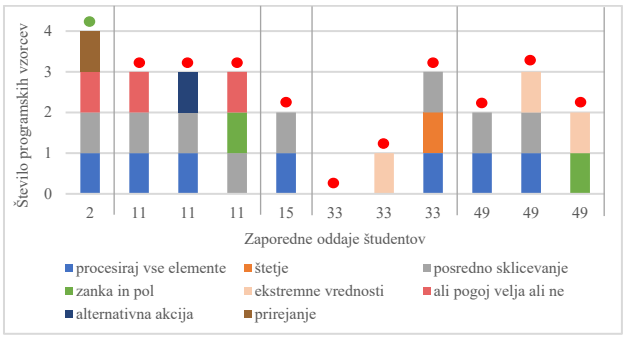
Vzorci: *procesiraj vse elemente*, *ali pogoj velja ali ne*, *prirejanje* in *posredno sklicevanje*.

```
seznam = ['testo', 'pelati',
'sir', 'olive', 'jajca']
najkrajsa = len(seznam[0])
for i in seznam:
    if(len(i) <= najkrajsa):
        najkrajsa = len(i)
print(najkrajsa)
```

Slika 6: Programska koda z označenimi vzorci za rešitvi študentov 2 in 9 za nalogo »Iskanje lastnosti«

3.4 Analiza zaporednih oddaj naloge – Iskanje lastnosti

Z analizo zaporednih oddaj smo spremljali proces gradnje rešitve za nalogo »Iskanje lastnosti« iz vidika uporabe programskih vzorcev pri študentih z identifikacijsko številko: 2, 11, 15, 33 in 49 (Slika). Te primere smo izbrali, ker želimo pokazati kako analiza programskih vzorcev v kodi bolj zanesljivo napove pravilnost rešitve, kot avtomatično preverjanje pravilnosti v Projekt Tomo. Ta je namreč rešitve študentov 11, 15, 33 in 49 označil kot pravilne, čeprav niso bile, rešitev študenta 2 pa kot nepravilno, čeprav je bila pravilna. Slednji deluje na osnovi klicev testnih funkcij, kar nekateri študenti uporabijo pri tem, da avtomatično preverjanje ukanijo v svoj prid. Programski vzorci pa ponazorijo idejo rešitve, saj lahko z njimi dobimo vpogled v rešitev na višjem nivoju abstrakcije. Rezultati nakazujejo, da ta način bolj zanesljivo napove pravilnost rešitve.



Slika 7: Programski vzorci v zaporednih oddajah študentov 2, 11, 15, 33 in 49 za nalogo »Iskanje lastnosti«

Študent 2 je v svojo rešitev vključil vse pričakovane vzorce rešitve Tip-1. Napaka, zaradi katere je sistem za avtomatsko preverjanje pravilnosti Projekt Tomo rešitev označil kot nepravilno, je bila odsotnost izpisa končne vrednosti. Gre zgolj za površnost, saj je očitno, da študent nalogo zna rešiti.

Študent 11 je trikrat oddal rešitev. Iz slike je razvidno kako je v vsako oddajo vključil drugo kombinacijo programskih vzorcev, nobena pa ni enaka kombinaciji enega od tipov reševanja. Trik, ki ga je uporabil, da je »ukanil« sistem preverjanja pravilnosti, je bilo preverjanje dolžine nizov s konkretnim številom 3. To je bila dolžina najkrajšega niza v podanem primeru. Takrat je to izpisal kot rezultat.

Študent 15 je sistem »ukanil« tako, da je z zanko dostopil do vseh vrednosti v seznamu, nato pa izpisal dolžino zadnjega. Ker je bil to najkrajši niz v podanem primeru je to sistem ovrednotil kot pravilno. Iz analize vključenosti programskih vzorcev pa je razvidno, da nobena od rešitev ni ustrezala pričakovanim kombinacijam.

Študent 33 je oddal rešitev trikrat. Nobena od rešitev ni vsebovala pričakovanih kombinacij vzorcev, vse od njih pa so bile nepravilne. Študent je sistem vrednotenja »ukanil« tako, da je med zaporednih dostopanjem do nizov v seznamu iz podanega primera hkrati gradil nov seznam z dolžinami teh nizov. Nato je le izpisal vrednost zadnjega elementa iz novega seznama.

Študent 49 je oddal tri rešitve. Vse so bile nepravilne, čeprav jih je sistem označil kot pravilne. Sistem vrednotenja je ukanil tako, da je ustvaril nov seznam in vanj sam ročno vpisal dolžine nizov iz podanega primera. Nato je na njem uporabil funkcijo *min*, ki je vrnila najmanjšega. Naša analiza je pokazala, da nobena od rešitev ni imela ustrezne kombinacije pričakovanih programskih vzorcev.

4 ZAKLJUČEK

V raziskavi smo se ukvarjali s prisotnostjo programskih vzorcev v rešitvah študentov uvodnega programiranja. Zanimalo nas je ali so vzorci prisotni oz. katere programske vzorce je možno najti. Skušali smo ugotoviti ali prisotnost pričakovanih programskih vzorcev dobro napoveduje pravilnost rešitve in kaj nam razkrije spremljanje procesa reševanja programerskega problema z opazovanjem uporabljenih kombinacij programskih vzorcev pri zaporednih oddajah.

Analiza rešitev programskih kod je pokazala, da študenti uporabljajo programske vzorce pri reševanju nalog iz

programiranja. Za razliko od zgolj pregledovanja kode nam omogoča vpogled v strukturo rešitve na višjem nivoju abstrakcije, kot kombinacijo kognitivnih struktur oz. programskih vzorcev. Prikaz na Slika in Slika pokaže kako pogled na rešitev iz vidika programskih vzorcev razkrije, da gre pri posameznem primeru za konceptualno ekvivalentni rešitvi, ki sta zgolj implementirani na različen način.

Rezultati so pokazali, da se v rešitvah pojavljajo specifične kombinacije vzorcev, ki dobro napovedujejo pravilnost rešitve. Vse pravilne rešitve so vsebovale pričakovane programske vzorce, medtem ko jih nepravilne niso. To je prikazano na Slika in Slika .

Med raziskavo smo našli primere, ko je sistem avtomatičnega vrednotenja v Projekt Tomo rešitev ocenil kot pravilno, analiza vključenosti programskih vzorcev pa je pokazala, da rešitev ne vsebuje pričakovanih vzorcev. Natančnejši pregled teh nalog je razkril, da so rešitve dejansko nepravilne. Študenti so s poznavanjem delovanja avtomatičnega vrednotenja tega ukanili. Analiza s programskimi vzorci, pa je takšne primere razkrila.

Največjo omejitev predstavljene metode vidimo v tem, da ni avtomatizirana, ampak jo moramo opraviti ročno. To je zamudno in pri večji količini rešitev zahteva veliko dela. Glede na vzpodbudne rezultate bomo nadaljnja raziskovalna prizadevanja usmerili v iskanje možnosti avtomatiziranja iskanja programskih vzorcev v kodi.

Menimo, da so rezultati raziskave pomembni za didaktiko programiranja, saj so pokazali, da je mogoče z uporabo programskih vzorcev učinkovito pristopati k reševanju problemov. Predstavljajo namreč nabor gradnikov, ki jih lahko študenti uporabijo pri snovanju rešitve na konceptualnem nivoju. Rezultati so pomembni tudi iz vidika ugotavljanja konceptualno ekvivalentnih rešitev, izboljševanja avtomatičnih sistemov za preverjanje pravilnosti in spremljanja procesa snovanja rešitve s sklapljanjem programskih vzorcev. To je začetnike pri programiranju še posebej pomembno **Error! Reference source not found.**, saj imajo ravno s tem največje težave.

ZAHVALA

Zahvaljujemo so Urški Erjavec, študentki 2. stopenjskega študijskega programa Poučevanje, smer Predmetno poučevanje, usmeritev Predmetno področje računalništvo na Pedagoški fakulteti, Univerze v Ljubljani, ki je v okviru magistrskega dela opravila analizo vključenosti programskih vzorcev v kodi študentov, ki so jo oddali kot rešitev izbranih domačih nalog v sistem za avtomatično vrednotenje pravilnosti kode - Projekt Tomo.

LITERATURA IN VIRI

[1] Pauliina Tuomi, Jari Multisilta, Petri Saarikoski, and Jaakko Suominen. 2018. Coding skills as a success factor for a society. Education and Information Technologies, 23 (1), 419–434.

[2] Francisco Buitrago Florez, Rubby Casallas, Marcela Hernandez, Alejandro Reyes, Silvia Restrepo, and Giovanna Danies. 2017. Changing a generation's way of thinking: Teaching computational thinking through programming. Review of Educational Research, 87 (4), 834–860.

[3] Jens Bennedsen and Michael E. Caspersen. 2007. Failure rates in introductory programming. AcM SIGcSE Bulletin, 39 (2), 32—36.

[4] Anabela Jesus Gomes and António José Mendes. 2010. A study on student performance in first year CS courses. In Proceedings of the 15th Annual Conference on Innovation and Technology in Computer Science Education. Association for Computing Machinery, New York, USA, 113–117. DOI: https://doi.org/10.1145/1822090.1822123

[5] Christopher Watson and Frederick W.B. Li. 2014. Failure rates in introductory programming revisited. In Proceedings of the 2014 conference on Innovation & technology in computer science education. Association for Computing Machinery, New York, NY, USA, 39–44.

[6] Yizhou Qian and James Lehman. 2017. Students' misconceptions and other difficulties in introductory programming: A literature review. ACM Transactions on Computing Education (TOCE) 18, 1 (December 2017), 1–24.

[7] Anthony V. Robins, Lauren E. Margulieux, and Briana B. Morrison. 2019. The Cambridge Handbook of Computing Education Research. Cambridge University Press.

[8] Leon E. Winslow. 1996. Programming pedagogy: A psychological overview. ACM Sigcse Bulletin, 28 (3), 17–22.

[9] Elliot Soloway. 1986. Learning to program = learning to construct mechanisms and explanations. Communications of the ACM 29, 9 (September 1986), 850–858.

[10] Matija Lokar. 2019. Project Tomo: Automated feedback service in teaching programming in Slovenian high schools. In Proceedings of the 8th Computer Science Education Research Conference. Association for Computing Machinery, Larnaca Cyprus, 123–124.

[11] Owen Astrachan and Eugene Wallingford. 1998. Loop patterns. In Proceedings of the Fifth Pattern Languages of Programs Conference. Allerton Park, Illinois, USA. Dostopno na naslovu https://users.cs.duke.edu/~ola/patterns/plopd/loops.html (10. 8. 2022)

[12] Joseph Bergin. 1999. Patterns for selection version 4. Dostopno na naslovu http://faculty.chas.uni.edu/~wallingf/patterns/elementary/papers/selection.pdf (10. 8. 2022)

[13] Michael Clancy and Marcla Linn. 1999. Patterns and pedagogy. ACM SIGCSE Bulletin 31, 1 (March 1999), 37–42. DOI: https://doi.org/10.1145/384266.299673

[14] Viera K. Proulx. 2000. Programming patterns and design patterns in the introductory computer science course. In Proceedings of SIGCSE'2000. Association for Computer Machinery, New York, NY, USA, 80–84.

[15] Matej Zapušek. 2022. Domenska ontologija programskih vzorcev pri uvodnem programiranju. Doktorska disertacija. University of Ljubljana, Slovenia.

[16] Leliane Nunes De Barros, Ana Paula dos Santos Mota, Karina Valdivia Delgado, and Patricia Megumi Matsumoto. 2005. A tool for programming learning with pedagogical patterns. In Proceedings of the 2005 OOPSLA workshop on Eclipse technology eXchange. San Diego, California, CA, USA, 125–129. DOI: https://doi.org/10.1145/1117696.1117722

[17] Michael De Raadt. 2008. Teaching programming strategies explicitly to novice programmers. University of Southern Queensland.

[18] Vinicius Alexis de Aquino Leal and Deller James Ferreira. 2016. Learning programming patterns using games. International Journal of Information and Communication Technology Education (IJICTE) 12, 2 (April 2016), 23–34. DOI: https://doi.org/10.4018/IJICTE.2016040103

[19] Kashif Amanullah and Tim Bell. 2018. Analysing students' scratch programs and addressing issues using elementary patterns. In Proceedings of the 2018 IEEE Frontiers in Education Conference (FIE). San Jose, CA, USA, 1–5. Dostopno na naslovu https://www.computer.org/csdl/proceedings-article/fie/2018/08658821/18j9j1yhzbi (10. 8. 2022)

[20] Raymond Lister, Elizabeth S. Adams, Sue Fitzgerald, William Fone, John Hamer, Morten Lindholm, Robert McCartney, Jan Erik Moström, Kate Sanders, Otto Seppälä, Beth Simon, and Lynda Thomas. 2004. A multi–national study of reading and tracing skills in novice programmers. *ACM SIGCSE Bulletin* 36, 4 (February 2004), 119–150.

Animacija, ustvarjena z orodjem Stop Motion

Animation Made With the Tool Stop Motion

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POVZETEK

Pouk v času epidemije je uvedel nove pristope upodabljanja šolskih prireditev. Kulturna šolska prireditev zajema govorni nastop, igro, ples in scenografijo. V času epidemije je bila prireditev prenesena v digitalno obliko in tako so si jo vsi učenci lahko ob istem času pogledali preko spletne povezave.

Poleg igre in nastopov učencev, ki so bili posneti, je bila videu dodana še animacija za popestritev. Animacija je oblika filma, v katerem se s hitrim izmenjevanjem risb ustvarijo gibljive podobe. Ustvarjamo iluzijo gibanja, v tem primeru s pomočjo fotografij. Pri pouku je učitelj primoran uporabiti orodje, ki je nezahtevno za uporabo, in z uporabo tega učenci najlažje usvojijo vse predvidene učne cilje ter razvijajo ustvarjalnost.

V prispevku je predstavljen proces načrtovanja, ustvarjanja ilustracij in fotografiranja z orodjem Stop Motion, ki nam omogoči iluzijo gibanja.

Končni rezultat izdelka je predstavljen v obliki posnetka. Za izbiro tega orodja smo se odločili, ker uporaba ni zapletena in je dostopno na vseh šolskih tabličnih računalnikih, s katerimi smo ustvarjeno fotografijo direktno uporabili v orodju.

Za uporabo orodja Stop Motion so bili učenci visoko motivirani, več dela so imeli z načrtovanjem snemalne knjige in risanjem ilustracij.

KLJUČNE BESEDE

Stop Motion, snemalna knjiga, skica, ilustracija, prireditev na daljavo

ABSTRACT

Lessons during the epidemic brought new approaches to depicting school events. The cultural school event includes a speech performance, a play, a dance and scenography. During the epidemic, the event was transferred to a digital format, where all students could watch the event at the same time via an online connection.

In addition to the play and performances of the students, which were recorded, animation was added to the video to make it more interesting. Animation is a form of film where moving images are created by rapidly exchanging drawings. We create the illusion of movement in this case with the help of photos. During the lesson, the teacher is forced to use a tool that is easy to use and that would make it easier for the students to learn all the intended learning goals and develop creativity.

The article presents the process of sketches, creation of illustrations and photography in the Stop Motion tool, which gives us the illusion of movement.

The final result of the product is presented in the form of a clip. We decided to choose this tool because it is not complicated to use, it is accessible on all school tablets, with which we used the created photo directly in the tool.

Students were highly motivated to use the Stop Motion tool, they had more work to do with making storyboard and drawing illustrations.

KEYWORDS

Stop Motion, storyboard, sketch, illustration, distance school event

1 UVOD

Po učnem načrtu za likovno umetnost iz leta 2011 učenec v tretjem vzgojno-izobraževalnem obdobju razvija uporabo digitalnih orodij pri pouku likovne umetnosti. Ti naj bi uporabljali digitalno tehnologijo pri razvijanju spretnih zmožnosti, in sicer:

- razvijanje izrazne zmožnosti pri risanju na ploskvi in s tem negovanje individualnega likovnega izraza;
- kot podporo kritičnemu mišljenju, ustvarjalnosti in inovativnosti;
- uporaba digitalne tehnologije, s pomočjo katere se izdela animirani film;
- uporaba osnovnih postopkov digitalnih tehnologij, s katerimi se izdela fotografijo in pozornost je usmerjena na kadriranje [1].

Kot učitelji likovne umetnosti se veliko srečujemo z digitalnim oblikovanjem, zato so nam IKT-orodja blizu. Uporaba in izpeljava učne ure v računalniški učilnici učencem omogoča občutek za tridimenzionalnost. Likovna umetnost ima poleg teoretičnega dela največji delež praktičnega dela, pri katerem se učencem zagotavlja sproščeno ustvarjanje in preizkus novo naučenih tehnik. Današnje generacije otrok si ne predstavljajo

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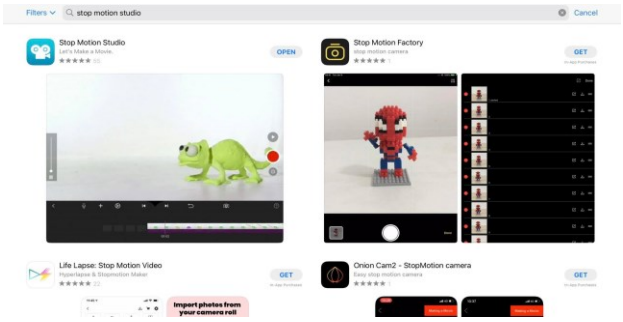
življenja brez računalnikov in interneta. Zaradi uporabe socialnih omrežij hitro izgubijo interes do vsakdanjih opravil in obveznosti. Otroška domišljija, branje, inovativnost so v pomanjkanju pri generacijah, ki so vsakodnevno izpostavljeni socialnim omrežjem, ki ponujajo neomejen dostop do sveta vplivnežev, umetnikov in iger. Vse predstavljene podobe, ki jih otrok vidi, spremlja na internetu, pustijo vtis. Učitelji si prizadevamo in poskušamo izčrpati pozitivne in poučne izseke tega. Usmeritev otroka in njegove ustvarjalnosti v pravo smer je delo, ki ga opravljamo učitelji. Tako pri likovni umetnosti poskušamo vstopiti v njihov digitalni svet in uporabiti njihove spretnosti v umetniškem izražanju. Za izdelavo animacije je bilo potrebno poleg ideje, zasnove in izvedbe na koncu tudi vse skupaj digitalno urediti in povezati zvok. V razvoj animacije so bili tako vključeni učenci 8. razreda.

V nadaljevanju prispevka bo natančneje predstavljeno orodje Stop Motion, ki smo ga skupaj z učenci 8. razreda uporabljali.

2 PRIMER UPORABE ORODJA STOP MOTION

2.1 Kaj je Stop Motion?

Stop Motion je aplikacija, ki se uporablja na tabličnih računalnikih in pametnih telefonih. Preko App Stora, Google Play trgovine ali drugih platform, ki jih zagotavljajo različni operacijski sistemi, se brezplačno naloži aplikacija Stop Motion Studio (Slika 1). Aplikacija je brezplačna za prenos in uporabo v najosnovnejši obliki. To je zadostno za ustvarjanje filmov stop-motion z zvokom v visoki ločljivosti.



Slika 1: Prenos aplikacije v App Store

Stop-motion je tehnika snemanja filmov, ki se uporablja za oživitev neživih predmetov z uporabo niza fotografij. Med vsakim posnetkom se predmeti v okvirju rahlo premaknejo, da se ustvari videz gibanja, ko se slike sestavijo. Količina časa, ki je potrebna za izdelavo videa stop-motion, je v celoti odvisna od dolžine in obsega projekta. Eksperimentiranje s kratkimi 15- do 30-sekundnimi videoposnetki naj traja manj kot eno uro. Seveda, če se želi ustvariti dovršene prizore ali uporabiti umetniške stvaritve, kot je glina, lahko projekt stop-motion traja več dni.

Ne glede na to, katero metodo se uporablja za ustvarjanje videa v stop-motionu, se uporabijo osnovni koraki:

- ustvariti sceno,
- postaviti telefon na stojalo in pripraviti prizor,
- nastaviti telefon ali tablico,
- fotografirati,
- narediti majhno spremembo prizora,
- posneti še eno fotografijo,
- narediti majhno spremembo prizora,
- posneti še eno fotografijo,
- ponavljajti tako dolgo, kot je potrebno,
- z aplikacijo ali programsko opremo za urejanje združiti fotografije v film [2].

Preden se lotimo dela, je smiselno, da se učencem predstavi nekaj primerov že ustvarjenih animacij stop-motion. Te je lahko najti na samem orodju Stop Motion ali pa na številnih spletnih straneh, posnetkih na YouTubu in seveda tudi socialnih omrežjih, ki so bistveni za današnji čas glede marketinga. Vsak umetnik se lahko predstavi brezplačno in dobi popularnost s pomočjo objave na svojih socialnih omrežjih, kot sta Instagram in TikTok.

Primera ilustriranih in izrezanih animacij sta Animacija [3] in Paper Cut [4]. Primera animacij s predmeti sta Reklama za Mac and Cheese [5] in Leteči kolač [6].

2.2 Uvodna motivacija

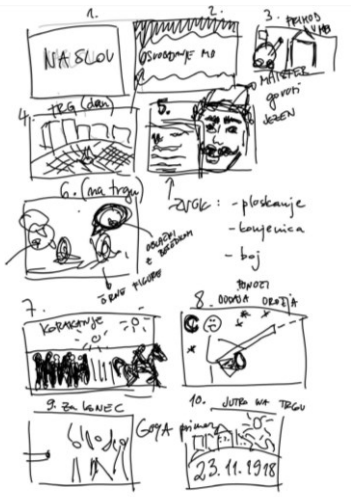
Po predstavitvi orodja za animacijo in ogledu posnetkov so učenci dobili predstavo, kakšen bo končen izdelek. Medpredmetno povezovanje nam ponuja ozadje in potek zgodbe, s katerima se ustvarijo skice prizorov, ki so uprizorjeni v animaciji. Učenci so se razdelili v skupine, znotraj katerih so si med seboj razdelili naloge in zastavili načrt. Samostojno so s pomočjo tabličnih računalnikov preverili zgodovinsko ozadje. Preučili so čas in prizorišče dogajanja in si na papir zarisali snemalno knjigo. Izdelek, ki je najbolj izstopal od drugih, je bil vključen v video kulturne prireditve. To je bila učencem dodatna motivacija za trud in inovativnost.

2.3 Kako ustvariti snemalno knjigo?

Ko dokončamo filmski scenarij in ugotovimo osnove svoje zgodbe, lahko začnemo risati svojo snemalno knjigo. Vse, kar potrebujemo, je kos papirja, razdeljen na okvirje. Šest sličic na stran je dober začetek, lahko jih je več. V vsak okvir narišemo osnovno sceno (Slika 2). Koristno je napisati opombe pod vsako risbo, za razumevanje prizorov. Uporabimo lahko tudi puščice za prikaz premikov kamere ali barv za razlikovanje predmetov scene od ozadja. Pomembno je, da prikažemo različne kote kamere in dejanja, ki jih želimo zajeti, in zabeležimo, kaj počnejo naši liki in kako jih nameravamo posneti. Čeprav je mogoče kar začeti fotografirati in to ugotoviti pozneje. Veliko lažje je imeti vizualizacijo filma pred animiranjem.

Nasveti za snemalno knjigo:

- Pri načrtovanju kotov kamere se prepričajte, da občinstvo ve, kje so vaši liki. Najbolje je, da pred snemanjem od blizu prikažete pregled prizora.
- Uporabite kot kamere, ki prenaša vašo zgodbo. Uporabite bližnje posnetke, ko želite sporočiti čustva, in široke posnetke, ko želite poudariti okolje.
- Prepričajte se, da ima vsak prizor v vaši snemalni knjigi svoj namen. Ne želite dolgočasiti svojega občinstva.
- Poskusite ne premikati kamere, razen če je to nujno. Tako bo snemanje veliko lažje, saj imate neprekinjeno svetlobo in vam ni treba prilagajati ozadja [7].

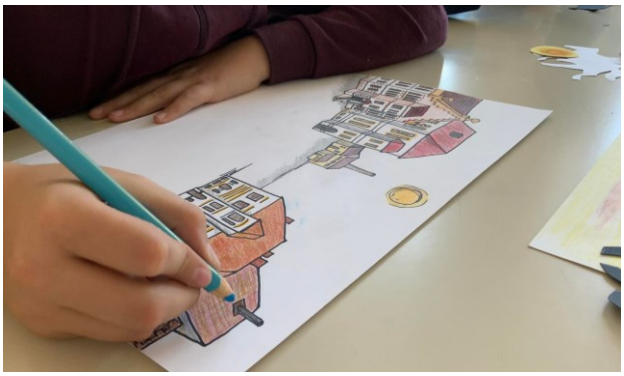


Slika 2: Skica snemalne knjige

2.4 Ilustracija

Ilustracija je likovna zvrst, ki smo se jo pri pouku likovne umetnosti odločili uporabiti pri izdelavi animacije. Učenci so dobili navodilo, da se podrobno spoznajo z zgodbo in ozadjem zgodovinskega dogajanja Rudolfa Maistra. Za inspiracijo jim je bila knjiga Naš Maister (v stripu). Zaradi zgodbe v stripu so si učenci lažje ustvarili začetno snemalno knjigo. Osredotočili so se na bistvene podatke in dogajanja. Pri risanju ilustracije je pomembno, da imajo pomembni liki v zgodbi vedno enako podobo, da se lažje prepoznajo. Pri ilustraciji za animacijo se lahko učenci več poigravajo z mimiko obraza in premikanjem ustnic in oči, ki sinhrono z zvokom dobijo življenje. Za vsak premik ustnic, oči, rok ali predmetov so si učenci narisali dodatne dele. Vsak del so si pazljivo označili in shranili, da so imeli pripravljene vse elemente za snemanje prizorov.

Učenci so za celostno podobo animacije uporabili svinčnik, suhe barvice in alkoholni flomaster (Slika 3). Za lažjo uprizoritev množice ljudi si je učenka s pomočjo enobarvnih papirjev zarisala silhuete ljudi (Slika 4). Razdelila jih je v več skupin, s čimer je potem v izdelavi animacije prikazala premikanje množice. S pomočjo dveh različnih odtenkov silhuet je pridobila globino prostora. Da je lahko njena ilustracija silhuet izstopala, je za ozadje uporabila le prelivanje barv, ki predstavlja čas poznega popoldneva (Slika 5).



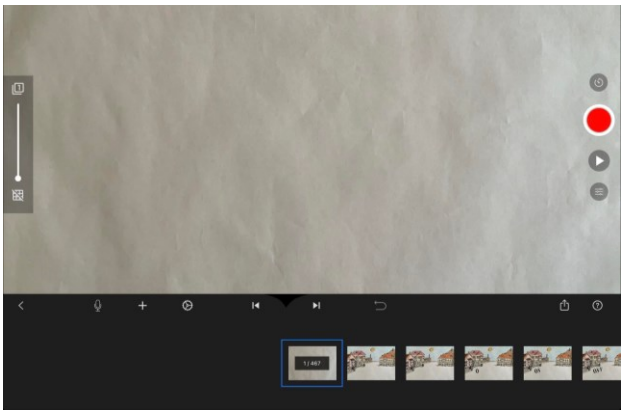
Slika 3: Učenečeva ilustracija

Slika 4: Izrezovanje

Slika 5: Postavitev elementov za primerjavo

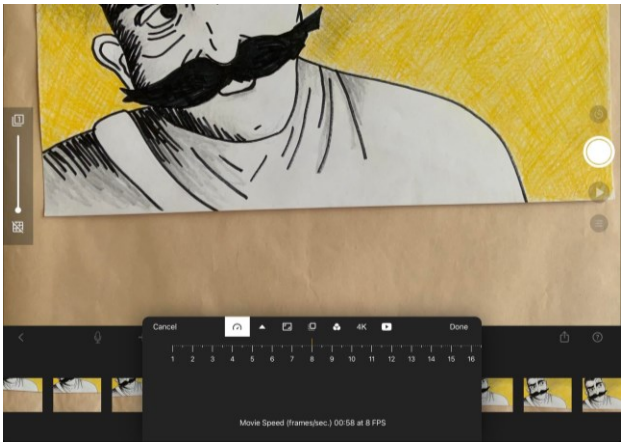
2.5 Fotografiranje in urejanje v aplikaciji

Za animacijo so učenci uporabili narisane ilustracije, narejene po načrtih snemalne knjige. Ko so bile vse ilustracije in ozadja pripravljeni, smo uporabili orodje Stop Motion. Kot že omenjeno, smo si za izpeljavo metode dela za ustvarjanje videa najprej postavili IKT-pripomoček na stabilno postavitev. Sledilo je fotografiranje ilustracij (oz. prizorov) in premikanje teh. Po končanih fotografiranih prizorih smo si ogledali narejeni posnetek (Slika 6). Med predvajanjem se je posnetek ustavil in uredil, kjer je bilo to potrebno (Slika 7). Za vsako posneto fotografijo orodje namreč ponuja možnost urejanja, spreminjanja in dodajanja (Slika 8, 9 in 10).

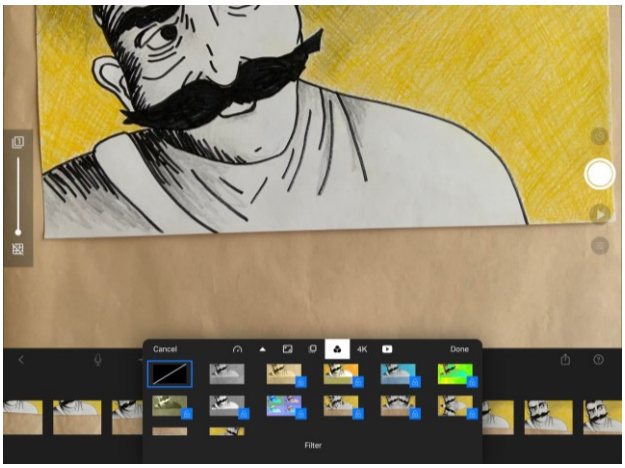


Slika 6: Predvajanje animacije

Slika 7: Urejanje fotografij



Slika 8: Urejanje hitrosti predvajanja fotografij



Slika 9: Urejanje barve fotografij

Slika 10: Dodajanje elementov v animaciji

3 REZULTATI

Interaktivne dejavnosti so bile izbrane premišljeno in so učence postopoma vodile od usvajanja minimalnih do temeljnih standardov znanja.

Končni projekt z vsem digitalnim oblikovanjem fotografij in montiranjem, dodajanjem zvoka znotraj orodja Stop Motion je bil združen v montaži s preostalimi igranimi posnetki, ki so ustvarili celoten video posnetek kulturne prireditve.

Celotna skupina učencev je dosegla zastavljene učne cilje in pokazala zanimanje za nov projekt, po zasnovi njihovih zgodb.

Povezava do končne kulturne prireditve, z vložkom animacije na 12 minuti in 32 sekund ter trajanje do 14 minute in 57 sekund: Misel pesnika in odločnost generala.

4 ZAKLJUČEK

Z digitalnim oblikovanjem in ustvarjanjem animacije se učenci soočajo s spretnostmi, ki jih silijo ven iz svojih okvirjev. Uporaba likovnih tehnik, ki se združijo z digitalnimi tehnikami, uporabljenimi v spletnem orodju, je trajnostna. Današnji umetniški svet vse več in več posega po internetnem prostoru, v katerem se predstavljajo, prodajajo umetniška dela. Umetnost je

v digitalni dobi širok pojem, saj se učenci lahko sedaj sprehodijo po spletnih galerijah, učilnicah ali svetu domišljije.

LITERATURA IN VIRI

[1] Učni načrt. 2011. Program osnovna šola, Likovna vzgoja. Ljubljana, Ministrstvo za šolstvo in šport, Zavod RS za šolstvo.

[2] How to make a stop-motion video on iPhone: Apps, ideas, and tips. Dostopno na naslovu https://backlightblog.com/stop-motion-video-on-iphone (8. 8. 2022).

[3] Ungaro Goncalves, C., 2020. Dear Sunset. Dostopno na naslovu https://www.instagram.com/p/CBI3M5SHxMO/ (8. 8. 2022).

[4] Bips, 2014. Stop Motion Video- paper stop motion. Dostopno na naslovu https://www.youtube.com/watch?v=Xo2ioUYugMA (8. 8. 2022).

[5] Peri, C., 2022. Mac and Cheese. Dostopno na naslovu https://www.instagram.com/p/CdZzxn0rDxV/ (8. 8. 2022).

[6] Dagnino, A., 2021. Floating brownie turns into an Energy Ball. Dostopno na naslovu https://www.instagram.com/p/CMmnKREKWfd/?utm_source=ig_embed&ig_rid=c18bc6d3-3dbc-4615-a841-1d0b6e21b354 (8. 8. 2022).

[7] Članek iz aplikacije Stop Motion Studio. Dostopno v aplikaciji Stop Motion Studio App (8. 8. 2022).

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Vseprisotne zdravstvene storitve in pametni senzorji
Pervasive Health and Smart Sensing

Uredniki / Editors

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PREDGOVOR

Pomen digitalnih zdravstvenih storitev v zadnjih desetletjih nenehno narašča. Staranje prebivalstva je neposredno povezano s povečevanjem števila kroničnih bolnikov, ki jim razvoj medicine sicer omogoča zdravstveno oskrbo in posledično tudi podaljševanje življenjske dobe, hkrati pa je zdravstveni sistem zaradi tega dodatno obremenjen. Razvoj digitalne tehnologije je prinesel vse več dostopnih orodij za stroškovno učinkovito vzdrževanje in izboljševanje zdravja in kakovosti življenja ter obenem pripomogel k razbremenitvi zdravstva. Nedavna pandemija COVID-19 je dodatno poudarila potrebo po zagotavljanju zdravstvenih storitev na daljavo. Tehnološki napredek je sicer nekoliko upočasnjen zaradi zakonodaje, saj digitalne tehnologije ne morejo nositi odgovornosti zaradi napačnih zdravstvenih odločitev, prav tako je zelo pomembno tudi varstvo podatkov in spoštovanje zasebnosti pacientov. Sodelovanje vseh pomembnih družbenih, zdravstvenih in pravnih akterjev tako pomaga postaviti stabilnejše in zanesljivejše temelje za razvoj, uvajanje in uporabo digitalnih zdravstvenih tehnologij in storitev. Vseprisotne zdravstvene storitve in uporaba pametnih senzorjev so tako ključni deli digitalnega zdravja. Pametni senzorji in razne nosljive naprave omogočijo spremljanje na daljavo in in tako dodatno podprejo spremljanje zdravstvenega stanja bolnikov v klinikah in izven njih. Dodatno lahko pametni in vseprisotni sistemi za spremljanje zdravja zmanjšajo določena tveganja in odkrijejo težave v zgodnejših fazah bolezni.

Konferenco »Vseprisotni zdravstveni sistemi in pametni senzorji« organizira EU projekt WideHealth, t.i. »widening« projekt, katerega glavni namen je vzpostavljanje trajnostne mreže raziskav med vključenimi partnerji. Konzorcij projekta sestavlja pet partnerjev (trije »widening« in dva »non-widening«), ki preko izmenjav in drugih raziskovalnih sodelovanj poglabljajo znanje na treh glavnih področjih: »data-driven healthcare«, »human factors in pervasive health« in »federated learning«. Namen konference »Vseprisotne zdravstvene storitve in pametni senzorji« je izmenjava strokovnega znanja in napredka raziskav na omenjenih področjih. Na konferenci bo predstavljenih 12 prispevkov, ki se osredotočajo na različne vidike pametnega zaznavanja in vsesplošnega zdravja. V prvem delu konference so vključeni prispevki, ki se osredotočajo na prepoznavanje človeških aktivnosti z uporabo nosljivih naprav (vključno z novejšimi tehnologijami, npr. pametnimi očali). Prispevki drugega dela konference se osredotočajo na objektivno in subjektivno spremljanje duševnega zdravja. V zadnjem, tretjem, delu so zbrani prispevki, ki predlagajo nove aplikacije, metodologije in IKT rešitve za vseprisotne zdravstvene sisteme ter izboljšanje varnosti in zasebnosti v takih sistemih.

FOREWORD

The importance of digital health is constantly growing in recent decades. The reasons are well known: on the one hand, the aging of the population is producing an increasing number of chronic patients, and the progress of medicine is keeping them alive and in need of care; on the other hand, the progress of digital technology is creating an increasing number of available tools to maintain and/or increase health and quality of life cost-effectively. The recent COVID-19 pandemic has further emphasized the need to provide remote medical services to patients, which has boosted the emergence and adoption of digital technologies, especially in telehealth and telemedicine. Technological advances have been slowed mainly due to legislation since bad medical decisions cannot be blamed on digital technologies, and security and privacy issues also cannot be neglected. However, the involvement of all the important social, medical, and legal actors helps set up a more stable and reliable foundation for developing, deploying, and using digital health technologies and services. Pervasive health and smart sensing are crucial parts of digital health. Smart sensors and wearables can augment the healthcare system, enabling remote monitoring and supporting the patient's medical condition in and out of the clinics. Furthermore, smart and pervasive health monitoring systems can reduce death risks, identifying the issues at earlier stages of the diseases. They are the main focus of our "Pervasive Health and Smart Sensing" conference, as the name suggests.

The conference is organized by the EU WideHealth project, a widening project that aims to conduct research on pervasive eHealth and establish a sustainable network of research and dissemination across Europe. It connects five partners (3 widening and two non-widening) to share and develop their research on three main topics: data-driven healthcare, human factors in pervasive health, and federated machine learning. The Pervasive Health and Smart Sensing conference aims to share expertise and research advancements in these areas. The 12 papers we have accepted at the conference focus on different aspects of smart sensing and pervasive health. Several works utilize wearable devices (including new types, i.e., smart glasses) and machine learning for human activity recognition. Several others focus on objective and subjective monitoring of mental health. Finally, there are papers proposing new applications, methodologies, and ICT solutions for pervasive health and improving the security and privacy in such systems.

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Optimized Method for Walking Detection by Wristband with Accelerometer Sensor

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ABSTRACT

This paper presents the part of the gait impairment measurement algorithm, which consists exclusively of the walking detection algorithm. The purpose of the optimized algorithm is to improve the detection of walking. Today's embedded devices (like wristbands) have low-level interrupts that detect steps and, consequently, walking. The problem is that these could be inaccurate in some cases. For example, a person can swing with a hand while sitting, and the device will detect steps. The importance of walking detection is crucial for gait impairment measurements, as gait data should only be collected when a person is walking in a "normal" manner and not performing any other walking-like activities. An algorithm to measure gait impairment will be developed in the later stages of this study. We focused on improving the walking detection algorithm with statistical methods in both time and frequency domains in contrast to computationally expensive algorithms that use machine learning. The walk detection algorithm has been optimized based on data collected by a wristband with a 3-axis accelerometer sensor. With our optimized algorithm, we got an average accuracy of 89.4%. We can conclude that our proposed method works well for detecting when a person is walking normally. The algorithm successfully detects "not natural walking" scenarios when the person is sitting and swinging their hand or walking with extreme hand movements.

KEYWORDS

wristband, walking detection, FFT, periodogram, activity recognition, hamming window

1 INTRODUCTION

Every year number of older adults fall and injure themselves. For example, in Western Europe, in 2017 alone, 13840 per 100,000 older adults over the age of 70 are known to have fallen and injured themselves to the extent of medical assistance [1]. To prevent such phenomena, measurement and monitoring of gait deterioration in the elderly must be developed. One part of the such algorithm must consist of a walking detection algorithm that detects whether a person is walking or not in a non-invasive way.

Wristbands with various sensors (e.g., accelerometer, gyroscope) have proven to be an excellent technology for automatic and non-invasive detection of daily activities. In this case, we can use the acceleration vector data from the accelerometer sensor to detect whether the person is walking or not. However, many studies have focused on using machine learning algorithms, which provide high accuracy but are computationally expensive to implement in embedded systems (wristbands).

We present to you a computationally inexpensive algorithm for detecting whether a person is walking or not. Furthermore, the algorithm can detect walking and other daily activities similar to the walking pattern and can be used on a low-power wristband system. In our case, the most crucial aspect of our gait detection algorithm should be to detect as minimal cases as possible where the algorithm predicts that the person is walking naturally. Still, in the actual case, the person is performing other activities.

An algorithm to measure gait deterioration (our next step) will help the elderly prevent falls. The algorithm will monitor a person's gait daily, and when a person's gait deteriorates dramatically, it will notify caregivers of increased chances of falling. Accordingly, caregivers can take the person to rehabilitative walking therapy or give them more care.

2 RELATED WORK

Advances in the accuracy and accessibility of wearable sensing technology (e.g., fitness bands and smartwatches) has allowed researchers and practitioners to utilize different types of wearable sensors to detect walking.

In [2] the authors explored the possibility of detecting activity from a smartphone-based accelerometer sensor. They used smartphones placed in different positions(backpack, pocket, in hand) to collect data when doing an activity (walking, fast walking, slow walking, running). To reduce complexity, they computed the magnitude of the 3-axis accelerometer. The magnitude vector is then processed using time and frequency domain statistical techniques. Finally, the statistical methods on the time-domain measures are applied for state recognition, while the statistical techniques on the frequency-domain features are implemented for walking movement distinction.

In [3], they use a smartphone with a gyroscope to collect data. They propose a new algorithm based on Fast Fourier Transform (FFT) [4] to identify the walking activity of a user who can perform different activities and hold the smartphone differently. The proposed algorithm (FFT) was able to achieve superior overall performance compared to the other two best-performing algorithms (Short Time Fourier Transform (STFT) and Standard Deviation Threshold (STD TH)).

The authors in [5] propose an algorithm that classifies human activity in real time based on data from an accelerometer attached to the subject. The algorithm uses dynamic linear discriminant analysis (LDA), which can dynamically update classifier matrices without storing all training samples in memory. LDA is used to find a transformation of extracted features that separate data distribution into different classes while minimizing the distribution of data of the same class in the newly transformed space.

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Compared to the state-of-the-art algorithm, our paper aims to combine the FFT and threshold algorithm from [2] and axis selection algorithm from [3] while adding an upper bound threshold to detect exaggerated hand movements and excluding them from false positives.

3 METHODOLOGY

The main goal of the research was to improve, or rather optimize, the gait detection algorithm based on statistical methods and frequency coefficients obtained from the measurements of the Empatica E4 bracelet accelerometer. To achieve this, we had to record data with the wristband while performing various activities and test the performance of our algorithm on the collected data. The data was collected using the Empatica E4 wristband [6]. The sampling frequency for the 3-axis accelerometer is 32 Hz. It has an 8-bit resolution and a default range of ± 2 g with sensitive motion detection along three axes: x, y and z.

3.1 Data collection

An Empatica E4 bracelet was used for data collection and placed on the subject's left wrist. The wristband was connected to a smartphone via Bluetooth and streamed real-time data that was uploaded to the Empatica server. We have designed various routes and defined actions on these routes, which the subjects should carry out. Data was then collected from different individuals who wore the bracelet and followed the planned route. Various walking styles were performed on the designed paths, such as normal walking, slow walking, fast walking, and walking with random hand movements. Some actions involved sitting in a chair and performing arm swings that are similar in motion to arm swings if the subject were walking.

In [2], data was gathered from 7 individuals doing different walking styles (slow walking, fast walking, normal walking). They collected 27 samples. In our case, the data was collected from 4 individuals shown in Table 1. We also collected a total of 27 samples.

Table 1: Table of participants

Participant	Gender	Age	Disability
A	Male	22	None
B	Male	24	None
C	Male	83	Difficulty walking
D	Female	79	None

Figure 1 shows all three axes of raw accelerometer data collected from the Empatica wristband. During an interval between 20 seconds and 70 seconds, the subject wearing the Empatica walked in a straight line.

3.2 Algorithm

Our optimized algorithm combines aspects from two papers [2][3]. From the first paper, we used the modified periodogram thresholding algorithm to detect walking only when the minimum required hand activity is reached in frequency ranges that correspond to human walking activity. From the other paper, we implemented this on the 3-axial accelerometer. For each time window, we select and process only the data on an axis with the most variance. Our contribution to the algorithm for walking detection is a combination of the two, with added upper bound

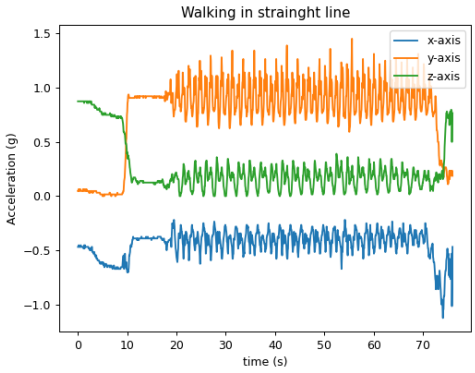

Figure 1: Example of raw signal from accelerometer sensor

threshold to prevent false walk detection when a subject is swinging a hand uncontrollably, shown in the main algorithm 2 on line (18). This is more thoroughly described below.

First, we use the time windowing algorithm (Algorithm 1) to process the data in a shorter time frame. Then, we need to divide the data into time windows (W). We found empirically that it is best if the data window length (w_t) is 5 seconds with a 2.5-second overlap (o_t).

The time windows are then filtered (x, y, and z axes are filtered separately) with a high-pass Butterworth filter to capture the signal proportionally (symmetrically) with respect to the time axis. The general shape of the frequency response of a Butterworth filter is defined as equation (1). Where f_c is the cutoff frequency, ϵ is the passband gain, and n is the order of the filter. We chose the order of n to be 5. We chose it heuristically. For our example, the cutoff frequency was set to 1 Hz.

$$H(f) = \frac{1}{\sqrt{1 + \epsilon^2 \left(\frac{f}{f_c}\right)^{2n}}} \tag{1}$$

In the next step, we detect which of the three axes is the most sensitive for each time window. This step is accomplished by calculating each filtered axis's standard deviation (STD) separately and selecting the one axis with the highest STD value.

Afterward, we compute modified periodogram coefficients from the most sensitive axis for each window. To calculate the modified periodogram in the algorithm 2 we multiplied signal windows with Hamming window, which is defined as (2). The Hamming window is an extension of the Hamming window and is a semi-cosine bell-shaped curve.

$$w(n) = 0.54 - 0.46cos\left(\frac{2\pi n}{N-1}\right), 0 \leq n \leq M-1 \tag{2}$$

Where N represents total length of the window.

For each time window, two main conditions had to be met for it to be classified as "walking."

Modified periodogram coefficients are computed using equation (3). Time windows that met the first condition (4), need to have computed modified periodogram coefficients that are on the interval 0.6 to 2 Hz ($S_{xx}(f_i)$ where f_i represents all the frequencies inside the interval) and had higher mean than the mean of coefficients in the interval outside 0.6 to 2 Hz ($S_{xx}(f_o)$ where f_o represents all the frequencies outside the interval).

$$S_{xx}(f) = |F(f)|^2 \tag{3}$$

Where F(f) is output from FFT at desired frequency f.

$$\overline{S_{xx}(f_i)} > \overline{S_{xx}(f_o)} \tag{4}$$

The second condition (5) that had to be met for the time window is that the STD of the vector norm of the unfiltered signal must be between 0.3 g and 0.7 g. The lower limit (0.3 g) ensures that walking is not falsely detected when the subject is not moving. The higher limit (0.7 g) prevents walking detection when subjects move their arms uncontrollably. Both limits were determined empirically based on our collected data set. The norm is calculated using equation (6) where x, y, and z are the time-windowed accelerometer signal vectors, each representing an axis. "i" means the same index on all three axes, ranging from 1 to the length of the time window (this is calculated from the raw signal using the (7) where N is a number of samples in a time window). Time windows that satisfy both conditions are classified as "walking"; all other window cases are classified as "not walking."

$$0.3 < \sigma_{norm} > 0.7 \tag{5}$$

$$norm_i = \sqrt{x_i^2 + y_i^2 + z_i^2} \tag{6}$$

$$\sigma_{norm} = \sqrt{\frac{\sum_{i=1}^{N}(norm_i - \overline{norm})^2}{N}} \tag{7}$$

Algorithm 1 for windowing

Require: $(acc_x, acc_y, acc_z), w_t, o_t$ ▷ o_t is the overlap w_t = length of the window
Ensure: (W_x, W_y, W_z)
  $W \leftarrow []$
  $s_t \leftarrow 0$ ▷ s_t = start index of windowl
  $e_t \leftarrow s_t + w_t$ ▷ e_t = end index of window
  for all (acc_x, acc_y, acc_z) **do**
    while $s_t \leq N$ **do** ▷ N is the number of samples in a window, i represents index of current sample in a loop
      $acc_i' \leftarrow acc_i[s_t : e_t]$
      $W \leftarrow W + [acc_i']$
      $s_t \leftarrow s_t + o_t$
      $e_t \leftarrow e_t + o_t$
    end while
  end for

Algorithm 2 for detection of walking

  function STATIONARY(d)
    $n_2 \leftarrow norm(d)$
    $m \leftarrow n_2[:] - mean(n_2)$
    $sd \leftarrow std(m)$
  end function
Require: W
Ensure: $boolean[]$
  for all (W_i) **do** ▷ i represents index of current window in a loop
    if $length(Stationary(W_i)) \geq 0$ **then**
      $W_x \leftarrow ButterworthFilter(W_i(x))$
      $W_y \leftarrow ButterworthFilter(W_i(y))$
      $W_z \leftarrow ButterworthFilter(W_i(z))$
      $n_{meanx2} \leftarrow avg(norm(W_x))$
      $n_{meany2} \leftarrow avg(2norm(W_y))$
      $n_{meanz2} \leftarrow avg(2norm(W_z))$
      $am \leftarrow argmax\{n_{meanx2}, n_{meany2}, n_{meanz2}\}$
      $pg \leftarrow periodogram(am, hamming)$ ▷ hamming is the windowing function
      if $(max(am) - min(am) > 0.3)$ **and** $pg(f > 0.6$ **and** $f < 2)$ **then**
        $boolean \leftarrow boolean + [1]$
      else
        $boolean \leftarrow boolean + [0]$
      end if
    end if
  end for

4 RESULTS

We ran the algorithm on different recordings taken with the Empatica wristband. Slow and fast straight walking, stair climbing, and sitting involving arm swing.

Figure 2 shows a dot plot where zero (on the y-axis) represents "no walking," and one represents "walking." The x-axis represents time (in seconds). Dots on the x-axis are linearly spaced by 2.5 seconds. During the first 8 seconds, the subject was standing, so for this part of the signal, the algorithm correctly classified it as "not walking." After 8 seconds, the subject started to walk in a straight line, and the algorithm correctly detected this activity as "walking." For our example, we can confirm that the algorithm works correctly under normal walking conditions.

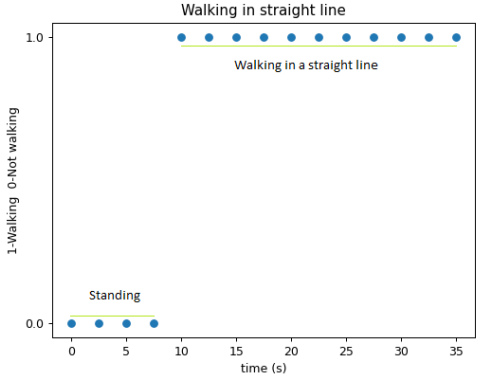

Figure 2: Proposed algorithm used on straight walking activity, recorded Empatica E4 wristband

Table 2: Table of activities and their accuracy

	Activity	Detected as "Walking"	Detected as "Not walking"	Accuracy
Walking	Walking and swinging hand	47.5s	7.5s	86.4%
	Slow walking	52.5s	2.5s	95.5%
	Stair climbing	17.5s	37.5s	68%
Not Walking	Fast walking	5s	52s	91.2%
	Standing	7.5s	47.5s	86.4%
	Sitting	0s	55s	100%
	Sitting and swinging hand	2.5s	52.5s	95.5%
	Walking and uncontrollably moving hand	0s	55s	100%

Figure 3 shows an example of a recording where several human activities are present, such as standing, sitting on a chair and performing random hand movements, walking and performing hand movements, and walking and performing exaggerated hand movements. It can be seen that the algorithm had difficulty in gait classification when high-amplitude arm movements were present during the subject's gait. This is because gait characteristics are lost in the noise of high-amplitude hand movements. For our purposes, the issue is not critical because the future end goal is to measure the subjects' gait impairment, so there is no problem in discarding the parts of the signal where the person does not walk in a "natural" way. However, we can also observe that there was deviation when the subject sat down and started swinging his arm (One instance at the 42nd second where the algorithm should predict "not walking" but instead, it predicted "walking"). On Figure 4 at about 78th second, we can observe that the algorithm detected sitting as if it were walking.

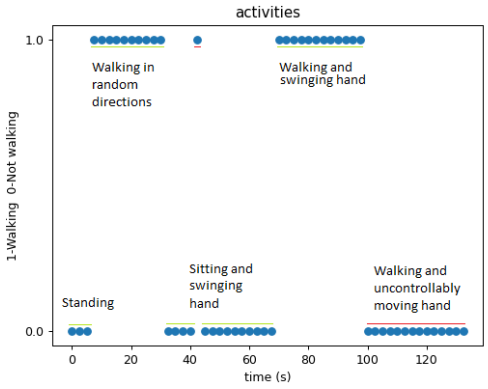

Figure 3: Proposed algorithm used on multiple activities, recorded on Empatica E4 wristband

We require that we have the least amount of false positives in our data set because we want to detect only the scenarios where a person is walking the most naturally. This is a typical binary classification problem, where the final results are shown in Table 2. The first three activities (walking and swinging hand, slow walking...) are considered natural walking and should be detected as walking. The next 6 (Fast walking, standing, sitting, sitting and swinging hand, walking and uncontrollably moving hand) activities should be considered as "not walking" because they are less optimal for feature collection for the algorithm that will be implemented in the next stages of this study. The study we are conducting is primarily meant for the elderly, so we categorized the "fast walking" scenario as not walking, as it is not common for the elderly to walk fast. In the stairs climbing case, the algorithm did not perform very well, but that is not relevant in our case. More importantly, in the last 6 cases algorithm performs well in detecting true negatives.

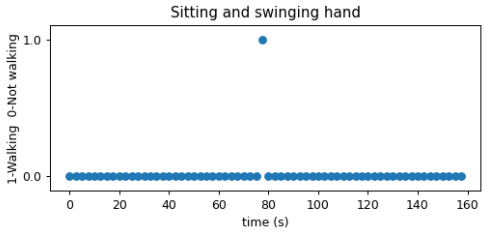

Figure 4: Proposed algorithm used when sitting and swinging hand, recorded on Empatica E4 wristband

5 CONCLUSION

In the related work, we described the state-of-the-art algorithms used in today's many applications. For this research, we selected two algorithms from many of them and expanded (optimized) the work for our purposes. The results of our algorithm were able to detect when a person was walking normally, slowly, and quickly. In addition, the algorithm correctly detected cases when a person does not walk while sitting but swings his arm.

To measure gait impairment, we only want to use time windows of the signal where we are certain that the person is walking and that there are no additional "unnecessary" hand movements. In the future, we will further improve the algorithm so that the deterioration of walking, our final goal, can be measured correctly.

REFERENCES

[1] Juanita A Haagsma et al. 2020. Falls in older aged adults in 22 european countries: incidence, mortality and burden of disease from 1990 to 2017. *Injury Prevention*, 26, (Feb. 2020), i67–i74. DOI: 10.1136/injuryprev-2019-043347.

[2] Chalne T ornqvist. 2017. *Walking movement detection using stationary stochastic methods on accelerometer data.* MA thesis. Lund University.

[3] Guodong Qi and Baoqi Huang. 2018. Walking detection using the gyroscope of an unconstrained smartphone. In (Jan. 2018), 539–548. ISBN: 978-3-319-66627-3. DOI: 10.1007/978-3-319-66628-0_51.

[4] E. O. Brigham and R. E. Morrow. 1967. The fast fourier transform. *IEEE Spectrum*, 4, 12, 63–70. DOI: 10.1109/MSPEC.1967.5217220.

[5] Yen-Ping Chen, Jhun-Ying Yang, Shun-Nan Liou, Gwo-Yun Lee, and Jeen-Shing Wang. 2008. Online classifier construction algorithm for human activity detection using a tri-axial accelerometer. *Applied Mathematics and Computation*, 205, 2, 849–860. Special Issue on Advanced Intelligent Computing Theory and Methodology in Applied Mathematics and Computation. DOI: https://doi.org/10.1016/j.amc.2008.05.099.

[6] [n. d.] Medical devices, ai and algorithms for remote patient monitoring. empatica. https://www.empatica.com/.

Android Integration of a Machine Learning Pipeline for Human Activity Recognition

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ABSTRACT

In the last decade, smartphones have seen a serious growth in the processing power. Coupled with greater affordability this has led to a worldwide smartphone ubiquity. Alongside the advances in processing and battery technology, there are great advances in sensor technology as well, and every smartphone today comes equipped with multiple sensors: accelerometer, gyroscope, magnetometer etc. The sensory data is already being used in a variety of applications, among which several focus on the human activity recognition. In this paper, we propose a smartphone Android integration of a machine learning pipeline for recognizing human activities. The proposed approach uses the 3-axis accelerometer in the smartphone, processes the data in real time, and then a machine learning model recognizes the user's activities in real time: walking, running, jumping, cycling and standing still. The proposed Recurrent Neural Network model and its machine learning pipeline are developed on a publicly open activity dataset, which are then implemented into the Android application and once again validated on a dataset recorded with a smartphone itself.

KEYWORDS

Human activity recognition, machine learning, Android integration, Tensorflow Light, recurrent neural network, accelerometer, magnitude.

1 INTRODUCTION

Human Activity Recognition (HAR) is the process of examining data from one or multiple sensors and determining which (if any) activity is being performed. The sensors are traditionally placed on key points on the human body and contain composite data (accelerometer, gyroscope, magnetometer data, etc.). Advances in sensor technology have made sensors more compact and precise over the years, but most importantly more affordable. Today these sensors can be found in the standard package of any smartphone.

The purpose of this paper is to leverage these smartphone sensors to perform HAR in real time, by utilizing an Android application which continuously reads its own sensor data, instead of using the traditional dedicated wearable sensors. The premise is that the smartphone sensors have reached the required quality to be comparable to the wearable sensors in accuracy [1]. The benefit of this approach is that it is much more convenient to use smartphone sensors for the common user, as smartphones have become ubiquitous.

Human activity recognition is a popular topic, which has been worked on extensively in the recent years [2]. Practical applications for HAR are mainly in improvement of the quality of life and medicine. A great example of HAR models being used in medicine can be found in paper [3], which focuses on fall detection mainly for the elderly population.

Using dedicated wearable sensors to recognize activities is the most common approach. Smartwatch is usually equipped with the same sensors as the smartphones and has a much more fixed position on the body (tightly around the wrist). The drawback is that the arms are more prone to random movement which introduces noise into the system and makes HAR more difficult. A detailed analysis on these issues can be found in paper [4].

Using data from smartphone sensors to train models for HAR has also been explored recently in [5], where a deep neural network is trained on the data from multiple sensors on the smartphone. In our study we go a step further and analyze and compare a simplified subset of the sensor data (only accelerometer magnitude) - which allows us to have a model that will work regardless of the smartphone orientation and to have a simple yet effective method of integrating a model into an Android application.

We propose an Android integration of a Machine Learning (ML) pipeline for recognizing human activities in real time on a smartphone. In particular, the proposed approach uses the 3-axis accelerometer in the smartphone, processes its data in real time, and then the ML model recognizes the user's activities: walking, running, jumping, cycling and standing still. The proposed Recurrent Neural Network (RNN) model and its machine learning pipeline are developed on a publicly open activity dataset, then implemented into an Android application, which finally, is once again evaluated on a dataset recorded with a smartphone itself. Additionally, as part of this study we release an Android application [6], which can be used by other researchers to easily gather data with a smartphone and as a practical demonstration of how to integrate an ML model with an Android application and use the built-in accelerometer data.

2 DATASET

The models were trained on a publicly available dataset which was originally used to evaluate the impact of sensor placement in activity recognition [7]. The dataset consists of

wearable sensor readings from 17 healthy subjects which perform any of 33 different activities. There are a total of 9 wearables placed on the body: two on each arm and leg, and one on the back. Each wearable sensor reads 13 values with a frequency of 50Hz: three for acceleration, three for rotation, three for magnet flux vector and four for orientation in quaternion format. This brings the total amount of readings to 117 per frame (9 wearable sensors with 13 values each). Out of all these measurements only six are used: the **3 accelerometer values** from each of the two upper leg sensors (left and right). These sensors are chosen as they are approximately at the location where a smartphone would be (in a side pocket). Additionally, the magnitude of each sensor is added as an additional feature, calculated as:

$$magnitude = \sqrt{acc_x{}^2 + acc_y{}^2 + acc_z{}^2} \quad (1)$$

Due to the position of the sensors, recognizing motion mainly expressed with the upper torso and arms is impossible, so the dataset is truncated to only activities that are dependent on the legs: walking, running, jumping, cycling and standing still.

3 METHODOLOGY

In order to adapt the dataset to fit the needs of this application, certain preprocessing and feature extraction is performed, described in detail in the following subsections.

3.1 Preprocessing and segmentation

The dataset contains a disproportionate number of readings for standing still in comparison to all other activities. To correct this a random under-sampling is performed (only 5% of the standing still data is used). Additionally, similar activities are grouped together, namely jogging and running are grouped together as running, and jumping upwards, jumping front and back, jumping side to side, and jump rope are grouped as jumping. The resulting distribution of data is illustrated on Figure 1, with running having the most amount of data (1760s), and cycling having the least (860s).

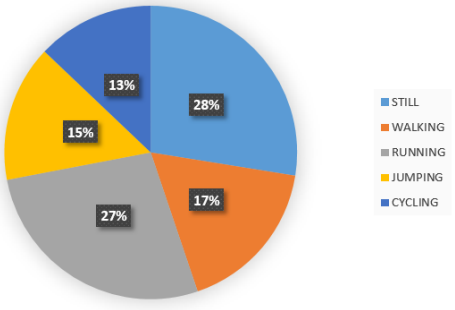

Figure 1 Activity distribution after selection

Once selection has been performed, the data is grouped into **3-second windows**. Since the data is collected at a frequency of 50Hz, each window contains 150 records.

3.2 Feature extraction

After the data has been split into 3-second windows, five statistical features are calculated per window. The first two are the **mean** and the **standard deviation** of the 150 values in the window. The three additional statistical features are:

- **Mean first-order difference**: average difference between consecutive values in the window. Computed by first creating a list of first-order differences between consecutive values in the window and then calculating the mean of this list.
- **Mean second-order difference**: average difference between consecutive elements in the list of first-order differences.
- **Min-max difference**: difference between the minimum and maximum value in the window.

The feature extraction is performed on every sensor (x, y, z axis and magnitude on both accelerometers, left and right), which gives a total of 40 features. The features are then separated into three datasets: *left accelerometer, right accelerometer* with 20 features each, and *combined accelerometers* which contains the data from both the left accelerometer and right accelerometer datasets, by matching the respective features (e.g., x-axis on the left accelerometer and x-axis on the right accelerometer are treated as the same feature: x-axis), thus the combined accelerometers dataset also contains 20 features, but it is twice as long.

To compare the effectiveness of a simplified version of the model that is orientation independent, a second version of the dataset is created. This dataset uses only the features extracted from the **magnitudes** of both accelerometers (5 features each). It is further split into three parts: *magnitude-only left*, *magnitude-only right* and *magnitude-only combined*, each containing five features.

3.3 ML Models

Multiple ML models were evaluated, such as K-NN, Linear SVM, Random Forest, Naïve Bayes and Neural Networks (DNN and RNN).

Ultimately the **RNN model** had the best performance. A simple RNN was chosen as the ML model for this application. The model is created using Keras and contains two RNN layers with 512 nodes each and tanh activation function. The final decision layer is a Dense layer with 5 nodes and a softmax activation function. It is trained for 100 epochs with a sparse categorical cross entropy activation function.

4 EXPERIMENTS

With the dataset prepared, the following experiments were conducted:

- Accuracy comparison between magnitude-only and full-featured versions of the dataset.
- Evaluation of models trained on data from the left accelerometer and evaluated on data from the right, and vice-versa.

4.1 Evaluation and metrics

The models were evaluated using **K-fold Cross-Validation**, where K is equal to the number of subjects, and in each iteration a different subject's data is used as the validation set. Splitting the data this way ensures that the test

data and train data do not both contain windows from the same subject (as consecutive windows from the same subject are very similar). Instead, when using the data from a separate subject as a validation set, a good estimate can be made of how the model will behave when a never seen before person's data needs to be evaluated.

In every iteration of the K-fold Cross-Validation a confusion matrix is generated from the predicted values. From there the precision and recall are calculated for every activity as well as the overall accuracy. These metrics are compiled for every iteration and the average values across all iterations form the overall evaluation of the model.

4.2 Results

Initially nine models were considered and evaluated on both the full-featured dataset and the magnitude-only dataset (for combined accelerometers). The results are illustrated on Figure 2, sorted by accuracy.

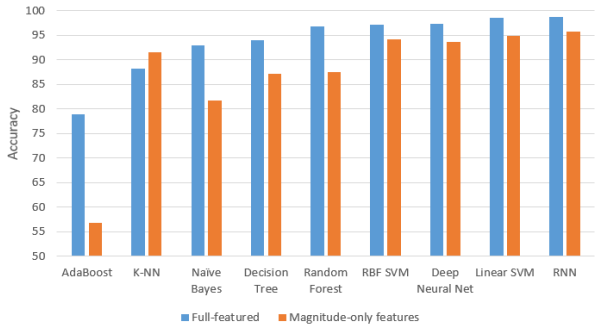

Figure 2 Accuracy comparison of all inspected ML models

The accuracy of the models with full features was expectedly higher than the magnitude-only version, with the drop in accuracy being on average 7% (K-NN being the exception with an increase in accuracy of 2%). The RNN had the highest accuracy in both cases, with 98.8% on the full-featured dataset and 95.8% on the magnitude-only dataset. Therefore, the following results focus on the RNN model.

The comparison in accuracy between the full-featured and magnitude-only versions was made on all three datasets (left, right and combined). The results for the RNN are displayed on Figure 3.

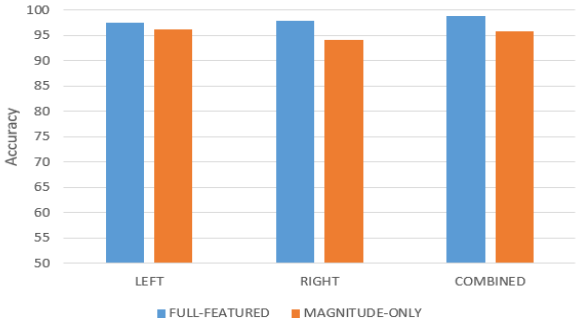

Figure 3 Comparing full-featured and magnitude-only datasets

The average drop in accuracy for the RNN was 3% which is well within acceptable boundaries. As a side note, the right side in general seems to show slightly weaker results, however at most this is 1.5% (when comparing the left simplified and right simplified sets) which could be due to random noise.

In order to evaluate if the model takes in a bias from the side on which it is trained or if the sides carry an intrinsic difference, the model was trained on one side and evaluated on the other. This was done twice, trained on left and evaluated on right, and trained on right and evaluated on left. The results are displayed on Figure 4, along with a control set which was trained and evaluated on the same side.

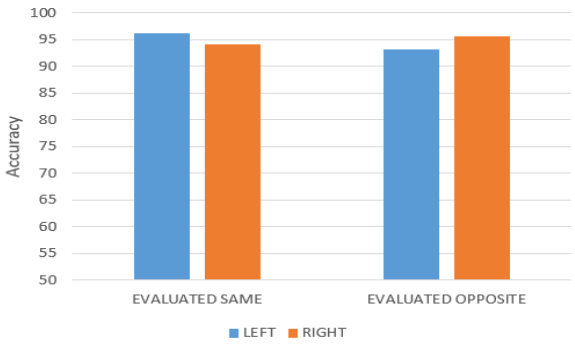

Figure 4 Comparison between same and opposite side evaluation

The accuracy differences are within 2% which is negligible, and in the case of the right accelerometer dataset, evaluating on the left actually increased the overall accuracy. This is due to the slight difference in quality between the left and right sides, and not due to switching sides when evaluating.

These results suggest that there is no significant side bias in the models and thus the activity recognition will work regardless of on which side the smartphone is located. This in addition to the simplified model's independence from orientation make it the ideal choice for integrating with a smartphone.

5 ANDROID INTEGRATION

In order to integrate with an Android smartphone device, the magnitude-only model with combined accelerometers was converted into a tflite format using the Tensorflow Lite library, which is the most commonly used library for artificial intelligence in Android. The converted models are then added in the file structure of an Android application which reads them into memory when it starts up and uses them in real time to recognize activities.

All Android devices come equipped with accelerometers (along with many other sensors) and they can be accessed with the built-in class SensorManager, which is part of the default library: android.hardware. The data read by the SensorManager is on a by-axis basis and in the standard unit of m/s^2. The orientation of the x, y and z axis is illustrated in Figure 5.

The frequency with which the sensor records data is adjustable, with the tradeoff being higher quality data vs lower battery consumption. In our implementation, the sensor delay is set to 20ms between reads (50Hz frequency).

Since there is no way to predict which way the smartphone will be oriented in the pocket, the magnitude of

the accelerometer is the only thing that is used in the feature calculation. The magnitude readings are kept in memory until 150 samples are accumulated (exactly 3s), which is the size of the window used in the training of the models. Then the same statistical features are calculated on the collected window: mean, std. deviation, mean first-order and second-order differences, min-max difference. These values are then placed in a tensor and it is sent as the input into the model, which is also kept in memory (in the form of an object). The output of the model is also a tensor (the output layer which has a softmax activation function), which is then converted into a single result (the node with the highest value) and is displayed on screen.

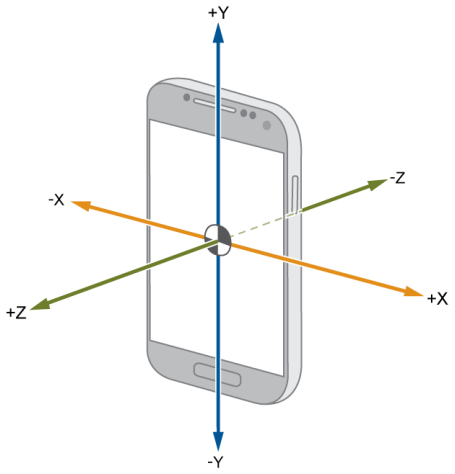

Figure 5 Accelerometer axis orientation in smartphones

Since 150 samples need to be accumulated before the features are calculated and the model is called to make the prediction, there is the side effect that the displayed value on screen is 3s behind (in other words the current activity the user is doing will be displayed in 3s). All the data read by the accelerometer along with the prediction and a timestamp and is kept in memory (a single entry will contain all the calculated features from the 3-second window, the model prediction and a timestamp). The user can choose to export this data to csv and use it as a dataset.

The model was evaluated on a practically collected dataset with a Samsung Galaxy s20 smartphone (5 minutes of each activity). The predicted value was compared to the actual activity by cross-referencing the timestamps (the activities were performed at specific times), and a confusion matrix was created, from which the precision, recall and f1 score, as well as overall accuracy, was calculated. The results are displayed on Figure 6.

	Precision	Recall	F1
still	0.929	0.939	0.931
walking	0.902	0.901	0.893
running	0.891	0.910	0.884
jumping	0.944	0.870	0.885
cycling	0.778	0.622	0.629

Figure 6 Precision, recall and f1 score results on the practically collected dataset on a Galaxy s20 smartphone

The overall accuracy of the model was **90.2%,** which is a noticeable drop from the 95.8% evaluated from the original training dataset. This is expected, as there is a certain amount of noise introduced to the system from the fact that the smartphone is not fixed in place as rigidly as the wearables.

6 CONCLUSION

This paper presented a practical way of training and implementing a HAR model in an Android application, along with solving the practical issues of reading smartphone accelerometer data such as unpredictable orientation and whether it is kept on the left or right side.

To determine whether there is an intrinsic difference between the left and right side or whether the models develop a side bias, an experiment was conducted where models were evaluated on the opposite side of where they were trained, and it was determined that no such bias existed.

To gain independence from orientation, a simplified dataset was created which used only the magnitude readings. Training on this dataset resulted in an expected drop in accuracy, but within an acceptable margin.

An RNN was trained on the magnitude-only dataset and integrated into an Android application which reads the accelerometer data and calculates the features in real time. The calculated features are used as an input for the model, which then outputs the predicted activity, and is subsequently shown on screen.

The sensors in the used smartphone did prove to be of a comparable quality to the wearable sensors as the model successfully recognized activities recorded with smartphone sensors with a solid accuracy of 90.2%, even though it was trained on a dataset from wearable sensors.

ACKNOWLEDGEMENT

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REFERENCES

[1] Patima Silsupadol, Kunlanan Teja, Vipul Lugade, “Reliability and validity of a smartphone-based assessment of gait parameters across walking speed and smartphone locations: Body, bag, belt, hand, and pocket”, Gait & Posture, Volume 58, 2017,

[2] O. D. Lara and M. A. Labrador, "A Survey on Human Activity Recognition using Wearable Sensors," in IEEE Communications Surveys & Tutorials, vol. 15, no. 3, pp. 1192-1209, Third Quarter 2013

[3] Kozina, S., Gjoreski, H., Gams, M., & Luštrek, M. (2013, September). Efficient activity recognition and fall detection using accelerometers. In International competition on evaluating AAL systems through competitive benchmarking (pp. 13-23). Springer, Berlin, Heidelberg.

[4] Gjoreski, M.; Gjoreski, H.; Luštrek, M.; Gams, M. How Accurately Can Your Wrist Device Recognize Daily Activities and Detect Falls? Sensors 2016, 16, 800. https://doi.org/10.3390/s16060800

[5] Charissa Ann Ronao, Sung-Bae Cho, Human activity recognition with smartphone sensors using deep learning neural networks, Expert Systems with Applications, Volume 59, 2016, ISSN 0957-4174

[6] https://github.com/ViktorSrbinoski/SmartphoneActivityRecognition

[7] Oresti Banos, Miguel Damas, Hctor Pomares, Ignacio Rojas, Mt Attila Toth, and Oliver Amft. A benchmark dataset to evaluate sensor displacement in activity recognition. In Proceedings of the 2012 ACM Conference on Ubiquitous Computing, UbiComp ’12, pages 1026–1035, New York, NY, USA, 2012. ACM.

Speaking Recognition with Facial EMG Sensors

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ABSTRACT

With the advent of interactive virtual reality (VR) applications, the interest in tools that allow users to engage with VR environments unobtrusively and intuitively is growing. One such interfacing tool for VR applications is speech recognition, which can contribute to enhanced human-computer interaction. In this study, we explore the usage of a novel VR facial mask equipped with seven surface electromyography (sEMG) sensors to recognize if the user is speaking or not using machine learning. We collected speaking and non-speaking data from 30 participants. The machine learning pipeline that was developed included data preprocessing, de-noising, filtering, segmentation, feature engineering, and training of a binary classification model. The experimental results indicate that the mask can be used to recognize the speaking activity. On the test data of five unseen participants, the best-performing model achieved an accuracy of 89% and an F1-macro score of 91. Additionally, by removing each sensor from the dataset, we analyzed the individual influence each sensor has on the models' outcomes. We did not observe a significant drop in the accuracy of the models, indicating that using the mask speaking can be detected even if some of the sensors are not used.

KEYWORDS

speaking recognition, machine learning, classification, wearable sensors, surface EMG, facial muscles.

1 INTRODUCTION

Virtual reality (VR) is an emerging technology that has introduced immersive user experience in virtual environments and is expected to revolutionize the way we interact with the digital world. VR applications have already been widely used in many different disciplines, ranging from research and training facilities to entertainment and healthcare. With the emergence of interactive VR applications, there is an increasing interest in new immersive tools that enable users to interact with VR surroundings in an unobtrusive and intuitive manner. One such interfacing tool for VR applications is speech recognition. Its incorporation with VR provides users with increased flexibility for interfacing with VR environments and can contribute to improved human-computer interaction.

In recent years, surface electromyography (sEMG)-based interfaces have been utilized for unobtrusive interaction in a VR environment. sEMG is used to measure muscle contractions using sensors applied directly on the skin by detecting changes in surface voltages on the skin when muscle activation occurs. In part due to its ability to be applied non-invasively, facial sEMG has been used to detect the activation of facial muscles that are activated during speaking. However, most sEMG sensors used in conventional speaking recognition systems have been attached around the user's lips and neck. This poses a number of practical issues, including the need for extra wearable devices in addition to the VR headset, limited facial muscle movement, and user discomfort.

To overcome these issues, in this study we explore the usage of a novel facial mask equipped with sEMG sensors. The mask is incorporated into a VR headset to recognize if the user is speaking or not. Our approach is based on signal processing and machine learning (ML), which are used to develop a binary classification model.

2 RELATED WORK

The first studies with sEMG sensors were performed by Piper[1]. Since then, researchers have been widely using sEMG sensors to measure the electrical signal that emanates from contracting muscles. The usefulness of the sEMG signal for measuring human performance was demonstrated by Inman [2] who investigated the technical aspects of human locomotion. By the early 1960s, the improvements in signal quality and convenience made the sEMG sensors a common tool in clinical and research laboratories. Despite their popularity, current recording methods can be problematic in maintaining signal fidelity when vigorous or long-duration activities are monitored [4] [3] .

Speech recognition by using sEMG was first used in the 80s [4] [6] . The results in these studies were preliminary but important for the further progress of the field. Jorgensen and Binsted [6] showed that it is possible to recognize speaking even if the words are spoken silently and/or without any actual sounds. Jou et al. [7] showed that it is possible to recognize not just the words but also the phonemes to a certain degree. Additional works include direct synthesis of speech via sEMG – which aids people who have problems with their vocal cords or airways [8] [9] .

Compared to the previous studies, we differ in the sense that we are using a novel facial mask – emteqPRO^{tm}, which is equipped with seven sEMG sensors. The sEMG sensors may be more error-prone compared to the intramuscular EMG sensors, and thus here we study their utility. Additionally, the location of our sEMG sensors makes the task of speaking recognition more challenging because the facial mask is placed on the upper part of the face (as part of the VR headset) and not the mouth and the lips – which would be more convenient for speech recognition.

3 DATASET

The data collection protocol included healthy participants that were asked to read a pre-defined text (news article). Additionally, we recorded a segment where the participants were sitting still, i.e., we recorded a baseline session with a neutral face. This data was recorded while the participants were watching a neutral video, without moving their facial muscles or speaking. A total of 30 participants were recorded, of which 18 were male and 12 were female, with a mean age between 19 and 25 years. The native language of all the participants was Macedonian.

During the data collection protocol, we were using the emteqPRO^{tm} mask [10] [11] to record sEMG sensor data. The mask has seven EMG sensors (Figure 1): two frontalis sensors (6 and 0 in Figure 1) used to monitor eyebrow movement; two orbicularis sensors (4 and 2 in Figure 1) used to monitor eye movements; two zygomaticus sensors (5 and 1 in Figure 1) used to monitor mouth and cheek movements; and one corrugator sensor (3 in Figure 1) used to monitor forehead movements.

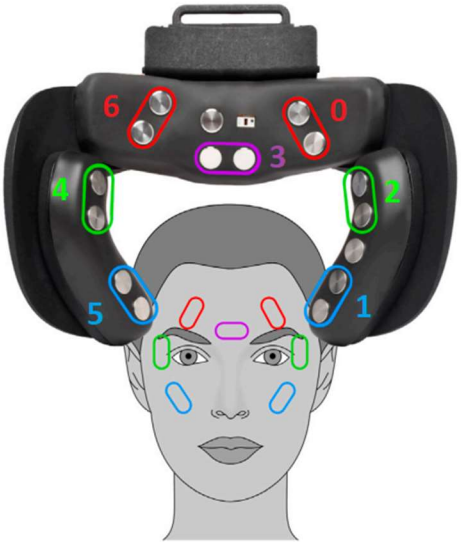

Figure 1: emteqPRO face mask with all 7 EMG sensors

4 DATA PREPROCESSING AND MODELING

The sEMG data were continuously recorded at a fixed rate of 1000 Hz. These data underwent a data preparation process, which included data filtering, segmentation, and feature engineering. To improve the quality of the sensor data, we performed signal de-noising and filtering. The EMG signals were initially filtered with a Hampel filter to eliminate sudden peaks in the signals that emerge as a result of quick movements. Additionally, we also applied a frequency-based filtering method based on spectrum interpolation [12] to reduce the noise caused by electromagnetic interference. [12] A sliding window technique was utilized for data segmentation. Specifically, the data were segmented into windows of size of 0.5 seconds with 0.4 seconds overlap (0.1 seconds slide). Finally, for each sEMG channel, we extracted 34 features, including various amplitude-based features, amplitude derivatives, auto-regressive coefficients, frequency-based features, and statistical features. The feature extraction procedure resulted in a total of 238 features.

The extracted features were used as input to four classification algorithms: (i) K- Nearest Neighbors [13] - a simple statistical algorithm where a datapoint is assigned a class according to the most numerous class of its k nearest neighbors; (ii) Support Vector Machine Classifier (SVM) [14] – an algorithm that works along the principle of finding a hyperplane in N-dimensional space to separate two classes of data points; (iii) Random Forest [15] - an ensemble learning method that trains N decision trees using random subsets of data and features and determines the instance's class by majority voting among the trained decision trees; and (iv) Extreme Gradient Boosting [16] - a gradient boosting algorithm which trains decision tree models sequentially, and each subsequent model strives to correct the errors of its predecessors.

5 EXPERIMENTS

5.1 Evaluation Setup

The recorded data was split into training (20 of the participants), validation (5 of the participants) and test datasets (5 of the participants). The train dataset was used to train the models, the validation was used to optimize hyperparameters, and the test dataset was used to report the accuracy. The evaluation metrics we used to test the performance of our models were accuracy and F1 score.

Additionally, the experiments were performed so that the training validation and test subsets do not have overlapping participants - i.e., each participant's data is found only in one of the three subsets. This is done so that we replicate a scenario where the model is used in practice on participants that are not in the training dataset.

5.2 Default Hyperparameters Results

Figure 2 presents the results (accuracy and F1-score) achieved by each of the algorithms with their default hyperparameters. We additionally included the Dummy classifier as a reference (which predicts the majority class). The results show significant improvement by all the algorithms compared to the Dummy classifier. The Random Forest and the SVM achieved similar results, while the XGBoost classifier achieved the best results overall (87% accuracy and 89% F1-score). Apart from this, this classifier also scaled efficiently with the size of the datasets, as it was able to quickly and efficiently create and train models. This was also beneficial for the hyperparameter optimization – explained in the next subsection.

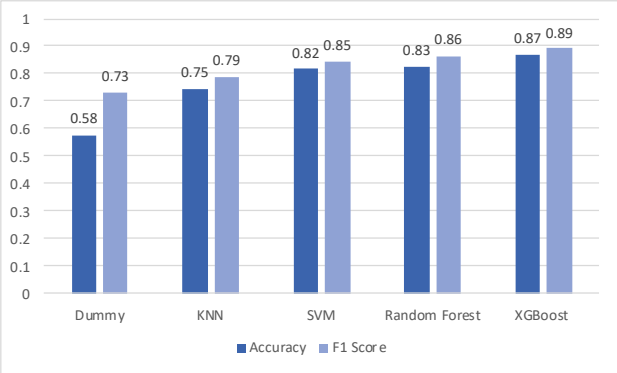

Figure 2: Algorithm comparison (accuracy and F1-score) using default hyperparameters

5.3 Optimized Hyperparameters Results

In the next step, we performed hyperparameter optimization. This process involves iterative changes of certain parameters of a classifier. During this process, an interval for every hyperparameter is defined, and afterward, each parameter is iteratively updated, and the performance of the models is monitored. During this step, all 238 features of the datasets were used, and a large number of numerical and other parameters (such as kernel for SVM, booster for XGB, etc.) were tuned.

Figure 3 presents the results (accuracy and F1-score) achieved by each of the algorithms after the hyperparameter optimization. The results show slight improvement for the KNN, SVM, and XGBoost algorithms, the latest one achieving 89% accuracy and 91% F1-score – which was the best score that we achieved on this dataset.

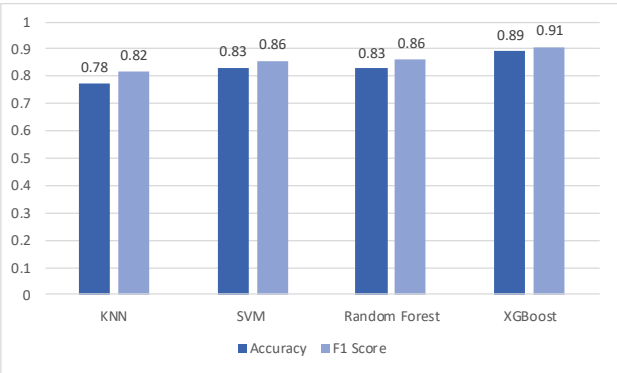

Figure 3: Algorithm comparison (accuracy and F1-score) using optimized hyperparameters

5.4 Continuous Recognition Results

Figure 4 illustrates the continuous recognition results for the five subjects from the test set achieved by the best-performing XGBoost classifier. A comparison was made between the true and the predicted class on a time scale, i.e., with a blue line, the true classes are presented (1 represents speaking, 0 represents not speaking). Additionally, the orange color presents the speaking predictions by the model. Each subject's data is separated with black dashed lines in the figure. The results show that a large portion of the error is down to the baseline sessions of the last two subjects in the test dataset, marked with red circles. In a large portion of the baseline sessions, the model is falsely predicting speaking activity. We speculate that the reason might be that these two subjects were moving their head during the baseline session, which may have caused the sensors to shift from their original position and deteriorate their contact with the skin.

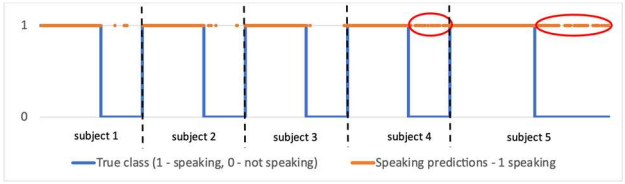

Figure 4: Continuous recognition results for the XGBoost algorithm. The blue line represents true classes (1 – speaking, 0 – not speaking), and the orange line represents the predictions (1 – speaking)

5.5 Sensor Analysis Results

We additionally analyzed the results achieved by the models if a certain sensor is missing. This way, we were able to check the importance of each sensor for the given task. Knowing the positions of the sensors on the face, we wanted to learn how the data would change if we were to drop data from a certain sensor while keeping the rest.

The results are shown in Figure 5, which in general, show that the drop in accuracy and F1 score is not significant for all the sensors. The accuracy drops from 87% to 85% at most. A more detailed analysis shows that the sensors placed on left and right orbicularis, corrugator, and left frontalis have the most impact on accuracy, i.e., the accuracy drops the most when one of these sensors is missing. One of the reasons for this is that while the participants were speaking, they were actually reading – which means they activated their eyes which is recorded by the orbicularis muscles. This analysis shows us that certain muscles activate more while speaking compared to others, so that is why the model itself gains or loses accuracy more, depending on which sensor is dropped.

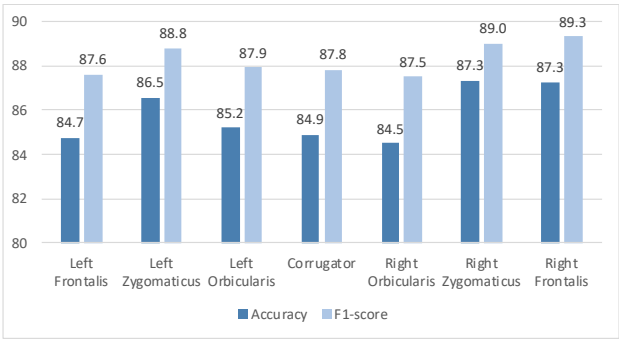

Figure 5: Sensor analysis showing the performance when a particular sensor is missing.

6 CONCLUSION

In this work, we presented a ML approach for speaking recognition using facial sEMG sensors integrated into a VR headset. The dataset was collected with 30 healthy participants while reading a news article and watching videos. The results

show that the best performing model is XGBoost, which achieved 89% accuracy. Additionally, the error analysis per participant showed that most of the misclassifications were incorrect speaking predictions in the baseline (non-speaking) sessions of two participants. We speculate that this is caused by the head movement of the participants and we plan to tackle this using the IMU sensor on the emteqPRO^{tm} mask.

An additional problem was that while the participants were reading, they were making small breaks, which were automatically labeled as speaking – but in fact were not speaking. This labeling problem will be tackled in future by using audio to exactly label the speaking segments.

Finally, we plan to implement person-specific normalization on the EMG data. This is an important step given that different participants have different facial muscles, and even more, those muscles are activated differently while doing the same facial expressions or speaking.

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REFERENCES

[1] Piper H (1912) Elektrophysiologie menschlicher Muskeln. Springer, Berlin, pp 1–163.

[2] Inman, V. T., Saunders, J. B., & Abbot, L. C. (1944). Observations on the function of the shoulder joint. Journal of Bone and Joint Surgery, 26, 1-30.

[3] M. Wand, M. Janke, and T. Schultz, "Investigations on Speaking Mode Discrepancies in EMG-based Speech Recognition," in Proc. Interspeech, 2011, pp. 601–604.

[4] N. Sugie and K. Tsunoda, "A speech prosthesis employing a speech synthesizer—Vowel discrimination from perioral muscle activities and vowel production," IEEE Trans. Biomed. Eng., vol. BME-32, no. 7, pp. 485–490, Jul. 1985.

[5] M. S. Morse and E. M. O'Brien, "Research summary of a scheme to ascertain the availability of speech information in the myoelectric signals of neck and head muscles using surface electrodes," Comput. Biol. Med., vol. 16, no. 6, pp. 399–410, 1986.

[6] C. Jorgensen and K. Binsted, "Web browser control using EMG based sub vocal speech recognition," in Proc. 38th Annu. Hawaii Int. Conf. Syst. Sci., 2005, p. 294c.

[7] S.-C. Jou, T. Schultz, M. Walliczek, F. Kraft, and A. Waibel, "Towards continuous speech recognition using surface electromyography," in Proc. Interspeech, 2006, pp. 573–576.

[8] J. Freitas, A. Teixeira, and M. S. Dias, "Towards a silent speech interface for portuguese," in Proc. Biosignals, 2012, pp. 91–100. [23] A. Toth, M. Wand, and T. Schultz, "Synthesizing speech from electromyography using voice transformation techniques," in Proc. Interspeech, 2009, pp. 652–655.

[9] K.-S. Lee, "Prediction of acoustic feature parameters using myoelectric signals," IEEE Trans. Biomed. Eng., vol. 57, no. 7, pp. 1587–1595, Jul. 2010.

[10] Gjoreski, H., I. Mavridou, I., Fatoorechi, M., Kiprijanovska, I., Gjoreski, M., Cox, G., & Nduka, C. EmteqPRO: Face-mounted Mask for Emotion Recognition and Affective Computing. In Adjunct Proceedings of the 2021 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2021 ACM International Symposium on Wearable Computers (pp. 23-25).

[11] Gnacek, Michal & Broulidakis, John & Mavridou, Ifigeneia & Fatoorechi, Mohsen & Seiss, Ellen & Kostoulas, Theodoros & Balaguer-Ballester, Emili & Kiprijanovska, Ivana & Rosten, Claire & Nduka, Charles. 2022. emteqPro-Fully Integrated Biometric Sensing Array for Non-Invasive Biomedical Research in Virtual Reality. Frontiers in Virtual Reality. 3. (Mar. 2022)

[12] Mewett, D. T., Reynolds, K. J., & Nazeran, H. Reducing power line interference in digitised electromyogram recordings by spectrum interpolation. Medical and Biological Engineering and Computing, 42(4), 524-531, (2004).

[13] D. Aha, D. Kibler (1991). Instance-based learning algorithms. Machine Learning. 6:37-66.

[14] Zhang, Yongli. (2012). Support Vector Machine Classification Algorithm and Its Application. 179-186.

[15] Breiman, "Random Forests", Machine Learning, 45(1), 5-32, 2001.

[16] Tianqi Chen and Carlos Guestrin. 2016. XGBoost: A Scalable Tree Boosting System. In Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD '16). Association for Computing Machinery, New York, NY, USA, 785–794.

Machine-learning models for MDS-UPDRS III Prediction: A comparative study of features, models, and data sources

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ABSTRACT

Parkinson's disease is the second most common neurodegenerative disease worldwide. Symptoms tend to fluctuate during the day and through disease progression. Clinical evaluations tend to occur spaced in time. Further, the assessments used are mostly subjective. The gold standard for evaluating disease severity is MDS-UPDRS. The increase in sensor usage enabled objective evaluation and continuous monitoring of the disease fluctuations. One of the symptoms that most affect mobility are gait disorders. The use of gait characteristics started to become popular to monitor the disease. However, the approaches used lack in-depth knowledge of machine learning models for disease staging. In our work, we try to estimate the MDS-UPDRS part III score from accelerometer data. We collected data from 74 patients using the Axitvity AX3 device both on the wrist and lower back. We did experiments with different models, features, and windows size. We achieved a 4.26 Mean Absolute Error on the on left out 10% data using both devices with a 2.5-second sliding window and a random forest model for prediction. We contribute with a comparison of the performed experiments and provide, according to our experiments, the optimal models for MDS-UPDRS part III estimation using only accelerometer data.

KEYWORDS

gait, accelerometer, mds-updrs, Parkinson's disease, features, machine learning, models

1 INTRODUCTION

Parkinson's Disease (PD) is a neurodegenerative disease that affects around 1% of the world's population. This disease is characterized by motor and non-motor symptoms [15]. Motor symptoms include bradykinesia, tremor, rigidity, and gait impairment. These are present in the early stages of the disease and worsen as the disease progresses.

Although there is no cure, the available pharmacological and non-pharmacological therapeutic interventions effectively control symptoms. However, as the disease progresses their efficacy tends to reduce and motor complications, such as motor fluctuations and dyskinesia, appear [11]. These have been labeled as 'ON' and 'OFF' stages [4]. To minimize the impact of these fluctuations and inform better the clinicians there is the need to periodically assess the symptoms. Generally, these evaluations require a visit to a clinic or hospital. Clinicians use validated assessments for PD to characterize a patient's current disease stage [9]. These assessments occur spaced in time and can be hard to capture all the fluctuations that may have happened between appointments. Further, instruments used in clinical practice focus on subjective evaluations. Namely, visual assessments during clinical visits that are supported by clinical scales.

The gold standard for evaluating disease severity in PD is the Movement Disorder Society-Sponsored Revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS). This is a comprehensive rating scale that assesses both motor and non-motor symptoms associated with Parkinson's [7]. To optimize disease management, close monitoring of symptom fluctuations is crucial. However, today this monitoring is usually performed through medical appointments, every six months, with a mean duration of 30 minutes. Additionally, what published evidence suggests is that patients perform differently during these moments, providing only information about their best capacity, rather than their usual performance in their daily lives.

The democratization of sensors' usage, namely the body-worn devices, that measure acceleration, and angular velocity allowed the increase of objective evaluations [10]. These devices passively monitor patients during clinical evaluation and in free-living environments. Furthermore, allow movement metrics and feature extraction that can be related to motor symptoms or clinical scales used for disease assessments [6]. Gait disorders are one of the symptoms that most affect mobility. Inertial measuring units can help to identify fluctuations. There have been studies that leverage the identification of walking bouts to extract gait metrics like step length or step variability [1, 4].

Research using these gait characteristics as a marker for PD has demonstrated the potential for monitoring the disease in several ways [2]. While the use of these gait characteristics has become a popular approach for monitoring PD, novel research has started to analyze signal processing metrics that could also be of use for this purpose. In a 2019 study, the contributions of signal-based features and gait characteristics for the classification of PD were analyzed [13]. Another emerging method to stage PD is the use of total scores of the entire MDS-UPDRS or subparts of the scale. Specifically, MDS-UPDRS III scores have been empirically demonstrated as a good metric for monitoring the progression of PD [12]. As such, several studies have focused on the prediction of this score to monitor disease progression. A recent example of this approach for the monitoring of PD progression is the 2021 study that leveraged a convolutional neural network (CNN) model trained using inertial data collected from the lower back during gait to estimate MDS-UPDRS III scores [14]. While these results are promising, the authors suggest that a comparison with traditional feature-engineered machine learning models could be an avenue for future work, towards

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the deployment of such technologies for continuous monitoring of PD. Other studies have revealed that it is possible to estimate PD progression using gait data collected with accelerometers [8]. However, the relative efficacy and effect of different approaches to data collection and processing, and machine learning pipeline design still lack consensus and clear comparisons that could help inform future research in this field.

In our work, we try to estimate the MDS-UPDRS part III from accelerometer data. We collected the data using the Axitvity AX3 device both on the wrist and lower back [3]. Our dataset contains data collected from 74 patients (HY between 2 and 4) at Campus Neurológico (CNS), a tertiary specialized movement disorders center in Portugal. The final subset of data contained 267 instances of gait from 104 evaluation sessions. We did different experiments with 4 models (Random Forest, XGBoost, SVM, Linear Regression), and 59 features from the statistical, spectral, and temporal domains. Furthermore, we used non-overlapping window sizes of 2.5 and 5 seconds. To validate the trained models we used Leave One Subject Out (LOSO) cross-validation.

Our results showed that the best configuration, with the lowest prediction error on the left out of 10% data, achieved a 4.26 MAE, with the Random Forest model, and a 2.5-second sliding window using combined data from the wrist and lower back. For all of the selected models, the configurations that achieved the best results using either of the validation schemes used data collected from the lower back or both sensors. Most models performed better using a 5-second window length, with the exception of the xgboost model. The best-performing linear regression and SVM-based models used the SURF and relieF feature selection methods.

Therefore, we contribute with the comparison of different models, features, sensor placement, and window sizes. We provide, according to our experiments, the optimal models for MDS-UPDRS part III estimation using only accelerometer data.

2 METHODS

The MDS-UPDRS III estimation was performed using different approaches to data collection, signal processing, and using different machine learning pipelines. In this section, we describe the steps taken together with the variables for each step, in order to enable a comparison between different design decisions and their effect on the estimation of the disease stage.

2.1 Data Collection

We collected data from 74 patients with PD at CNS from periodic evaluations conducted by trained physiotherapists. Each participant wore an Axivity AX3 on the wrist and lower back during a set of clinical assessments. Accelerometer data was set to record at 100 Hz. Our dataset includes 267 instances of gait from 104 evaluation sessions of the 10-meter walk. MDS-UPDRS were also applied for each patient in each session. Among these patients, 49 were male and 23 were female, while the gender of the remaining 2 patients was not reported. The average patient age was 70.4 years (SD=13.12). The average weight was 71.76 kg (SD=13.89) and the average height was 166.49 cm (SD=9.26). Finally, the average MDS-UPDRS III score was 40.92 (SD=14.31) and 2.57 (SD=0.97) for the H&Y scale.

2.2 Data Pre-Processing

In order to isolate gait instances, the selected data files were segmented using the annotated timestamps for the 3 trials of the 10-meter walk test. Visualization of each of the segmented gait instances was then created in order to exclude session data that contained sensor failures and misalignment, or mismatched timestamps. During this step, the vector magnitude of the accelerometry signal was computed and appended to each segment using the traditional euclidean vector norm formula $\sqrt{x^2 + y^2 + z^2}$. To avoid the possible temporal drift associated with the process, a resampling step was performed after segmentation to ensure even sampling, as required for the extraction of some of the used Time and Frequency domain features. Finally, all segments were filtered using a fourth-order, digital low pass Butterworth filter with a cut-off frequency of 20 Hz in order to remove possible "machine noise" [5].

2.3 Evaluated Models and Features

We used 16 statistical, 26 temporal, and 17 spectral domain features, with a total of 59. They were computed from all accelerometry axes and vector magnitude. A sliding window technique was used to segment the signal into non-overlapping windows from which the features were extracted. Different feature data frames were then created using 2.5 and 5-second windows, both of which were previously used in the literature [14], in order to assess the effect of window size on the estimation task. During this feature extraction process, MDS-UPDRS III scores were also computed and appended to the corresponding windows for both data frames. The first step toward feature selection was to use a variance filter to exclude features with low (<0.025%) or zero variance which lowered the feature space from 2081 to 266 in the 2.5-second window and 3081 to 452 in the 5-second window. While this reduction may seem drastic, it is to be expected because of the way Time Series Feature Extraction Library works, computing the same feature several times for different frequencies for example which results in a large number of feature columns with hardly any variability, and thus, descriptive power. A further feature selection step was performed using four different feature selection methods that implement different strategies for feature ranking. Each of these feature selection algorithms was used to rank and select the top 10/25/50 features to be used for the regression task using the linear regression algorithm, and with the support vector-based model. The complete feature subset was also used for these models, in order to establish a baseline comparison with the remaining tree-based models that are less affected by the number of features due to their capability to perform intrinsic feature selection.

For each model, a set of parameters were selected and used in a grid search procedure to test all possible combinations. This procedure was then carried out for each sensor placement and the combined sensors, and for the different sliding window lengths used during feature extraction, in order to compare the effect of these variables for the estimation task. Leave One Subject Out (LOSO) cross-validation was used during the grid search procedures in order to avoid overfitting and optimize the models for generalizability. Finally, the optimal models for each combination of these variables were saved and used for the ensuing validation tasks. To validate the trained models, the original dataset was split into training and testing subsets. The training subset comprised 90% of the data and was used during the grid-search procedure for training the models using LOSO cross-validation. The remaining 10% of the data was then used as a validation set to test the model's performance on unseen data from patients whose data the model had already seen, providing information on

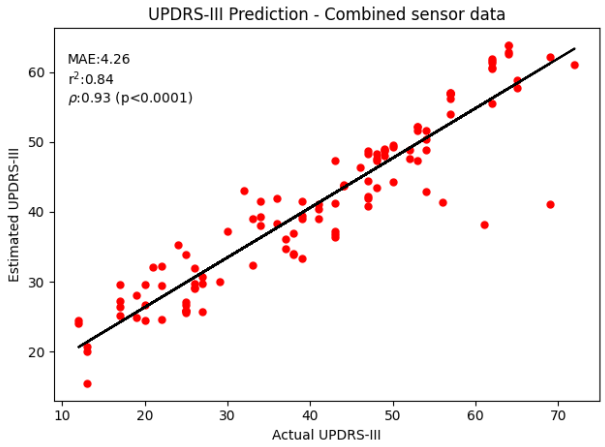


Figure 1: Overall optimal predictions on the 10% of left out data using a Random Forest model on data collected from both sensors and a 2.5s sliding window. Each point represents a window.

the model's ability to estimate MDS-UPDRS III scores for patients that were already known to these models. These steps yield two different scores for each of the optimal models using the same Mean Absolute Error (MAE) evaluation metric: the average MAE for all LOSO splits during training and the MAE for the held-out validation set. For the purpose of this study, this metric is defined as the mean absolute difference between real (x) and estimated (y) MDS-UPDRS III scores over the number of samples used for estimation.

3 RESULTS AND DISCUSSION

This section lays out the results from all of the steps taken toward UPDRS III estimation, including data processing, feature extraction and selection, and finally model training and validation results.

3.1 Optimal configurations

The configuration with the lowest prediction error on the left out 10% of data used data from both devices processed using a 2.5-second sliding window and a Random Forest model for prediction, achieving 4.26 MAE and strong correlation (ρ = 0.93) as illustrated in Figure 1. The best performing configuration when performing LOSO CV was a Support Vector-based model, using data from both sensors but a 5-second feature extraction window, achieving a MAE of 9.99. While predictions using this model on the validation set were less accurate than some of the other options at 7.94 MAE, it achieved the best balance when considering both of the validation schemes. Table 1 summarizes the optimal results achieved by each model along with the used data sources and sliding window length for the 10% left out and LOSO validation tasks.

3.2 Sensor placement and windows size

Both device placement and window length used during feature extraction significantly impacted the performance of all models. For all of the selected models, the configurations that achieved the best results using either of the validation schemes used data collected from the lower back or both sensors combined. Specifically, all of the non-tree-based models performed better in both

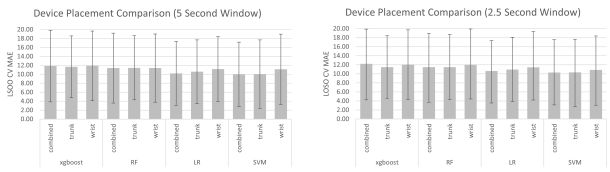
val_m	model	device_placement	win_length	ft_sel	num_fts	loso_mae	val_mae
1	rf	combined	250	-	266	11.50	**4.26**
1	xgboost	trunk	500	-	229	11.67	4.39
1	svm	combined	500	SURF	25	9.99	7.95
1	lin_reg	combined	500	reliefF	25	10.21	8.98
2	rf	combined	500	-	452	11.39	11.39
2	xgboost	trunk	250	-	133	11.49	5.74
2	svm	combined	500	SURF	25	**9.99**	7.95
2	lin_reg	combined	500	reliefF	25	10.21	8.98

Table 1: Optimal configurations used by each model to achieve optimal MAE on the left out 10% of data (val_m => 1) and LOSO (val_m => 2).

validation schemes using data from both sensors, with the exception of the SVM-based model using a 2.5-second window, which compared to the other options using the same window length achieved lower, albeit negligible, validation MAE using data from the wrist. As for the tree-based models, optimal validation MAE was attained by models using both sensors with the 2.5-second sliding windows, and data from the lower back for the same models using the 5-second window. Figures 2a and 2b illustrate the intra and inter-model comparison for both of the validation schemes, using different window lengths. While the fluctuations were relatively low using LOSO CV, most models performed better using a 5-second window length, with the exception of the xgboost model. MAE using the left out 10% of validation data fluctuated more considerably but was also lowest using 5-second windows for all models except RF.

3.3 Optimal parameters

As for model parameters, excluding linear regression, the remaining models had different parameters to achieve the best performance during LOSO CV. For Random Forest (criterion: mae ; max_features: 0.333 ; n_estimators: 250), for xgboost (colsample_bynode: 1; eta: 0.1 ; importance_type: total_gain; max_depth: 3 ; num_parallel_tree: 100 ; tree_method: gpu_hist), and for svm (C: 10 ; epsilon: 0.3 ; gamma: auto ; kernel: rbf). The xgboost was the one that used only the trunk sensor. The others models used both devices. We used a Grid Search procedure that exhaustively tested all parameter combinations for each model, independently of the used device placements and sliding window lengths. The exhaustive nature of the grid search procedure makes this method of parameter optimization computationally expensive. For this reason, and considering that the procedure was used for several models, the used parameter space for each model was not as comprehensive as those used in some other works with a smaller scope and narrower focus. However, the present results should still serve as a good starting point for model tuning in future research.



(a) LOSO CV MAE values (Y-axis) for different device placements using 5-second windows.

(b) LOSO CV MAE values (Y-axis) for different device placements using 2.5-second windows.

Figure 2

3.4 Feature importance

For the models that benefited from it, several feature selection methods were tested, along with different numbers of features to select. The best performing linear regression and SVM-based models used the SURF and relieF feature selection methods respectively, both selecting 25 as the optimal number of features. We then selected the top 20 for each model. Among the 8 top performing models across the two tested window lengths, no model used data exclusively from the wrist, and only 3 models used data exclusively from the trunk. As for the remaining models, the majority of top-ranking features were extracted from devices mounted on the lower back. In some cases, no wrist features were ranked among the top 20, which suggests that although these were used for the estimation task, their contribution is minimal, which is in line with the minimal performance gain in these models when compared to their counterparts using data exclusively from the lower back. Features from the anteroposterior plane of movement (z-axis) were the most prevalent among the top 20 extracted from the trunk sensor, consisting of 50 out of the 140 features considered for this analysis. The vertical plane of movement (x-axis) produced the least amount of features among those considered here, with only 22 ranking among the top contributing features. Spectral-domain features were the most prevalent among these, making up almost half of the 140 considered features, with temporal domain features coming in second by a small margin, and temporal features last consisting of a quarter of this total.

3.5 Limitations

The dataset used in this study consisted of data collected from 74 patients. While this number of patients is significant for preliminary results, a larger sample size could improve the estimation task and further validate the present findings. Beyond the volume of data used to train the models, a wider range of MDS-UPDRS III and Hoehn and Yahr scores could also possibly improve the results, by including a wider variety of walking patterns that in smaller sample sizes could be considered outliers and negatively affect performance. Furthermore, the inclusion of a healthy cohort in the dataset could provide a baseline for the models to recognize healthy gait, exacerbating the difference between data from healthy and affected subjects. Therefore, in future work a longitudinal study in free-living environments with a larger sample size to address our limitations and extend our conclusions.

4 CONCLUSIONS

This paper presents a study that compares the different models, features, and window sizes to estimate MDS-UPDRS part III using accerometeler data. One of the most common disorders for people with PD is gait. The increase in sensor usage opened the opportunity for increasing objective evaluations. However, there is a lack of knowledge of the current machine learning approaches. In our work, we compare 4 machine learning models (random forest, xgboost, svm, and linear regression), 59 features (16 statistical domain, 26 spectral domain, and 17 temporal domain), and windows size (2.5 and 5 seconds). To validate our models we used LOSO cross-validation. We showed that the configuration with the lowest prediction error on the left out 10% of data used data from both devices processed using a 2.5-second sliding window and a Random Forest model for prediction, achieving 4.26 MAE. This work opens the opportunity to improve the knowledge of machine learning approaches. However, in future work, there are opportunities for longitudinal studies in free-living environments with larger datasets.

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REFERENCES

[1] Raquel Bouça-Machado, Diogo Branco, Gustavo Fonseca, Raquel Fernandes, Daisy Abreu, Tiago Guerreiro, Joaquim J Ferreira, and CNS Physiotherapy Study group. 2021. Kinematic and clinical outcomes to evaluate the efficacy of a multidisciplinary intervention on functional mobility in Parkinson's disease. *Frontiers in neurology* 12 (2021), 637620.

[2] Raquel Bouça-Machado, Constança Jalles, Daniela Guerreiro, Filipa Pona-Ferreira, Diogo Branco, Tiago Guerreiro, Ricardo Matias, and Joaquim J Ferreira. 2020. Gait kinematic parameters in Parkinson's disease: a systematic review. *Journal of Parkinson's disease* 10, 3 (2020), 843–853.

[3] Clare L Clarke, Judith Taylor, Linda J Crighton, James A Goodbrand, Marion ET McMurdo, and Miles D Witham. 2017. Validation of the AX3 triaxial accelerometer in older functionally impaired people. *Aging Clinical and Experimental Research* 29, 3 (2017), 451–457.

[4] Silvia Del Din, Alan Godfrey, Brook Galna, Sue Lord, and Lynn Rochester. 2016. Free-living gait characteristics in ageing and Parkinson's disease: impact of environment and ambulatory bout length. *Journal of neuroengineering and rehabilitation* 13, 1 (2016), 1–12.

[5] Aiden Doherty, Dan Jackson, Nils Hammerla, Thomas Plötz, Patrick Olivier, Malcolm H Granat, Tom White, Vincent T Van Hees, Michael I Trenell, Christoper G Owen, et al. 2017. Large scale population assessment of physical activity using wrist worn accelerometers: the UK biobank study. *PloS one* 12, 2 (2017), e0169649.

[6] Alberto J Espay, Paolo Bonato, Fatta B Nahab, Walter Maetzler, John M Dean, Jochen Klucken, Bjoern M Eskofier, Aristide Merola, Fay Horak, Anthony E Lang, et al. 2016. Technology in Parkinson's disease: challenges and opportunities. *Movement Disorders* 31, 9 (2016), 1272–1282.

[7] Christopher G Goetz, Barbara C Tilley, Stephanie R Shaftman, Glenn T Stebbins, Stanley Fahn, Pablo Martinez-Martin, Werner Poewe, Cristina Sampaio, Matthew B Stern, Richard Dodel, et al. 2008. Movement Disorder Society-sponsored revision of the Unified Parkinson's Disease Rating Scale (MDS-UPDRS): scale presentation and clinimetric testing results. *Movement disorders: official journal of the Movement Disorder Society* 23, 15 (2008), 2129–2170.

[8] Murtadha D Hssayeni, Joohi Jimenez-Shahed, Michelle A Burack, and Behnaz Ghoraani. 2021. Ensemble deep model for continuous estimation of Unified Parkinson's Disease Rating Scale III. *Biomedical engineering online* 20, 1 (2021), 1–20.

[9] Anthony E Lang, Shirley Eberly, Christopher G Goetz, Glenn Stebbins, David Oakes, Ken Marek, Bernard Ravina, Caroline M Tanner, Ira Shoulson, and LABS-PD investigators. 2013. Movement disorder society unified Parkinson disease rating scale experiences in daily living: longitudinal changes and correlation with other assessments. *Movement Disorders* 28, 14 (2013), 1980–1986.

[10] Walter Maetzler, Josefa Domingos, Karin Srulijes, Joaquim J Ferreira, and Bastiaan R Bloem. 2013. Quantitative wearable sensors for objective assessment of Parkinson's disease. *Movement Disorders* 28, 12 (2013), 1628–1637.

[11] C Warren Olanow, Yves Agid, Yoshi Mizuno, Alberto Albanese, U Bonucelli, Philip Damier, Justo De Yebenes, Oscar Gershanik, Mark Guttman, F Grandas, et al. 2004. Levodopa in the treatment of Parkinson's disease: current controversies. *Movement disorders* 19, 9 (2004), 997–1005.

[12] Antoine Regnault, Babak Boroojerdi, Juliette Meunier, Massimo Bani, Thomas Morel, and Stefan Cano. 2019. Does the MDS-UPDRS provide the precision to assess progression in early Parkinson's disease? Learnings from the Parkinson's progression marker initiative cohort. *Journal of neurology* 266, 8 (2019), 1927–1936.

[13] Rana Zia Ur Rehman, Christopher Buckley, Maria Encarna Micó-Amigo, Cameron Kirk, Michael Dunne-Willows, Claudia Mazzà, Jian Qing Shi, Lisa Alcock, Lynn Rochester, and Silvia Del Din. 2020. Accelerometry-based digital gait characteristics for classification of Parkinson's disease: what counts? *IEEE open journal of engineering in medicine and biology* 1 (2020), 65–73.

[14] Rana Zia Ur Rehman, Lynn Rochester, Alison J Yarnall, and Silvia Del Din. 2021. Predicting the Progression of Parkinson's Disease MDS-UPDRS-III Motor Severity Score from Gait Data using Deep Learning. In *2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)*. IEEE, 249–252.

[15] Ole-Bjørn Tysnes and Anette Storstein. 2017. Epidemiology of Parkinson's disease. *Journal of neural transmission* 124, 8 (2017), 901–905.

Elements of a System for Automatic Monitoring of Specific Mental Health Characteristics at Home

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ABSTRACT

Addressing one's mental health has never been more important. The incidences of mental diseases, such as depression or anxiety disorders, have drastically increased in recent years. The longer an adequate treatment is delayed, the greater the impact on the severity of the illness which often results in long absences from work. With the development of smart devices and wearables, it is already possible to measure many physiological parameters in everyday life. In addition, monitoring people in their natural environment offers many advantages, e.g. it is not based on retrospective feelings and memories but can measure and reflect the momentary state. This conceptual paper presents an overview of possible elements of a system for automated monitoring of mental health characteristics in the home. We describe examples of typical parameters for various mental disorders and present different systems and methods to measure them. Furthermore, we show how the individual components of a system can be connected to get a holistic view of specific mental health characteristics. Finally, we also discuss challenges and limitations.

KEYWORDS

mental health, wearables, ubiquitous sensing, monitoring concept

1 INTRODUCTION

Being mindful of mental health is more important than ever. In 2019, according to the World Health Organization (WHO), one in eight people worldwide suffered from a mental disorder [20]. That is associated with significant impairments in thinking, emotion regulation, or behavior. The WHO also states that in 2020, the number of people with depression and anxiety disorders increased significantly, due to the COVID-19 pandemic.

The most common mental illnesses include depression, anxiety disorders, bipolar disorder, and obsessive-compulsive disorder (OCD), among others. Often, initial symptoms are not recognized and, consequently, diagnoses are made late, which in many cases leads to a worsening of the symptoms [6]. Nevertheless, mental illnesses have, partly overlapping, typical characteristics. For example, fatigue, and lack of energy are among the most common symptoms of depression, or checking things over repeatedly are signs of OCD. Some of these characteristics are measurable and interpretable with modern sensors, devices, and machine learning models especially when it comes to behavioral or determining physiological parameters. In addition, studying people in their natural environment respectively at home, so-called ambulatory assessment, has many advantage as it can minimize retrospective bias. On the one hand, it enables long-term monitoring which makes it easier to detect small changes. On the other hand, data can be collected at the time of occurrence and do not have to be remembered and described retrospectively when the actual condition has already passed [17].

This paper presents a collection of elements that can be included in a system for automatic monitoring of mental health characteristics in the home environment. These approaches go beyond conventional questionnaires and refer to technical possibilities for measuring individual characteristics. For this, we look at various characteristics of individual mental disorders and present ways in which these can be measured in an automatic way. However, questionnaires, for example in the form of ecological momentary assessments (EMAs), can always be considered as an additional tool for comparison with the automatic measurements. Finally, we also review different solutions for measurability and propose a potential system overview.

2 BACKGROUND

Mental illnesses are disorders that are very diverse and individual and can affect thinking, mood, and behavior. In 2019, 280 million people were living with depression, 301 million people had an anxiety disorder, 40 million people had a bipolar disorder and 14 million people suffered from an eating disorder [20]. But also lesser-known disorders, such as OCD, which affects about 2.3% of people at least once in their lifetime [11], should not be ignored.

There are characteristics or behavioral patterns that can be observed in various mental illnesses and also generally indicate a bad mental health state. These include, but are not limited to, sadness and dejection, excessive anxiety or worry, decreased ability to concentrate, significant fatigue, low energy, sleep problems, and inability to cope with everyday problems or stress [2].

Nevertheless, each mental disorder also has very specific characteristics. Depressed patients, for example, often describe feeling empty and worthless inside and experiencing hopelessness, sadness, and restlessness. Sleep is also affected in most patients, but it can go both ways, with insomnia or excessive need for sleep as symptoms. Furthermore, a loss of interest in hobbies and social activities may also indicate depression. Sometimes patients even report unexplained physical problems such as back pain or headaches [1]. People with bipolar disorder also experience the above symptoms during the depressive phase. But in addition to this, patients also go through manic episodes. In this phase, many characteristics of the depressive episode reverse. Patients often experience an energetic and euphoric phase where their motivation is increased, concentration is improved, less sleep is required, and they feel the drive to be active [3].

There are several types of anxiety disorders, including generalized anxiety disorder (GAD), panic disorder, social anxiety disorder, and phobia-related disorders [4]. They have in common

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that people suffer from anxiety over a long period of time, which also often increases and interferes with daily activities ranging from the job to personal relationships. In anxiety disorders, individuals often experience physical symptoms. GAD often comes with headaches, muscle and stomach pain, or other unexplained aches. During a panic attack, affected people may feel a racing heart, sweat intensely, tremble, experience loss of control, or feel chest pain. In addition, people with social anxiety disorder tend to blush, adopt a rigid posture, or speak with an overly soft voice.

For OCD, patients suffer from recurrent obsessive thoughts or compulsive acts. Obsessive thoughts are ideas, images, or impulses that repeatedly appear in the mind of the affected person. The patient cannot successfully suppress these thoughts. Further, more obvious symptoms of OCD are compulsive acts or rituals. They are closely related to the obsessions and serve to alleviate them and the anxiety that is constantly present. The patient is aware of the unusualness of these actions. Most compulsive acts involve cleaning (especially hand washing), repetitive checking to ensure that a potentially dangerous situation does not occur, or order and cleanliness [5].

For any mental illness, not every patient needs to experience all of the characteristic symptoms. Because symptoms can overlap between disorders, it can be difficult to clearly assign them to a single mental illness. By having a system that automatically monitors a range of characteristics, a more holistic picture of mental status can be created, and changes can be detected early.

Diagnoses for mental illness can only be made by professionals. Experts often use various forms of questionnaires and scales to determine the severity of an illness (e.g. Beck Depression Inventory for depression or Yale-Brown Obsessive Compulsive Scale for OCD). However, collecting and analyzing sensor data to monitor mental health in general, is a topic that has been studied a lot in recent years but is still very relevant and has great potential. The majority of studies are related to the analysis of smartphone data, but wearables are also increasingly used for mental health studies. When it comes to the specific monitoring of certain mental illnesses, the vast majority of these studies relate to anxiety disorders, depression, bipolar disorder or stress in general [14]. This paper focuses on technical possibilities to unobtrusively measure certain mental health characteristics in the home environment by using the latest technologies.

3 MONITORING SYSTEM ELEMENTS

To monitor certain mental health characteristics in the home environment, it is possible to use various new wearable devices, human activity recognition (HAR), indoor positioning systems (IPSs) and already derived parameters from consumer devices.

3.1 Smart Devices and Wearables

The smartphone is an integral part of everyday life and almost all of us carry it with us all the time. Although it is the most common everyday smart device, the use of so-called wearables has also been rising rapidly in recent years [19]. The term Internet of Things (IoT) is shaping the technological development of the last decade. It includes devices such as activity trackers, smartwatches, and smart rings. Since these are worn on the body and therefore often called wearables, they can measure physiological parameters such as heart rate variability (HRV), blood oxygen level, or skin conductivity. The modern smart devices contain a variety of sensors, such as oximetry sensors, skin temperature, and ambient temperature sensors, electrodermal activity sensors, heart rate sensors but also Global Positioning System (GPS) and inertial measurement units (IMUs). The latter is a combination of several inertial sensors such as a 3D accelerometer and a 3D gyroscope. However, the term IoT covers many more areas and intelligent devices, such as connected personal scales, smart ovens, and stoves, or smart lighting systems which can be grouped together under the term smart home.

3.2 Human Activity Recognition

The topic of HAR has been widely researched as it offers enormous potential and numerous use cases [8, 9, 12]. It comprises the research field of automatic detection and differentiation of various everyday activities and can be divided into video-based and sensor-based HAR. With the development of new and increasingly powerful smart devices and wearables, HAR is becoming less expensive, easily accessible, and unobtrusive. Research shows that when combining data from different devices, such as smartphone and smartwatch, the results become even more accurate [13]. These days, HAR goes far beyond simple classifications, such as the distinction between sitting, standing, and walking. Among others, HAR also finds great application in the healthcare sector, e.g. through gait analyses that indicate diseases such as Alzheimer's [18] or in systems that focus on elderly care to detect falls [10], for example.

3.3 Indoor Positioning Systems

The ability to determine a person's exact location in a home can help better identify activities that are connected to specific locations, for example, compulsive or eating behavior. Although GPS offers high coverage, it is not suitable for indoor localization because the receiver and satellite have to be in the line of sight, and walls, roofs, and other objects prevent this. That is why in recent years approaches for IPS have been designed which use various available technologies such as radio-frequency identification (RFID), Wireless Local Area Networks (WLAN), Bluetooth Low Energy (BLE) beacons, and more recently Ultra Wideband (UWB) [15, 21, 22]. Localization techniques can be divided into triangulation algorithms (e.g. Time of Arrival (ToA), Time Differences of Arrival (TDoA), Received Signal Strength Indicators (RSSI)-based, Angle of Arrival (AoA)), scene analysis (e.g. Fingerprinting-based techniques) and proximity detection algorithms [21]. The latter is the process of determining whether a user is close to a certain range. This concept is often found in combination with BLE beacons, which are installed stationary at points of interest and send Bluetooth packets that are picked up and processed by the user's smartphone, calculating the distance. In a scene analysis with using Fingerprints, measurements as e.g. RSSI-values, are collected in an offline phase for different positions and stored in a map. For position determination in real-time, the current measurements are then compared with offline measurements to determine the user's location [22].

Different localization techniques have advantages and disadvantages and it depends on the use case which methods are suitable. Most triangulation techniques (e.g. AoA) provide high accuracy but require complex hardware and extensive synchronization. Whereas RSSI- and Fingerprinting-based methods are fairly easy to use but with lower accuracy or, in the case of Fingerprinting, with a dependence on a predefined map that is sensitive to any change in the home environment [22].

3.4 Derived Parameters

In addition to using raw sensor data for use cases like HAR or IPS, consumer devices often provide pre-calculated values and derived parameters, such as about sleep. Many device manufacturers try to draw conclusions about sleep duration, sleep quality, and sleep phases. Additionally, information such as screen time, the frequency with which the phone is picked up, or the number of calls and messages is also documented. Even though many of these values are pre-calculated and in some cases do not provide much information on their own, they can give insights when combined with each other and with data from additional devices.

4 EXEMPLARY SYSTEM OVERVIEW

This section describes example characteristics and their monitoring possibilities, and proposes a connected system architecture.

4.1 Characteristics Monitoring

The possible elements of a monitoring system presented in the previous section, offer particular value when combining them. Different systems and methods are needed to measure specific psychological characteristics. To illustrate this, we looked at some symptoms and characteristics of mental illnesses and considered how these can be measured. The following Table 1 shows a short list of mental health characteristics and possible ways of measuring them. This table represents an exemplary overview and therefore does not claim to be complete. With this table, we show that different characteristics can be measured and documented with the same sensors, wearables, and systems but also that one characteristic can be determined with more than one measurement. We focused on the three main elements for monitoring, namely a HAR system, measuring and evaluating physiological parameters (abbreviated with PP in the table), and using an IPS. Additionally, we list other parameters or devices which can support the measurement of the respective characteristic. For some characteristics, additional information might increase the accuracy and lead to a greater knowledge gain (indicated by (x) in the table). In general, it can be said that oftentimes the combination of different input signals and parameters leads to a better system quality [7]. We do not present the exact algorithms and devices, as these depend heavily on other external factors (availability of devices, overall use case, acceptance of the user, privacy aspects).

It has long been known that sleep, e.g. in form of insomnia, is an essential feature of mental disorders such as depression or anxiety [16]. Sleeping behavior can be observed across a variety of systems and devices. By means of a HAR system, for example, it is possible to document how often a person wakes up at night, how restful the sleep is, and when and whether one gets out of bed in the morning. Monitoring this behavior can help in observing depressive phases, where patients sometimes find it difficult to get out of bed at all. But beyond that, it can also make sense to include other information, such as the position in the apartment in order to get more contextual information.

The measurement of physiological parameters can help for the majority of the characteristics. By measuring skin conductance, for example stress, which plays a major role in many mental illnesses, could be detected. Furthermore, it is also known that social behavior changes in some mental disorders. For example, social interaction decreases in depressive or anxiety patients but increases in people in a manic phase.

For some characteristics, it is particularly interesting to look at changes over time because mental illnesses often have very individual expressions. For this purpose, it can be helpful to train a personalized machine learning model for a potential patient in order to observe variations from normal behavior. In general, personalized models are well suited to represent the individual aspects of everyday activities.

Table 1: Listing of exemplary mental health characteristics and possibilities of monitoring them. HAR corresponds to the detection of human movements with motion sensors, PP stands for measuring physiological parameters and IPS implies the positioning of a person in the room or home.

Characteristic	HAR	PP	IPS	Others
Sleeping Behaviour	x	x	(x)	derived smartphone and smartwatch parameters (sleep hours, sleep phases, sleep quality)
Compulsive Handwashing	x		(x)	
Compulsive Checking	x		x	
Stress Level	(x)	x		
Eating Behavior	x	x	x	interaction with IoT devices, e.g. personal scale, microwave
Social Interaction		(x)	(x)	derived smartphone and smartwatch parameters (screen time, pick up times, phone call and messages frequencies)

4.2 Connected System

In Figure 1 we demonstrate how the individual components of a system for monitoring characteristics of mental disorders can be connected. Depending on the concrete use case, data from multiple devices will be constantly collected. For energy efficiency, it makes sense to store the collected data on the respective device first, and only send it to a data hub from time to time. For this, smartphone applications like SensorHub [7] are very useful. Multiple (wearable) sensors can be connected via Bluetooth, collecting and storing the data in a central place and a unified format to provide complete control over the data. Additionally, systems like SensorHub provide the possibility to get point-in-time feedback from the user by repeatedly querying certain conditions (behavior, feelings, experiences), so-called EMAs. This is extremely valuable and these subjective sensations could be supported and enriched by objective, quantifiable sensor measurements.

A system designed to give a holistic view of a current state is not intended to make assessments or provide results at any time. That means these kinds of systems have a long-term character rather than being a snapshot. Moreover, when working with raw sensor data, this often means that it needs a lot of pre-processing and cleaning. This includes e.g. filtering and de-noising. When it comes to machine learning, domain-specific knowledge is also helpful in order to come up with meaningful features.

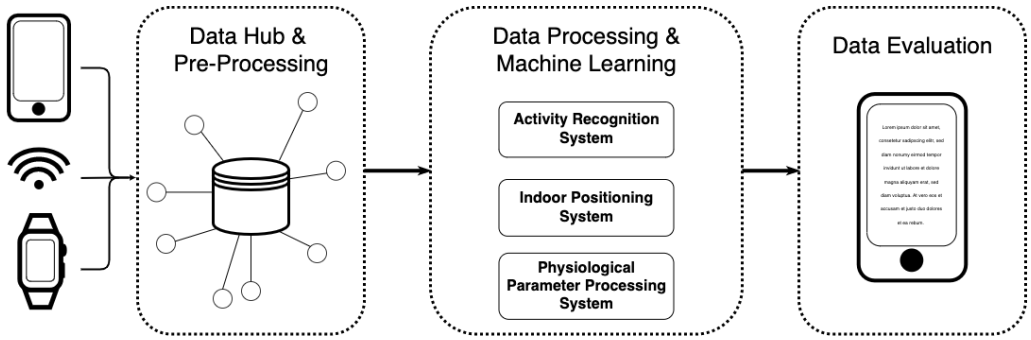

Figure 1: System Overview to Monitor Mental Health Characteristics at Home

5 CHALLENGES AND LIMITATIONS

Each component of an overall system has its advantages and disadvantages. It always has to be determined which features predominate for the specific use case. It should also be noted that issues like data security, especially with such sensitive topics as mental disorders, play a tremendous role. For this, all actions should be transparent to the user. The consumer must be informed in advance about all processes, devices and measurements, and be able to stop the monitoring at any time. This complete transparency can result in the user consciously or subconsciously adapting his/her behavior when he/she feels observed. However, these effects should be negligible, as this type of monitoring happens over a longer period of time and thus integrates into everyday life over time.

Furthermore, it should be kept in mind that systems that integrate everyday user devices (smartphone, smartwatch, and activity tracker) are also always limited in their battery power, especially if they are in constant use. Here, a balance must be found between monitoring frequency and consumption. The times when the devices have to be charged (usually daily) must also be taken into account in the system design.

In general, one of the most important factors is that the monitoring system is as pleasant and unobtrusive as possible for the user. It must be installed with as little effort as necessary and be perfectly integrated into everyday life.

6 CONCLUSION

This paper presented possible ways to measure various characteristics of mental disorders. We want to emphasize that systems of this type are not diagnostic tools and are in no way equivalent to professional assessments. But they can support and help to describe a given state and to perceive and document changes. In general, it is helpful to make psychological characteristics measurable and thus to support the subjective feelings of patients by means of objective measurements. Moreover, even small changes can be detected and documented at an early stage and help to take countermeasures in time. It could provide new insights into behavioral patterns, overlaps of different diseases, and personal aspects. Furthermore, these forms of monitoring systems cannot only be used for early detection but also for relapse supervision.

In future work, an exemplary monitoring system will be built for detecting compulsive behavior as it occurs in patients suffering from OCD. We also want to determine to what extent such systems are accepted by potential patients and also what other limitations and possibilities are encountered.

REFERENCES

[1] 2018. Depression (major depressive disorder). https://www.mayoclinic.org/diseases-conditions/depression/symptoms-causes/syc-20356007
[2] 2019. Mental illness. https://www.mayoclinic.org/diseases-conditions/mental-illness/symptoms-causes/syc-20374968
[3] 2020. Bipolar Disorder. https://www.nimh.nih.gov/health/topics/bipolar-disorder
[4] 2022. Anxiety Disorders. https://www.nimh.nih.gov/health/topics/anxiety-disorders
[5] The American Psychiatric Association (APA). [n.d.]. *What Is Obsessive-Compulsive Disorder?* https://www.psychiatry.org/patients-families/ocd/what-is-obsessive-compulsive-disorder/
[6] Elisabetta Burchi, Eric Hollander, and Stefano Pallanti. 2018. From treatment response to recovery: a realistic goal in OCD. *International Journal of Neuropsychopharmacology* 21, 11 (2018), 1007–1013.
[7] Jonas Chromik, Kristina Kirsten, Arne Herdick, Arpita Mallikarjuna Kappattanavar, and Bert Arnrich. 2022. SensorHub: multimodal sensing in real-life enables home-based studies. *Sensors* 22, 1 (2022), 408.
[8] Maria Cornacchia, Koray Ozcan, Yu Zheng, and Senem Velipasalar. 2016. A survey on activity detection and classification using wearable sensors. *IEEE Sensors Journal* 17, 2 (2016), 386–403.
[9] L Minh Dang, Kyungbok Min, Hanxiang Wang, Md Jalil Piran, Cheol Hee Lee, and Hyeonjoon Moon. 2020. Sensor-based and vision-based human activity recognition: A comprehensive survey. *Pattern Recognition* 108 (2020), 107561.
[10] Miguel Ángel Álvarez de la Concepción, Luis Miguel Soria Morillo, Juan Antonio Álvarez García, and Luis González-Abril. 2017. Mobile activity recognition and fall detection system for elderly people using Ameva algorithm. *Pervasive and Mobile Computing* 34 (2017), 3–13.
[11] Wayne K Goodman, Dorothy E Grice, Kyle AB Lapidus, and Barbara J Coffey. 2014. Obsessive-compulsive disorder. *Psychiatric Clinics* 37, 3 (2014), 257–267.
[12] Oscar D Lara and Miguel A Labrador. 2012. A survey on human activity recognition using wearable sensors. *IEEE communications surveys & tutorials* 15, 3 (2012), 1192–1209.
[13] Felipe Barbosa Araújo Ramos, Anne Lorayne, Antonio Alexandre Moura Costa, Reudismam Rolim de Sousa, Hyggo O Almeida, and Angelo Perkusich. 2016. Combining Smartphone and Smartwatch Sensor Data in Activity Recognition Approaches: an Experimental Evaluation.. In *SEKE*. 267–272.
[14] Mahsa Sheikh, Meha Qassem, and Panicos A Kyriacou. 2021. Wearable, environmental, and smartphone-based passive sensing for mental health monitoring. *Frontiers in Digital Health* (2021), 33.
[15] Santosh Subedi and Jae-Young Pyun. 2020. A survey of smartphone-based indoor positioning system using RF-based wireless technologies. *Sensors* 20, 24 (2020), 7230.
[16] Daniel J Taylor, Kenneth L Lichstein, H Heith Durrence, Brant W Reidel, and Andrew J Bush. 2005. Epidemiology of insomnia, depression, and anxiety. *Sleep* 28, 11 (2005), 1457–1464.
[17] Timothy J Trull and Ulrich Ebner-Priemer. 2013. Ambulatory assessment. *Annual review of clinical psychology* 9 (2013), 151.
[18] Ramachandran Varatharajan, Gunasekaran Manogaran, Malarvizhi Kumar Priyan, and Revathi Sundarasekar. 2018. Wearable sensor devices for early detection of Alzheimer disease using dynamic time warping algorithm. *Cluster Computing* 21, 1 (2018), 681–690.
[19] Vini Vijayan, James P Connolly, Joan Condell, Nigel McKelvey, and Philip Gardiner. 2021. Review of wearable devices and data collection considerations for connected health. *Sensors* 21, 16 (2021), 5589.
[20] World Health Organization (WHO). 2022. Mental disorders. https://www.who.int/news-room/fact-sheets/detail/mental-disorders
[21] Ali Yassin, Youssef Nasser, Mariette Awad, Ahmed Al-Dubai, Ran Liu, Chau Yuen, Ronald Raulefs, and Elias Aboutanios. 2016. Recent advances in indoor localization: A survey on theoretical approaches and applications. *IEEE Communications Surveys & Tutorials* 19, 2 (2016), 1327–1346.
[22] Faheem Zafari, Athanasios Gkelias, and Kin K Leung. 2019. A survey of indoor localization systems and technologies. *IEEE Communications Surveys & Tutorials* 21, 3 (2019), 2568–2599.

Towards Multi-Modal Recordings in Daily Life: A Baseline Assessment of an Experimental Framework

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ABSTRACT

Background: Wearable devices can record physiological signals from humans to enable an objective assessment of their Mental State. In the future, such devices will enable researchers to work on paradigms outside, rather than only inside, of controlled laboratory environments. This transition requires a paradigm shift on how experiments are conducted, and introduces new challenges. **Method:** Here, an experimental framework for multi-modal baseline assessments is presented. The developed test battery covers stimuli and questionnaire presenters, and multi-modal data can be recorded in parallel, such as Photoplethysmography, Electroencephalography, Acceleration, and Electrodermal Activity data. The multi-modal data is extracted using a single platform, and synchronized using a shake detection tool. A baseline was recorded from eight participants in a controlled environment. Using Leave-One-Out Cross-Validation, the resampling of data, the ideal window size, and the applicability of Deep Learning for Mental Workload Classification were evaluated. In addition, participants were polled on the acceptance of using the wearable devices. **Results:** The binary classification performance declined by an average of 7.81% when using eye-blink removal, underlining the importance of data synchronization, correct artefact identification, evaluating and developing artefact removal techniques, and investigating on the robustness of the multi-modal setup. Experiments showed that the optimal window size for the acquired data is 30 seconds for Mental Workload classification, with which a Random Forest classifier and an optimized Deep Convolutional Neural Network achieved the best-balanced classification accuracy of 70.27% and 74.16%, respectively. **Conclusions:** This baseline assessment gives valuable insights on how to prototype stimulus presentation with different wearable devices and suggests future work packages, paving the way for researchers to investigate new paradigm outside of controlled environments.

1 INTRODUCTION

The concept of Mental Workload (MW) originates from the field of psychology, refers to the amount of working memory used in the brain, and is historically researched on in the context of laboratories [1]. High levels of MW experienced over an extended period of time lead to Mental Fatigue (MF). It can be assumed that the onset of MF depends on contextual factors such as level of sleep during previous nights, overall health, emotional state, and more. MF can increase the amount of mistakes an individual does, and hinder work-performance amongst others. The impact of MF on economies can be estimated from the finding that a fatigued work-force costs the US economy an approximation of 18 billion USD per year [2]. Methods that quantify the level of MW an individual experiences in and outside of laboratory environments are of interest to a broad community.

MF can be circumvented in various ways, e.g. by taking more Micro-Breaks [2]. To quantify the impact of interventions, measurement frameworks have to be developed in controlled environments and evaluated for use in uncontrolled environments. Subjective measurements of MW can be performed using questionnaires or discussions with individuals. However, these approaches take time, require active truthful participation, and are therefore not suited for every context. To overcome this hurdle, objective measurement methods are researched, amongst which EEG seems promising [3].

To-be-developed measurement frameworks for experiments mainly conducted in controlled environments, such as MW quantification, need to be combined with research on the quality and amount of sensor data needed, accurate synchronization between different modalities, and precise data labeling. Merging research on all these aspects into one skeleton would increase the overall usability of the resulting framework. This paper presents an experimental framework for baseline assessment on the use-case of objective measurements of MW conducted across university students. As data storage, compression, and transmission consume a lot of battery power [4], the length of time windows required for accurate classifications, the sampling-rate required, and the time-series classification performance were evaluated. Finally, participants of this study were surveyed about their experiences with the two well-established wearable devices used, since this framework can be customized in terms of stimulus presentation and multi-modality used for the Affective Computing research community in general. The measurement framework is presented in detail, and necessary steps towards an experimental framework for multi-modal recordings in uncontrolled environments are outlined.

2 EXPERIMENTAL FRAMEWORK

The experimental framework for this study was built using PsychoPy (v2022.2.0) [5] running under Python 3.10.4 in a controlled environment, as a preliminary step for recordings in daily life. Among the most frequently used software packages for visual stimulus presentation[1], Psychopy was preferred due to the usability, automated calibration feature, and the real-time stimulus

*Both authors contributed equally to this research.

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[1] http://hans-strasburger.userweb.mwn.de/psy_soft.html#imagen

presentation [6]. The setup was implemented to induce MW in line with common practice from state-of-the-art studies (e.g. [7]). As a first step, participants were asked the put all the devices into a box and shake them, to synchronize the devices. Then, high magnitude tapping onto the space bar was performed to synchronize with Psychopy. After instructing participants to minimize movement, a five minute relaxation video[2] was presented for baseline recording. An eye-closing session of one-minute duration followed, before the MW was induced. Participants had to work on the N-Back task (*n=3*) for five minutes. Afterwards, participants had to work for five minutes on the Stroop task, where four colors (yellow, green, blue, and red) were shown for a duration of 3 seconds. For every wrong answer, a *buzz* sound was played to intensify the workload and provide feedback to the participants. Both tasks were followed by the pairwise NASA Task Load Index (NASA-TLX) questionnaire [8]. By using physiological data recorded during the relaxation video and eye-closing session as *'Low-to-No-Workload'*-class, and using the data from both MW tasks as *'High-Workload'*-class, a binary classification task was formed. Physiological data recorded during answering of the questionnaires, or reading instructions for the MW tasks, was excluded. With a ratio of *4:10* for *'Low-to-No-Workload'* to *'High-Workload'*, the recorded data was imbalanced.

Two wearable devices were used: The Empatica E4 which records skin temperature (4 Hz), PPG (64 Hz), and GSR (4 Hz), alongside acceleration-readings (32 Hz) that can be used for the identification and removal of artefacts. The Muse S device was used, which records EEG (256 Hz) and accelerometer data (50 Hz). Following the 10/20-system for electrode placement [9], the EEG electrodes of the Muse S [3] device are located at TP9, AF7, AF8, TP10, with a reference electrode at FPz.

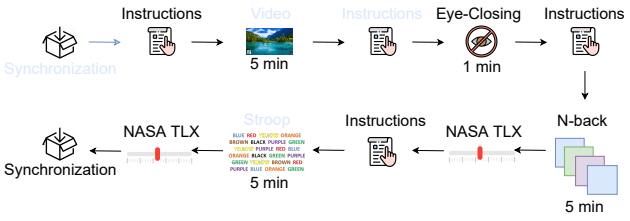

Figure 1: Study design of the experimental paradigm utilized for the multi-modal framework

3 METHODS

The Muse S data was recorded using MindMonitor [4] and loaded by *devicely* [5], whereas the Empatica E4 data was recorded using the SesnsorHub Application [10]. Synchronization was performed at simultaneous peaks in the accelerometer data, using *jointly*[6] on readings from both wearable devices. Acceleration was caused once in the beginning and once at the end of the experimental protocol: The devices were placed in the same box, and the box was shook. This procedure was repeated after the experiment. Potential offsets and time-shifts in the recordings were automatically corrected by Jointly. Labeling of the sensor data was performed using the information contained in the logs from PsychoPy. How data labeling will be performed for recordings in uncontrolled environments remains an open question.

Once the data was labeled, data cleaning needed to be performed. As time-series data is not uniform over time (e.g. due to a temporary loss of connection), missing values needed to be interpolated. Linear interpolation was performed by filling missing data with the mean value of two neighboring data points. Additionally, head-movements and eye-blinks predominantly compromised the EEG recordings, while movements of the hand predominantly compromised readings from the Empatica E4. Removal of artefacts in the data from the Empatica E4 was performed in three steps: First, both the raw values for acceleration and BVP were normalized to the range of [-1, 1]. Second, a fourth-order Butterworth band-pass filter with 0.5 Hz and 3.5 Hz cutoff-frequencies was applied. Third, a Savitzky-Golay filter was applied, using a 101-sample window and a 5th-degree polynomial. These steps removed the baseline-drift in the recorded BVP signal. Additionally, adaptive noise cancellation was performed to remove movement-artefacts from the BVP signal, by using linear recursive least-squares filtering. Removal of artefacts from the EEG signal was performed using spectral filtering with an infinite impulse response filter. Following parameter recommendations from the literature [11], a Chebyshev type 2 band-pass filter with 0.5 Hz and 48.5 Hz cutoff-frequencies and 40 dB attenuation in the pass-band was applied. Thereby, the power-line interference and other artefacts such as jaw-clenching were removed. Strong artefacts for EEG recordings, especially in the frontal channels, are eye-blinks [12]. Here, eye-blink were removed using the independent component analysis (ICA) [13].

Spatial filtering of the EEG data was investigated using the common spatial pattern (CSP) algorithm [14] implemented in the *meet*[7] repository [15]. CSP performs a generalized eigenvalue decomposition of two distinct mutlivariate sets of data, for which an additive underlying mixture of sources is assumed. CSP basically maximizes power differences between the two conditions *'Low-to-No-Workload'* and *'High-Workload'*. After derivation of filter values for each channel, the filter with the highest Eigenvalue is chosen and applied to both the *'Low-to-No-Workload'*-, and the *'High-Workload'*-, classes. The result is the sum of all the multiplications of the respective scalar-filters with the corresponding electrode-channels, resulting in one single channel which best describes the underlying phenomenon optimized for.

Temporal filtering describes the process of either rejecting recordings from the process of building trials all-together (e.g. physiological data recorded during answering of questionnaires), or of building trials from the recorded data. Two important parameters have to be taken into account: *window-size*, and *window-overlap*. Here, multiple parameters for the *window-size* were evaluated: *5 sec, 10 sec, 30 sec*. The *window-overlap* was constantly chosen to be *0.5 sec* smaller than the respective *window-size*: *4.5 sec, 9.5 sec, 29.5 sec*.

To extract different features, the cleaned BVP signal was used to extract the heart rate variability using *NeuroKit2* [8] package [16], which locates the peaks in the peak to peak (RR) interval of the hear rate variability and calculates different time-and frequency-domain features, partially mentioned below. Additionally, the mean and standard deviations (SD) from GSR and skin temperature were extracted. The different feature-sets utilized

[2]https://www.youtube.com/watch?v=S6jCd2hSVKA
[3]https://choosemuse.com/de/muse-s/
[4]https://mind-monitor.com/
[5]https://github.com/hpi-dhc/devicely
[6]https://github.com/hpi-dhc/jointly
[7]https://github.com/neurophysics/meet
[8]https://neuropsychology.github.io/NeuroKit/

were extracted from the training data only, and can be summarized as follows: **CSP features:** Gamma, Beta, Alpha, Theta and Delta band powers, mean over the band powers, mean and SD of the absolute band powers; **BVP features:** Mean and SD of the RR intervals (peak to peak of Hear Rate Variability), SD of the successive differences between RR intervals, ratio of SD and mean RR intervals, low frequency band power (0.04 - 0.15 Hz), high frequency band power (0.15 - 0.4 Hz), very high frequency band power (0.4 - 0.5 Hz), ratio of low-high band power; **GSR:** Mean and SD of absolute values, mean amplitude of Skin Conductivity Response (SCR) peaks; **Local Skin Temperature:** Mean and SD of absolute values; and **PSD features:** Power spectral density of raw EEG of TP9, TP10, AF7, AF8.

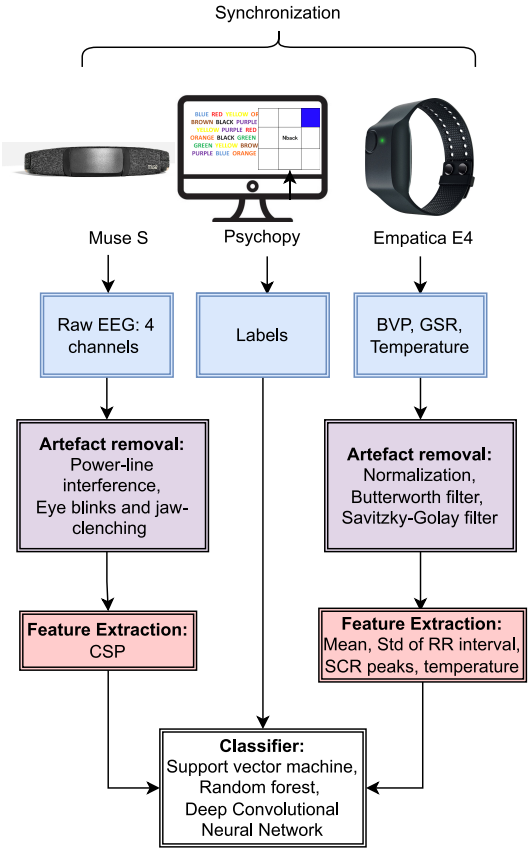

Figure 2: The flowchart of the employed study protocol with the necessary intermediate steps.

In total, three different evaluations were performed on the data recorded in a controlled environment. First, two different feature sets were investigated for data resampled to 10 Hz, using a Random Forest (RF) classifier. This evaluation was performed to investigate on the possibility of reducing the sampling rate required per modality. Second, the optimal time window for time series classification (TSC) of MW was investigated on by comparing the performance of different feature sets utilized by RF and a Support Vector Machine (SVM). Therefore, the modalities were utilized at the respective sampling rates recorded with and simply combined. Third, the application of Deep Learning to this task was investigated using a Deep Convolutional Neural Network (DCNN) [17]. The DCNN was built of ten layers: Input (2D convolution, 5x5, ReLu), 1st Hidden (2D Max Pooling, 2x2), 2nd Hidden (2D convolution, 5x5, ReLu), 3rd Hidden (2D Max Pooling, 2x2), 4th Hidden (Flatten), 5th Hidden (Fully-Connected, ReLu), 6th Hidden (Dropout), 7th Hidden (Fully-Connected, ReLu), 8th Hidden (Dropout), Output (Fully-Connected, Single-Output, Sigmoid).

For the RF, the default hyperparameters of the *RandomForestClassifier* from *scikit-learn* were chosen. For the SVM, a radial basis function kernel was utilized, and the gamma value was calculated for each evaluation. The best hyperparameters of DCNN were identified using the sequential model based optimization (SMBO) algorithm with the tree-structured parzen estimator (TPE), which has been shown to outperform both grid search and random search [18]. The derived hyperparameters are listed in Table 1. The inputs to all classifiers were min-max normalized.

Hyperparameter	Value Range	Baseline	Optimized
Dropout	0 - 0.5 (0.1)	0.5	0.3
Epochs	1 -200 (5)	200	25
Batch Size	1 - 1000 (50)	500	350
Conv. Layer 1	10 - 100 (10)	20	70
Conv. Layer 2	25 - 250 (25)	50	125
Hidden Layer 1	100 - 1000 (50)	500	200
Hidden Layer 2	100 - 1000 (50)	250	750
Window Size	5 - 30	5	30
Input Height	20 - 130 (10)	28	110
Input Width	20 - 130 (10)	28	110

Table 1: Hyperparameters for the DCNN. Values in parenthesis indicate incremental steps. Window size in seconds.

4 RESULTS

The first experimental evaluation used two different sets of features, each resampled to 10 Hz. Averaged results of all of the Leave-One-Out Cross-Validation for the classification tasks are shown in Table 2.

Set #	Window Size	Blink Removal	Balanced Acc.
Set 1	1200 sec	no	74.06
Set 1	1200 sec	yes	65.52
Set 1	**6000 sec**	**no**	**82.21**
Set 1	6000 sec	yes	73.49
Set 2	1200 sec	no	77.31
Set 2	1200 sec	yes	72.43
Set 2	**6000 sec**	**no**	**80.94**
Set 2	6000 sec	yes	71.84

Table 2: TSC Performance for RF. Set 1: Raw TP9, TP10, AF8, AF7, Skin Temperature, BVP features. Set 2: Set 1 + GSR. The row of the best performance is printed in bolt face.

The second experiment evaluated on the optimal *window-size*. Results are visualized in Figure 3, where the PSD feature set refers to all the extracted features mentioned in 3, and the FE feature-set refers to all but the PSD features. With the FE feature-set, while RF performed best across all time-windows, the average time series classification performance increased only marginally across all TSC models when varying the *window-size*. The best performance of 70.27% balanced accuracy was achieved for RF with FE for a *window-size* of *30 sec*.

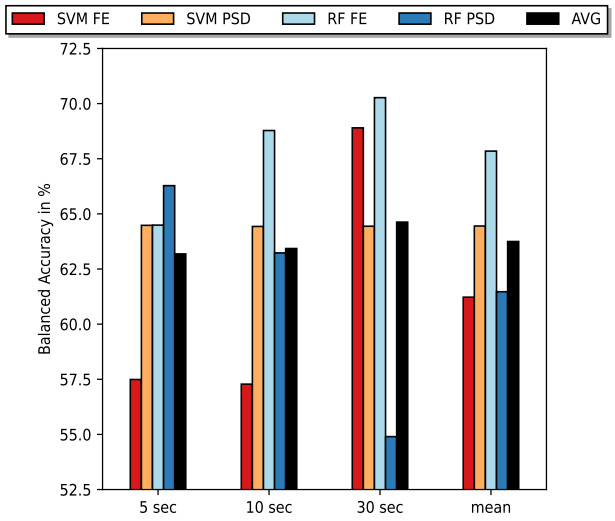

Figure 3: TSC Performance for RF and SVM. The choice of features and windows significantly impacted inter-subject TSC performance.

The third experiment investigated on the applicability of Deep Learning to this task. The *baseline*-DCNN achieved a balanced accuracy of 59.79%, whereas the *optimized*-DCNN achieved a balanced accuracy of 74.16%.

Eight participants were recruited in this baseline assessment and provided subjective feedback on their experiences with the setup: No participant complained about uncomfortable feelings due to pressure from the sensors, but sensors felt too bulky, and the utilization of three different devices—two sensors and one phone for recordings—seemed too complicated.

5 CONCLUSION

In the first experiment, it was found that eye-blink removal worsened the TSC performance. This finding was consistent across all test-runs, and the average loss in balanced classification accuracy was with 7.81% substantial. Amongst others, reasons for this circumstance are: Firstly, the existence of only one eye-blink per time window of 20 seconds duration was assumed, which proved false. Secondly, more advanced algorithms for automatic eye-blink removal and signal restoration exist, which outperformed ICA-based methods [19, 20] and should have been applied.

In the second experiment, it was found that the best accuracy was achieved for a time-window with *window-size* of *30 sec*. This finding is in line with findings in the literature on affective computing (e.g. [21]). Furthermore, the FE feature set performed better for this task than the PSD feature set, for which the TSC performance stagnated or even declined. Future work should investigate on computing PSD features from further cleaned EEG data, and on features such as power in key frequency bands.

Finally, it was found that the optimization of the DCNN also led to choosing a *window-size* of *30 sec*. This finding is in line with the results from the second experiment, where the average performance also peaked for the *window-size* of *30 sec*. However, as this was the maximum value evaluated for, it might be that the models would have performed better for longer time-windows.

The performed baseline assessment highlights future work, such as to investigate on better algorithms for artefact removal (e.g. [19, 20]); on longer *window-sizes*, different DL models, more features such as power-ratios; to recruit more participants; and to investigate on feature-importance. Also, resampling the sensor data to frequencies other than 10 Hz and investigating the effect of interventions to remove MF in controlled environments, should be performed. The presented framework needs to be extended to allow automatic randomization of the tasks, recovery from crashes, more robust data extraction, to be evaluated for applicability to uncontrolled environments, and published. Experimental paradigms for measuring MW need to be taken from controlled environments, and frameworks that are under development need to be tested and evaluated in uncontrolled settings.

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REFERENCES

[1] Hart et al. 1988. Development of nasa-tlx (task load index): results of empirical and theoretical research. In *Advances in psychology*. Vol. 52. Elsevier, 139–183. DOI: 10.1016/S0166-4115(08)62386-9.

[2] Khosro Sadeghniiat-Haghighi and Zohreh Yazdi. 2015. Fatigue management in the workplace. *Industrial Psychiatry Journal*, 24, 1, (Jan. 1, 2015), 12. DOI: 10.4103/0972-6748.160915.

[3] Hogervorst et al. 2014. Combining and comparing EEG, peripheral physiology and eye-related measures for the assessment of mental workload. *Frontiers in Neuroscience*, 8. DOI: 10.3389/fnins.2014.00322.

[4] Casson. 2019. Wearable EEG and beyond. *Biomedical Engineering Letters*, 9, 1, (Jan. 2019), 53–71. DOI: 10.1007/s13534-018-00093-6.

[5] Peirce et al. 2022. *Building experiments in PsychoPy*. ISBN-13: 978-1473991392. Sage.

[6] Rolf Kötter. 2009. A primer of visual stimulus presentation software. *Frontiers in neuroscience*, 21.

[7] Giorgi et al. 2021. Wearable technologies for mental workload, stress, and emotional state assessment during working-like tasks: a comparison with laboratory technologies. *Sensors*, 21, 7, 2332. DOI: 10.3390/s21072332.

[8] Ernesto A. Bustamante and Randall D. Spain. 2008. Measurement invariance of the nasa tlx. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 52, 19, (Sept. 2008), 1522–1526. DOI: 10.1177/154193120805201946.

[9] Chatrian et al. 1985. Ten percent electrode system for topographic studies of spontaneous and evoked eeg activities. *American Journal of EEG technology*, 25, 2, 83–92. DOI: 10.1080/00029238.1985.11080163.

[10] Chromik et al. 2022. Sensorhub: multimodal sensing in real-life enables home-based studies. *Sensors*, 22, 1, 408. DOI: 10.3390/s22010408.

[11] Apicella et al. 2021. High-wearable EEG-based distraction detection in motor rehabilitation. *Scientific Reports*, 11. DOI: 10.1038/s41598-021-84447-8.

[12] Ajay Kumar Maddirala and Kalyana C. Veluvolu. 2021. Eye-blink artifact removal from single channel EEG with k-means and SSA. *Scientific Reports*, 11. DOI: 10.1038/s41598-021-90437-7.

[13] A. Hyvärinen and E. Oja. 2000. Independent component analysis: algorithms and applications. *Neural Networks*, 13. DOI: 10.1016/S0893-6080(00)00026-5.

[14] Blankertz et al. 2008. Optimizing spatial filters for robust eeg single-trial analysis. *IEEE Signal Processing Magazine*. DOI: 10.1109/MSP.2008.4408441.

[15] Waterstraat et al. 2017. On optimal spatial filtering for the detection of phase coupling in multivariate neural recordings. *NeuroImage*, 157. DOI: 10.1016/j.neuroimage.2017.06.025.

[16] Makowski et al. 2021. Neurokit2: a python toolbox for neurophysiological signal processing. *Behavior research methods*, 53. DOI: 10.3758/s13428-020-01516-y.

[17] Sarkar et al. 2016. Wearable eeg-based activity recognition in phm-related service environment via deep learning. *international Journal of Prognostics and Health Management*, 7. DOI: 10.36001/ijphm.2016.v7i4.2459.

[18] Bergstra et al. 2013. Hyperopt: a python library for optimizing the hyperparameters of machine learning algorithms. In *Proceedings of the 12th Python in science conference*. Vol. 13. Citeseer.

[19] Nguyen et al. 2020. A deep wavelet sparse autoencoder method for online and automatic electrooculographical artifact removal. *Neural Computing and Applications*, 32. DOI: 10.1007/s00521-020-04953-0.

[20] Olaf Dimigen. 2020. Optimizing the ICA-based removal of ocular EEG artifacts from free viewing experiments. *NeuroImage*, 207. DOI: 10.1016/j.neuroimage.2019.116117.

[21] Athavipach et al. 2019. A wearable in-ear EEG device for emotion monitoring. *Sensors*, 19, 18. DOI: 10.3390/s19184014.

Assessing Sources of Variability of Hierarchical Data in a Repeated-Measures Diary Study of Stress

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ABSTRACT

There are different methodological approaches to stress recognition in different disciplines. In machine learning literature, a typical approach is to select a target variable and try to predict it as generally as feasible, but possibly with person-specific feature normalization or personalization of models. In medical, psychological, and social sciences, the nested nature of data is often taken into account by using multilevel models, especially with repeated measures data. In our diary study, we asked participants to assess different aspects of stress every 90 min for 15 working days. They accessed their questionnaires through an Android application which also served to passively record phone usage and sensor data. At the same time they wore Empatica E4 wristbands which collected physiological data. This study design lends itself well to hierarchical consideration. In this paper, we use variance partitioning, a technique which is also a part of multilevel modelling, to inform a machine learning pipeline. We show how consideration of different sources of variability can help us decide how to personalize normalization of data or machine learning models.

KEYWORDS

stress detection, ecological momentary assessment, variance partitioning, hierarchical data

1 INTRODUCTION

Chronic stress is a well researched medical, psychological, and sociological phenomenon which has been shown to have detrimental health consequences [8]. It is less clear, however, how daily experiences of stress translate into a long-term experience of chronic stress [13]. In the STRAW project, we have tackled this question by carrying out a longitudinal diary study [6].

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In machine learning literature, this problem falls under the topic of affective computing [19]. Typical studies settle for one definition of stress and either measure it by simply asking about it or using one of the established psychological questionnaires [2]. Next, stress detection is relayed to machine learning models as a supervised problem in which objectively measured data are used as predictors of self-reports, serving as labels.

The aim of this paper is to employ statistical techniques from medical and social sciences to inform machine learning modelling. Specifically, we analyse daily aggregated data collected in our study and consider possibilities for analysis on a lower, within-day level. We do this by describing the data in terms of multilevel models and then assess how each level of measurements contributes to the overall stress variability.

2 METHODS

2.1 Data Collection

Three main data types were collected using different measuring devices. Physiological parameters were measured by Empatica E4 wristbands, while participants filled in questionnaires on their smartphones for 15 working days. These ecological momentary assessments (EMAs) were presented at random intervals throughout the working day, roughly 90 minutes apart, while an additional, longer questionnaire was offered in the evening, asking about the day as a whole. The questions in each EMA session (a set of questions) were selected from questionnaires that measure different aspects of stress and related constructs, such as stress appraisal, negative affect, job demand and job control. Smartphone sensor data and phone usage data were continuously collected by a self-developed Android application based on the AWARE framework [9]. The contents of the questionnaires and the data types collected have already been described in an extensive protocol paper [6].

We collected the data of 56 participants, recruited from academic institutions in Belgium (29 participants) and Slovenia (26 participants). Only the data pertaining to $N = 55$ participants were complete, which included 26 women and 29 men. Their mean age was 34.9 years with the range from 24 years to 63 years and they held various positions in their institutions, such as PhD students, employees in administration, and tenured professors.

The participants adhered to the study protocol well. In their participation period, each participant responded to more than 96 EMA sessions on average. The median time difference between two subsequent workday EMA sessions was 93 minutes, just a bit over what was designed [12].

2.2 Classical Machine Learning Data Analysis

As the first step of the analysis, we followed a classical machine learning approach for detecting stress (see Figure 3 in [2]). After preprocessing, we calculated hand-crafted features. For phone sensor data, we used a modified *Reproducible Analysis Pipeline for Data Streams* (RAPIDS, [20]) library, which calculates behavioural features using R, Python, and Snakemake [16] following a well-defined set of rules (steps). For physiological data, we used our in-house developed Python library, `cr-features` [11].

The data were aggregated on a daily basis, by averaging target variables and calculating statistical physiological features that were first calculated on short segments. Next, we standardized the data *within* participants, i.e., by subtracting the daily mean and dividing by daily standard deviation. Finally, we used a leave-one-subject-out validation technique and tested various linear (e.g., linear regression), non-linear (e.g., support vector regression) and ensemble machine learning techniques (e.g., ADA boost regressor) from `scikit-learn` [17].

2.3 Variance Partitioning

Multilevel models (also known as mixed-effect, random-effect or mixed models) are methods commonly used in medical, biological, and social sciences to analyse hierarchical (nested) data [10]. Labels in our dataset are nested in at least three levels: each participant collected data on multiple days and each day included several measurements. We analysed self-perceived data from questionnaires using mixed models in other publications [4, 5], while in this paper we use the related technique of variance partitioning for exploring variability of the data at different levels. Variance partitioning (or partitioning of sums of squared deviations) can be used to ascribe the overall variability in a dataset to different sources of variability. In multilevel models, this sources can be different levels of analysis.

2.3.1 Simple Linear Regression. To model daily stress, we can use linear regression in the following form:

$$y_j = \beta_0 + \beta_1 x_{j1} + \cdots + \beta_p x_{jp} + \epsilon_j \tag{1}$$

Here, y_j represents the mean of the chosen indicator of stress on a day j, β_0 is the intercept term, $\{x_{j1}, \ldots, x_{jp}\}_{j=1}^{n}$ represent daily values of p features (or predictors), $\{\beta_1, \ldots, \beta_p\}_{j=1}^{n}$ their corresponding regression coefficients, while ϵ_j is the error term which captures all other factors related to variable y, which are not described by the available features (predictors included in the model). The index j runs from 1 to n, where $n = N \times n_d$ is the product of the number of participants (N) and the number of days each one participated in the study (n_d).

As we are interested in variance partitioning only, we can focus on the intercept and omit all the predictor terms. Equation (1) thus becomes:

$$y_j = \beta_0 + \epsilon_j \tag{2}$$

In the context of machine learning, this is known as a baseline or a dummy model, which predicts the same value for all days and participants: the mean.

2.3.2 A Two-Level Model. To model the differences between participants using a linear regression model, we can include a personalized intercept term. The regression equation can be described in two parts, where the first level is given by[1]:

$$y_{ij} = \beta_{i0} + \epsilon_{ij} \tag{3}$$

Here, we are trying to predict the stress score for each day $j = 1, \ldots, n_d$ *within* each participant $i = 1, \ldots, N$.

We model the intercepts as the sum of the overall intercept, γ_{00} and person-specific intercepts, u_{i0}, also called the random error component. The second level regression equation is given by[2]:

$$\beta_{i0} = \gamma_{00} + u_{i0} \tag{4}$$

2.3.3 A Three-Level Model. Since participants in our study answered the EMA prompts repeatedly throughout the day, we can add a third level of analysis, that is we consider *within-day* variability. In this case, we are trying to predict the score for each EMA session $k = 1, \ldots, n_s$ *within* each day j *within* each participant i. This is a more fine-grained level of analysis and includes many more instances, namely $n = N \times n_d \times n_s$

Joining the expressions for all three levels of intercept, the equation can be written as:

$$\begin{aligned} y_{ijk} &= \beta_{ij0} + \epsilon_{ijk} \\ &= \left(\gamma_{i00} + v_{ij0}\right) + \epsilon_{ijk} \\ &= \left(\left(\delta_{000} + u_{i00}\right) + v_{ij0}\right) + \epsilon_{ijk} \end{aligned} \tag{5}$$

Now, the top level intercept, β_{ij0} is composed of three different components. The first one, δ_{000}, is fixed for all participants and days, and it represents the overall intercept corresponding to the mean of scores aggregated per EMA session. The other two are random effects, where u_{i00} is the person-specific intercept, while v_{ij0} is the intercept specific to each day within each person.

3 RESULTS

3.1 Machine Learning on Daily Aggregated Data

As described in Section 2.2, we followed a typical machine learning approach to detect daily stress. We chose negative affect as an indicator for stress, which was measured with the Positive and Negative Affect Schedule (PANAS, [22]). This is the most commonly used questionnaire in similar diary studies looking at daily measures of stress [13]. It is composed of a list of adjectives describing emotional states, which are self-assessed on a scale from 1 to 5.

This approach did not yield good predictions as shown in Fig. 1. In fact, most of the models performed no better than the dummy model, as evaluated by the median of the R^2 metric across all participants. Even when considering the individual rounds of the leave-one-subject-out validation scheme, the best model (in this case an instance of an XGBoost regressor) achieved a maximum of $R^2 = 0.52$. This corresponds to 52 % of explained variance for that particular participant.

We considered modelling within-day stress as the natural next step. However, this gives the possibility of processing the data on the level of days, rather than only subjects. For example, standardization, feature selection, and model cross validation could

[1] In general, this equation would include predictor terms, such as $\beta_{i1} x_{ij1}$, but they are omitted for clarity as mentioned above.

[2] Similarly, we could write the equation for person specific regression coefficients as $\beta_{1i} = \gamma_{10} + u_{1i}$ and also model person-specific predictors as $\gamma_{01} W_i$.

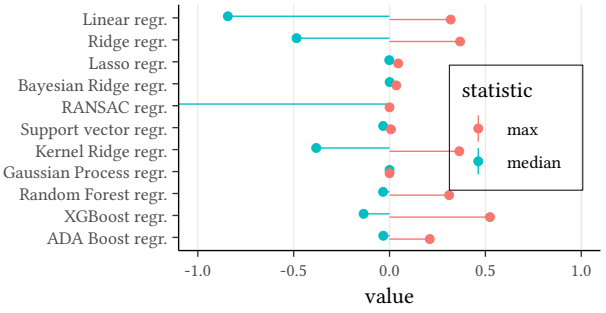

Figure 1: Median and maximum R^2 value as achieved by different regression methods in a leave-one-subject-out validation scheme.

all be done on the lowest, daily level. To get an idea of whether a more fine-grained analysis of the data might be warranted, we turned to variance partitioning.

3.2 Sources of Variability

As mentioned in Section 2.2, the data for machine learning experiments were standardized within participants, i.e., the normalization was personalized. In multilevel modelling terms, this is equivalent of introducing a participant random effect. By defining an intercept-only linear mixed model using the `lme4` library [3], it turned out that the variance explained by these person-specific intercepts was $\sigma_u^2 = 0.20$, which amounted to 57 % of the total variance.

The random effect of participants is illustrated in Figure 2. It shows that the participants differ in how they evaluated their negative affect. Their mean assessments are mostly distributed within 1 point away from the overall mean, but some differed from it by almost 2 points

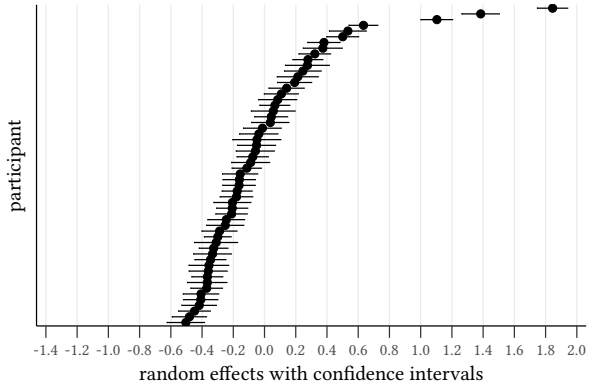

Figure 2: The offset of person random effects (roughly corresponding to person-specific means of daily stress) from the main intercept effect (roughly corresponding to the overall mean).

Next, we considered a three-level model with data aggregated on an EMA session basis. We modelled a random effect by varying the intercept among subjects *and* among days within subjects. The variance that was explained by adding the day level was $\sigma_v^2 = 0.08$ or 11 % of the total variance. This is in addition to the proportion of variance already explained at the subject-level, so the total proportion of explained variance increased to 68 %.

This is also illustrated in Figure 3 which shows that individual days differ from the overall mean by maximum of 1.5 points. On the ordinal axis, the random effects are ordered by participant, similarly to Fig. 2. Within participants, however, the data are ordered consecutively by date. This is manifested in the noisy structure of the confidence intervals as opposed to the monotonously increasing random effects shown in red points.

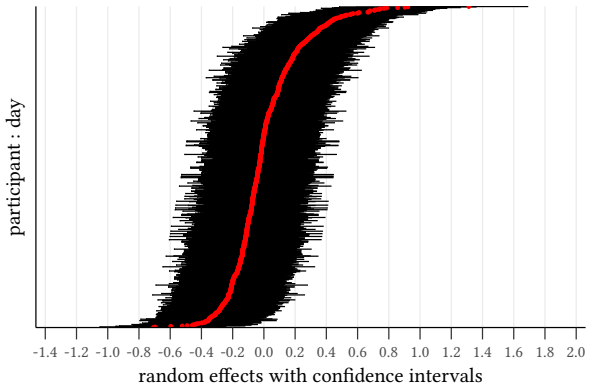

Figure 3: The offset of random effects of interaction terms of person and day (roughly corresponding to person-day-specific means of stress in one EMA session) main intercept effect (roughly corresponding to the overall mean).

By including day-specific intercepts, this model performs significantly better ($\chi^2 = 509$, $p < 0.001$). We next consider what that means in the context of machine learning.

4 DISCUSSION

When considering two sources of variability, the person and the day level, we showed that much of the total variance can be ascribed to within-person differences. This can be interpreted to confirm the merit of personalized normalization of the data, but other interpretations are also possible.

It should be noted that we only dealt with the target variable in this work. Thus, variance partitioning does not help with deciding whether to normalize independent variables. In general, it is advised to normalize physiological data since there exists inherent variability of physiological functioning in the general population [18]. Similarly, explorative analysis indicated that phone sensors vary across devices and it is also feasible to assume that people's phone usage varies significantly (independent of their stress level).

For the target variable itself, the proportion of variance explained with within-person differences can be interpreted in at least two ways. Either the participants were on average exposed to different levels of stress and this is why their assessments differ in a systematic way. Alternatively, participants can have differing thresholds of evaluating something as stressful. Since the self-reports are completely subjective, it is not possible to differentiate between these two interpretations with the self-assessments as labels. It would be possible to explore this further by taking physiological measures as ground truth for stress and use them to explain subjective measures. Treating the physiological measures as universal is problematic, however, and they might not even be related to stress deterministically. Physiological responses

are not specific to different stress states, but rather a more complex relationship exists between the stimuli, physiology, and the parameters that control dynamics between them [7].

Finally, normalization is not at all the only option of removing the person-specific variation. Methods such as linear discriminant analysis offer ways that have been shown to perform better [1].

Including person-day random effects in the three-level model, the intercept model performs better than the one with only person random effects included. Following the same reasoning as for the two level model, this could be interpreted that day-specific normalization would be beneficial. There are several arguments against this interpretation, however.

First, as indicated in Section 2.2, participants responded to questionnaires 5 or 6 times a day. Standardizing with this little data is dubious, while using such small samples for feature selection or model validation is unacceptable. Second, the questionnaire data are not truly continuos, but in fact interval data (at best) that can take 5 possible values. Since each EMA session included only two items from each questionnaire, aggregating at this level brings the number of possible values to only 9. Aggregating on a daily level, however, summarises about 10 different measurements, increasing the resolution to 0.1 point. This makes daily means much closer to a continuous variable which can be modelled by regression methods.

We can therefore argue that normalizing data by considering each day as a separate unit is not appropriate. We can conclude, however, that treating each EMA session as its own instance is beneficial. As stated in Section 3.2, analysis on the EMA session level can explain at least 11 % of variance that is not captured by the variability between participants. This conclusion is also illustrated in Figs. 2 and 3: while the general pattern of random effects shown by red points in Fig. 3 can already be sensed in Fig. 2, the noisy structure of confidence intervals is noticeable and worth exploring further.

5 CONCLUSIONS

Multilevel models are a well established method in medical, biological, and social sciences for analysing nested and longitudinal data. In machine learning, research of comparable methods is in its early stages [15]. Some tree-based methods are capable of taking into account hierarchical (or clustered) nature of data, such as MixRF [21], and least squares support vector machines (LS-SVM) have been extended for handling longitudinal data, resulting in a mixed effects LS-SVM [14].

The aim of this paper was not to build multilevel models, statistical or machine learning ones, but rather use variance partitioning to explore how different levels of nested data can be leveraged. We have shown that while standardization or similar techniques do not lend well to the lowest level due to small sample size, restricting analysis to a higher level discards an important part of variance. In this way, variance partitioning can help us build better machine learning models by enabling us to systematically explore different levels of hierarchical data and decide what data transformations to apply to each level.

REFERENCES

[1] Folami Alamudun, Jongyoon Choi, Hira Khan, Beena Ahmed, and Ricardo Gutierrez-Osuna. 2012. Removal of subject-dependent and activity-dependent variation in physiological measures of stress. In *Proceedings of the 6th International Conference on Pervasive Computing Technologies for Healthcare*. IEEE. DOI: 10.4108/icst.pervasivehealth.2012.248722.

[2] Ane Alberdi, Asier Aztiria, and Adrian Basarab. 2016. Towards an automatic early stress recognition system for office environments based on multimodal measurements. A review. *Journal of Biomedical Informatics*, 59, (Feb. 2016), 49–75. DOI: 10.1016/j.jbi.2015.11.007.

[3] Douglas Bates, Martin Mächler, Ben Bolker, and Steve Walker. 2015. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*, 67, 1. DOI: 10.18637/jss.v067.i01.

[4] Larissa Bolliger, Ellen Baele, Elena Colman, Gillian Debra, Junoš Lukan, Mitja Luštrek, Dirk De Bacquer, and Els Clays. 2022. The association between day-to-day stress experiences, recovery, and work engagement among office workers in academia. An ecological momentary assessment study. *PLOS ONE*. Submitted.

[5] Larissa Bolliger, Gillian Debra, Junoš Lukan, Rani Peeters, Mitja Luštrek, Dirk DeBacquer, and Els Clays. 2022. The association between day-to-day stress experiences and work–life interference among office workers in academia. An ecological momentary assessment study. *International Archives of Occupational and Environmental Health*. DOI: 10.1007/s00420-022-01915-y. In press.

[6] Larissa Bolliger, Junoš Lukan, Mitja Luštrek, Dirk De Bacquer, and Els Clays. 2020. Protocol of the stress at work (STRAW) project: how to disentangle day-to-day occupational stress among academics based on EMA, physiological data, and smartphone sensor and usage data. *International Journal of Environmental Research and Public Health*, 17, 23, (Nov. 2020), 8835. DOI: 10.3390/ijerph17238835.

[7] Justin Brooks, Joshua C. Crone, and Derek P. Spangler. 2021. A physiological and dynamical systems model of stress. *International Journal of Psychophysiology*, 166, (Aug. 2021), 83–91. DOI: 10.1016/j.ijpsycho.2021.05.005.

[8] Daniel J. Brotman, Sherita H. Golden, and Ilan S. Wittstein. 2007. The cardiovascular toll of stress. *The Lancet*, 370, 9592, 1089–1100. DOI: 10.1016/s0140-6736(07)61305-1.

[9] Denzil Ferreira, Vassilis Kostakos, and Anind K. Dey. 2015. AWARE: Mobile context instrumentation framework. *Frontiers in ICT*, 2, 6, 1–9. DOI: 10.3389/fict.2015.00006.

[10] Andrew Gelman and Jennifer Hill. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge University Press, 648. ISBN: 9780521686891.

[11] Vito Janko, Matjaž Boštic, Junoš Lukan, and Gašper Slapničar. 2021. Library for feature calculation in the context-recognition domain. In *Proceedings of the 24nd International Multiconference INFORMATION SOCIETY – IS 2021*. Slovenian Conference on Artificial Intelligence (Ljubljana, Slovenia, Oct. 4–8, 2021). Mitja Luštrek, Rok Piltaver, and Matjaž Gams, editors. Vol. A, 23–26. https://library.ijs.si/Stacks/Proceedings/InformationSociety/2021/IS2021_Volume_A.pdf.

[12] Junoš Lukan, Larissa Bolliger, Els Clays, Oscar Mayora, Venet Osmani, and Mitja Luštrek. 2021. Participants' experience and adherence in repeated measurement studies among office-based workers. In *Adjunct Proceedings of the 2021 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2021 ACM International Symposium on Wearable Computers* (Virtual, Sept. 21–24, 2021). ACM. DOI: 10.1145/3460418.3479367.

[13] Junoš Lukan, Larissa Bolliger, Nele S. Pauwels, Mitja Luštrek, Deirk De Bacquer, and Els Clays. 2022. Work environment risk factors causing day-to-day stress in occupational settings. A systematic review. *BMC Public Health*, 22, 1. DOI: 10.1186/s12889-021-12354-8.

[14] Jan Luts, Geert Molenberghs, Geert Verbeke, Sabine Van Huffel, and Johan A. K. Suykens. 2012. A mixed effects least squares support vector machine model for classification of longitudinal data. *Computational Statistics & Data Analysis*, 56, 3, 611–628. DOI: 10.1016/j.csda.2011.09.008.

[15] Daniel Patrick Martin. 2015. *Efficiently Exploring Multilevel Data with Recursive Partitioning*. PhD thesis. University of Virginia, Enfield, Connecticut.

[16] Felix Mölder et al. 2021. Sustainable data analysis with snakemake. Version 2. *F1000Research*, 10, 33. DOI: 10.12688/f1000research.29032.2. peer review: 2 approved.

[17] F. Pedregosa et al. 2011. Scikit-learn: machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830.

[18] R. W. Picard, E. Vyzas, and J. Healey. 2001. Toward machine emotional intelligence: analysis of affective physiological state. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 23, 10, 1175–1191. DOI: 10.1109/34.954607.

[19] Jianhua Tao and Tieniu Tan. 2005. Affective computing: a review. In *Affective Computing and Intelligent Interaction*. Springer Berlin Heidelberg, 981–995. DOI: 10.1007/11573548_125.

[20] Julio Vega, Meng Li, Kwesi Aguillera, Nikunj Goel, Echhit Joshi, Kirtiraj Khandekar, Krina C. Durica, Abhineeth R. Kunta, and Carissa A. Low. 2021. Reproducible analysis pipeline for data streams. Open-source software to process data collected with mobile devices. *Frontiers in Digital Health*, 3. DOI: 10.3389/fdgth.2021.769823.

[21] Jiebiao Wang, Eric R. Gamazon, Brandon L. Pierce, Barbara E. Stranger, Hae Kyung Im, Robert D. Gibbons, Nancy J. Cox, Dan L. Nicolae, and Lin S. Chen. 2016. Imputing gene expression in uncollected tissues within and beyond GTEx. *The American Journal of Human Genetics*, 98, 4, 697–708. DOI: 10.1016/j.ajhg.2016.02.020.

[22] David Watson, Lee Anna Clark, and Auke Tellegen. 1988. Development and validation of brief measures of positive and negative affect. The PANAS scales. *Journal of Personality and Social Psychology*, 54, 6, 1063–1070. DOI: 10.1037/0022-3514.54.6.1063.

Academic Performance Relation with Behavioral Trends and Personal Characteristics: Wearable Device Perspective

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ABSTRACT

Understanding the relevant factors related to students' academic performance can help to construct a more precise methodology for conducting successful academic life. Several studies examine the relationship between students' lives and academic performances using statistical techniques with subjective responses collected via questionnaires in the literature. In the last decade, wearable devices, such as smartwatches and smartphones, have gained popularity in the research community since they can provide objective measurements of the users' activity, sleep, and mood states with integrated sensors. It is possible to extract markers related to individuals' physiological and psychological states. This study explores the most important factors from wearables and questionnaires about students' academic grades using the NetHealth dataset. We utilize machine learning techniques, specifically Random Forest, rather than classical statistical analyzes in literature. We believe that we contribute to interpreting the underlying factors related to grade by examining objectively-measured multi-modal datasets. We also focus on classifying the grades with Random Forest and achieve overall 76% accuracy. The most important factors affecting academic performance are observed to be sleep, big five personalities, health, and mental health.

KEYWORDS

Wearable computing, machine learning, multi-modality, well-being, pervasive computing, student grades, behavioral patterns, personality traits

1 INTRODUCTION

Understanding the underlying factors of academic performance may help students to perform better throughout their academic life. Many studies have investigated these factors affecting academic performance, including family history, psychological well-being, and physical activity [**1**, **2**, **3**, **4**]. Some approached the situation from family history [**1**], and some focused on the existence of physical activity in the curriculum [**2**]. Also, some studies considered sleep based on self-reported measures [**3**]. However, they are based on one modality, focusing on one factor and trying to understand its effect on the target (i.e., students' academic performance). This approach does not provide a meta-understanding between different modalities. Thus, a multi-modal approach is necessary to obtain a more expanded view.

This study focuses on multi-modal data analysis collected from objectively measured wearable devices' sensors and several surveys corresponding to the subject's origin, sex, education level, bad habits, as well as state-of-the-art sleep, big five, mental health inventories (the details are given in Table 1). We aim explore the factors affecting students' academic performances.

We utilize the NetHealth open source data [**5**] which contains students' sleep routines, daily physical activities, communication behaviors collected with mobile phones, and a detailed survey about family history, living conditions, and personality. Data related to sleep and activity is collected from wearable devices and documented. We aim to find the relation between some of the abovementioned aspects and academic performance.

We have a large dataset from different academic periods (waves) and various survey data. However, the surveys were not filled in every period, hence, we focused on one period with the least amount of missing information. Before applying our models, we performed a preprocessing procedure by imputing the data with proper techniques to handle missing values and preparing them for the final analysis. We utilized machine learning techniques, specifically Random Forest (RF) algorithm, both for factor selection and classification. In addition, we provide essential parameters for the student's academic performance. These are related to sleep, big five personalities, health, mental health, personal information, and origin data in order. We believe that these information can be helpful in understanding affecting factors for further improvement of student life to get better performance during their academic life.

One of the essential contribution of our work is bringing different factors together and trying to produce a combination of them. In that way, we aim to find the most important predictors for students' academic performance by combining other focus areas, such as sleep, mental health, and activities, in the scope of one study.

Considering the studies utilizing NetHealth data, some are analyzing the data on different topics such as biometric-based authentication [**6**], physical activity and sleep pattern [**7**]. There are studies doing network analysis [**8**, **9**], physical activity prediction [**10**]. To the best of our knowledge, no similar study exists among the listed papers.

The rest of the paper is organized as follows: In Section 2, we explain state of the art on student grades studies and from point of wearable domain. In Section 3, we explain dataset details and the preprocessing steps for further analyses. In Section 4, we present academic grade's classification results with different balancing strategies. We give factors for best case. Finally, in Section 5, we discuss our findings with other future study ideas.

2 RELATED WORKS

Many related works exist about student's academical performance from the point of different domains such as educational, psychological and smartphone sensing [**11**, **12**, **13**, **14**].

Objectively measured signals sensed from wearables applied into the research field related to student's mental health and

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academic performance, to the best of our knowledge, starts with StudentLife [**11**] project.

In [**12**], authors collect the day-to-day and week-by-week impact of workload on stress, sleep, activity, mood, sociability, mental well-being and academic performance via smartphone sensors. They examined strong correlations between smartphone sensors and student's mental health along with their academical scores by not counting behavioral differences.

In [**13**], authors extracted related factors to the students academical grades from academic related behaviors, personality, affect, stress, lifestyle and sensed behaviors with wearables. They modelled behavior change points to capture individual's behaviors while having the same final grade. One of the findings is study duration has positive correlation with the final grade.

In [**14**], researchers examined the relation between wearable device sensors and survey with student's grade in a similar manner. They used SVM with different kernel setups. They found social features such as negative email contacts and negative interactions are lower on students with high GPA. Also, accelerometer sensor in wearables have an impact on discriminating the higher and lower performants. This study is similar to our experiment, where there is multi-modal data from wearable sensors and surveys. We also examine the related factors on different datasets, but our study also explores class balancing scenarios.

3 METHODOLOGY

3.1 Dataset

We utilized the NetHealth dataset[1]. It is collected from undergraduate students from Notre Dame (ND) University between Fall 2015 and Spring 2019. Thus, there are 8 waves corresponding to each semester. There are approximately 700 students' data from the 2015 – 2017 period and 300 from the 2017 – 2019 period caused by the drops in participation. Data collection consists of the social network, physical activity, sleep data from Fitbit wearable device, and ground truth data from questionnaires about physical and mental health, social-psychological states, tastes, and various self-reported behaviors, demographics, and background traits. The collection procedure is approved through IRB protocols, and each participant has consented. Nevertheless, not all data collection is publicly shared due to privacy concerns.

The details of the collected dataset per modality are as follows. We performed our study with boldly-marked sub-datasets.

- Communication data: Collection of smartphone-based communication logs data.
- **Wearable data**: Collected measurements regarding activity and sleep such as the number of steps, active minutes, heart rate, sleep duration, sleep time, and awaken time using Fitbit.
- **Courses and grades data**: Administrative records from ND Registrar's Office containing course and grade information.
- Calendar: Weekly calendar showing the days about the beginning of classes, break weeks, holidays, etc.
- **Survey data**: Self-reported questionnaires related to physical and mental health, social-psychological states, tastes, and various self-reported behaviors, and demographics and background traits.
- Network survey data: Interactions' network data with the related information such as relationship type, duration, frequency of interaction, similarity, etc.

[1] http://sites.nd.edu/nethealth/

3.2 Preprocessing

As stated in Section 3.1, there are 8 waves. Each wave has different survey questions and thus responses. For instance, in waves 1, 2, 3, 7, there are no questions related to stress, while in 4, 5, 6, 8, there are. Similarly, sleep ground truth is not collected during the study waves 5, 7. Thus, we chose to work on wave 1 as it contains relatively higher responses than other waves.

Firstly, we constructed a sub-dataset from NetHealth concentrating on our purpose. The details are explained in Section 3.2.1. Then, we prepossessed our data by deleting highly correlated ones (in Section 3.2.3). Finally, we applied the Random Forest algorithm for the rest of the study.

3.2.1 Dataset Preparation. As the dataset includes many different data types, each of them has various parameters, we decided which parameters to use before starting our study. We considered all parameters from wearable devices and course-grades datasets. However, we selected some of the collected data from the survey dataset. Surveys constitute, mainly, *bad habits, big-five personality inventory, education, exercise, health, mental health, origin, personal information, sex, and sleep* related answers. We used only the summarizing parameters provided by the survey for mental health, personal information, and sleep. We select some parameters from the origin category manually. We used the parameters of parents' status, economic condition, number of siblings, and religion. Table 1 gives the final list of utilized parameters. At the end of the naming, some parameters have _1 indications, which relate to the measuring from wave1.

3.2.2 Handling Missing Values. Once the dataset was prepared for analysis, we noticed missing values over columns. We preferred to keep these columns and impute them since they are partially missed. We applied the most frequent imputation technique to the categorical ones and the mean imputation technique to the numerical ones. However, there is enough correlation for activity-related wearable data to use the KNN imputation technique. Thus, we used this technique. Finally, sleep data from wearables did not contain any missing values.

3.2.3 Correlation. We checked the correlation between parameters to reduce dimensionality. We deleted the ones which exhibit higher than %80 correlations. These are *cardiomins, fatburnmins, lowrangemins, minsasleep, minsawake, peakmins* parameters. We can deduct the information related to them from other parameters, for instance, cardiocals for cardiomins and fatburnmins. We decided on the threshold value after many experiments. When we increase it, we keep the highly correlated ones, and when we decrease the threshold, more parameters will be deleted, which causes unnecessary parameter loss. Eliminating them prevents misleading results due to highly correlated features in detecting interactions between different features. We had 93 parameters. After removal of the 6 highly correlated ones, we have 87 features.

3.2.4 Target value's distribution. In this study, we are working towards the identification of important parameters and the application of machine learning methods regarding students' grades. Thus, before starting the analysis, we examined target values, i.e., student grades distribution, to observe whether there is class imbalance. The distribution is in Figure 1. Here, it is seen that we

Table 1: Details of the features

Dataset	Measured Values
Wearable data (Activity)	complypercent (percent minutes using Fitbit), meanrate (mean heart rate), sdrate (st. dev. heart rate), steps, floors, sedentaryminutes, lightlyactiveminutes, fairlyactiveminutes, veryactiveminutes, lowrangemins (low range minutes), fatburnmins, cardiomins, peakmins, lowrangecal, fatburncal, cardiocal, peakcal
Wearable data (Sleep)	timetobed (time went to bed), timeoutofbed (time out of bed), bedtimedur (minutues in bed in minutes), minstofallasleep (minutes to fall asleep), minsafterwakeup (minutes in bed after waking), minsasleep (minutes asleep), minsawake (minutes awake during sleep period), Efficiency (minsasleep/(minsasleep + minsawake)
Courses and grades	AcademicPeriod, CourseReferenceNumber, FinalGrade
Survey data (Bad habits)	usetobacco_1 (used tobacco), usebeer_1 (drank beer), usewine_1 (drank wine or liquor), usedrugs_1 (used rec drugs like marij. or cocaine), usedrugs_prescr_1 (used presc. drugs not prescribed), usecaffine_1 (drank caffenated drinks)
Survey data (BigFive/Personal inventory)	Extraversion_1, Agreeableness_1, Conscientiousness_1, Neuroticism_1, Openness_1
Survey data (Education)	hs_1 (high school type), hssex_1 (high school sex composition), hsgrade_1 (high school average grade), apexams_1 (# of hs ap exams), degreeintent_1 (highest intended degree), hrswork_1 (paid hours senior year), ndfirst_1 (Notre Dame first choice of applied colleges?)
Survey data (Exercise)	hsclubrc_1 (club activities), exercise_1 (excersise), clubsports_1 (play club, intramural or rec sports) , varsitysports_1 (play varsity sports), swimming_1 (swim), Dieting_1 (special type of diet), PhysicalDisability_1 (physical disability)
Survey data (Health)	SelfEsteem_1 (on the whole, I am satisfied with myself), Trust_1 (most people can be trusted), SRQE_Ext_1 (external self-regulation (exercise)), SRQE_Introj_1 (introjective self-regulation (exercise)), SRQE_Ident_1(identified self-regulation (exercise), SelfEff_exercise_scale_1 (when i am feeling tired), SelfEff_diet_scale_1 (self_efficacy score (diet items)), selfreg_scale_1 (i have trouble making plans to help me reach my goals)
Survey data (Mental health)	STAITraitTotal_1 (state_trait anxiety score), CESDOverall_1 (CES depression score), BAIsum_1 (beck anxiety score), STAITraitGroup_1 (state_trait anxiety 2 category), CESDGroup_1 (CES depression - 2 categories), BAIgroup_1 (beck anxiety (3 category)), majorevent_1 (life changes)
Survey data (Origin)	momdec_1 (is your mother deceased?), momusa_1 (was mother born outside usa?), daddec_1 (is your dad deceased?), dadusa_1 (was your dad born outside usa?), parentstatus_1 (parents living together or divorced/living apart), dadage_1 (father's age), momage_1 (mom's age), numsib_1 (number of siblings), birthorder_1 (which # in birth order are you?), parentincome_1 (parent's total income last year), parenteduc_1 (combined parent education), momrace_1 (mother's race), dadrace_1 (father's race), momrelig_1 (mother's religious preference), dadrelig_1 (father's religious preference), yourelig_1 (your religious prefence)
Survey data (Personal info)	selsa_rom_1 (romantic loneliness), selsa_fam_1 (family loneliness), selsa_soc_1 (social loneliness)
Survey data (Sex)	gender_1 (gender)
Survey data (Sleep)	PSQI_duration_1 (computed time in bed), PSQIGlobal_1 (PSQI total score), PSQIGroup_1 (PSQI two categories), MEQTotal_1 (MEQ (chronotype) score - high score morning person), MEQGroup_1 (MEQ (chronotype) groups - 5 categories))

have *A* grade on the majority, and we have very few instances from the *B-, C+, C, C-* classes. More specifically, we have 41856, 19321, 10048, 7265, 2526, 1617, 1258, 354, 4346 from classes *A, A-, B+, B, B-, C+, C, C-, S (satisfactory)*, respectively. To well classify minority classes, we applied the SMOTE (synthetic minority over-sampling) technique to produce synthetic data by keeping the same class distribution [**15**]. After SMOTE, we got 41856 instances from each class.

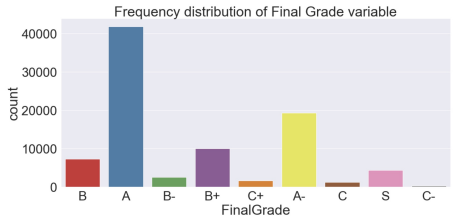

Figure 1: Target value distribution: Grade

3.3 Model details and performance metrics

As a classification method, we used RF algorithm because it is an ensemble method and performs better than the other used methods in literature in this domain [**16**]. The used parameters for RF are n estimators 1000, criterion Gini, and max features sqrt from scikit-learn toolkit[2]. %75 and %25 train and test sizes are chosen, respectively.

4 CLASSIFICATION PERFORMANCE EVALUATION

Since our target variable is already categorical, we used the dataset after preprocessing without any other change in the classification task. In Table 2, we present f1-score details of each class performance and the global average of the f1-scores with the accuracy metric. We obtained %76 average accuracy. We see that the best performances are achieved for the classes *B-, C+, C-, S*. Before SMOTE application, it was %65 average accuracy; furthermore, we had lower f1 scores for these indicated classes, but we did not present the details due to the page limit. The confused instances may be observed in Figure 2. For instance, *A* class is confused mostly with *A+* with an important ratio. It is expected since these are very close classes. The class *S* is mostly confused with others. It can be interpreted as expected since a satisfactory result corresponds to passing the course. SMOTE generates instances based on a similarity measurement rather than replicating existing ones. Thus, the bias is relatively lower compared to simple replications of instances since these are newly generated ones. Nevertheless, we also applied the under-sampling strategy and down-sampled higher class instances to be equal to the class with fewer instances. Thus, we obtained 354 instances for each class. When we applied RF to that data, we obtained even worse performance, which is 47% average accuracy. It is expected since we deleted most data points, so learning with few instances led to lower results.

In addition, in Figure 3, we provide the most critical factors to obtain this classification performance by calculating the most important 20 parameters via RF feature selection. The order is following: *MEQTotal (sleep), Trust (health), Extraversion (big five), selsa_soc (personal info), selsa_rom (personal info), Openness (big five), Neuroticism (big five), SRQE_Ext (health), dadage (origin), PSQI_duration (sleep), PSQIGlobal (sleep), BAISum (mental health), hsgrade (education), SRQE_Introj (health), CESDOverall (mental health), SelfEff_exercise_scale (health), Agreeableness (big five), momage (origin), MEQGroup (sleep).* The explanation of these parameters is presented in Table 1. We can interpret this result as the most important factors arrive from survey datasets. The important sub-surveys are sleep, big five, health, mental health, personal information, and origin.

[2]https://scikit-learn.org/stable/

Table 2: Classification performance details

	precision	recall	f1-score	support
A	0.53	0.56	0.55	10434
A-	0.52	0.44	0.47	10410
B	0.66	0.71	0.68	10449
B+	0.67	0.60	0.63	10507
B-	0.85	0.87	0.86	10507
C	0.89	0.92	0.91	10494
C+	0.88	0.89	0.88	10418
C-	0.98	0.98	0.98	10502
S	0.78	0.83	0.80	10455
accuracy			0.76	94176
macro avg	0.75	0.75	0.75	94176
weighted avg	0.75	0.76	0.75	94176

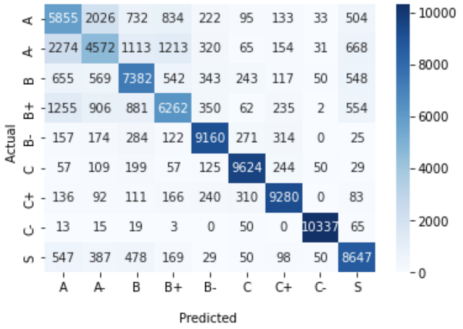

Figure 2: Confusion Matrix

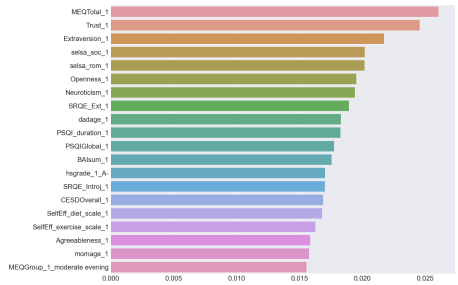

Figure 3: Feature Importance for Classification

5 DISCUSSION AND CONCLUSION

In this study, we applied a machine learning technique, RF, to see how accurately we can classify and predict students' grades using surveys and wearable data. In addition, we extract the most important factors affecting the model's performance. Results indicate *sleep, big five, health, mental health, personal information, and origin* survey parameters have higher effects on performance. We differ from state-of-the-art [**12**, **13**, **14**] by applying SMOTE.

For further research, one may examine other waves since there are 8 to obtain more instances from each class. Also, since the dataset is collected from one of the top University students, it is expected to have higher grades, i.e., A, A+. Thus, applying a similar experimental data collection setup to students with lower performances in the courses may be helpful.

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REFERENCES

[1] Misty, Lacour, and D. Tissington Laura. "The effects of poverty on academic achievement." Educational Research and Reviews 6.7 (2011): 522-527.

[2] Shephard, Roy J. "Curricular physical activity and academic performance." Pediatric exercise science 9.2 (1997): 113-126.

[3] Purta, Rachael, et al. "Experiences measuring sleep and physical activity patterns across a large college cohort with fitbits." Proceedings of the 2016 ACM international symposium on wearable computers. 2016.

[4] GOMES, Maria V., Luciano Francisco Sousa ALVES, and Louelson AL COSTA. "de Azevedo." Dinâmica socioespacial urbana de Cuité–PB resultante da implantação do campus de saúde e educação da UFCG. 152f. João Pessoa (2014).

[5] Purta, Rachael, et al. "Experiences measuring sleep and physical activity patterns across a large college cohort with fitbits." Proceedings of the 2016 ACM international symposium on wearable computers. 2016.

[6] Vhaduri, Sudip, and Christian Poellabauer. "Multi-modal biometric-based implicit authentication of wearable device users." IEEE Transactions on Information Forensics and Security 14.12 (2019): 3116-3125.

[7] Purta, Rachael, et al. "Experiences measuring sleep and physical activity patterns across a large college cohort with fitbits." Proceedings of the 2016 ACM international symposium on wearable computers. 2016.

[8] Fridmanski, Ethan, et al. "Clustering in a newly forming social network by subjective perceptions of loneliness." Journal of American College Health (2020): 1-6.

[9] Liu, Shikang, et al. "Network analysis of the NetHealth data: exploring co-evolution of individuals' social network positions and physical activities." Applied network science 3.1 (2018): 1-26.

[10] Faust, Louis, et al. "Physical activity trend extraction: a framework for extracting moderate-vigorous physical activity trends from wearable fitness tracker data." JMIR mHealth and uHealth 7.3 (2019): e11075.

[11] StudentLife Dataset 2014. http://studentlife.cs.dartmouth.edu/.

[12] Wang, Rui, et al. "StudentLife: assessing mental health, academic performance and behavioral trends of college students using smartphones." Proceedings of the 2014 ACM international joint conference on pervasive and ubiquitous computing. 2014.

[13] Wang, Rui, et al. "SmartGPA: how smartphones can assess and predict academic performance of college students." Proceedings of the 2015 ACM international joint conference on pervasive and ubiquitous computing. 2015.

[14] Sano, Akane, et al. "Recognizing academic performance, sleep quality, stress level, and mental health using personality traits, wearable sensors and mobile phones." 2015 IEEE 12th International Conference on Wearable and Implantable Body Sensor Networks (BSN). IEEE, 2015.

[15] Chawla, Nitesh V., et al. "SMOTE: synthetic minority over-sampling technique." Journal of artificial intelligence research 16 (2002): 321-357.

[16] Can, Yekta Said, et al. "Stress detection in daily life scenarios using smart phones and wearable sensors: A survey." Journal of biomedical informatics 92 (2019): 103139.

Detection of postpartum anemia using machine learning

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ABSTRACT

Postpartum anemia is seen as a health problem and should be treated. We evaluate performance of nine machine learning regression models in predicting the postpartum anemia six weeks after childbirth. We focus on tree key parameters: ferritin, haemoglobin, and transferrin saturation. Our models are compared with the baseline model, which always predicts the mean value of the training data. We found that the models for ferritin and transferrin saturation have good predictive performances, whereas this was not the case for haemoglobin prediction, as all of the implemented models were outperformed by the baseline model.

KEYWORDS

postpartum anemia, haemoglobin level, machine learning

1 INTRODUCTION

Postpartum anemia is a common maternal health problem globally and constitutes a significant health problem in women after birth, even in the developed world. Women may develop it either because of antepartum depletion of iron stores or peripartum excessive blood loss [1]. It is associated with several negative consequences, such as maternal fatigue [2, 3]. With the unacceptably high prevalence of anaemia in women after childbirth in both, up to 50% in developed and up to 80% in developing countries [4], it appears to be of great importance to treat iron deficiency effectively. Ferrum sulphate perorally is the most commonly used iron for pospartum anemia because of its low cost and simple use. Definition of postpartum anaemia rely on haemoglobin values alone, defined as Hb level <100 g/L. Postpartum haemorrhage defined as a blood loss of 500 ml or more within 24 hours after birth is one of the most frequent complications of delivery. This makes women vulnerable and frequently results in postpartum anemia. Consequently, this increases the risk for a peripartum blood transfusion, a treatment with potential severe adverse outcomes [5]. With the unacceptably high prevalence of anaemia in women after childbirth in both, up to 50% in developed and up to 80% in developing countries [4], it appears to be of great importance to treat iron deficiency effectively. In addition to the increased transfusion risk, peripartum iron deficiency anaemia can affect the wellbeing of both the mother and child. It causes cardiovascular symptoms like palpitations and dizziness, breathlessness. It increases a risk of infections as well as excessive postpartum bleeding. Furthermore, postpartum anemia adversely affects maternal mood, cognition, and behavior resulting in increased fatigue, reduced physical and mental performance [6]. This is associated with several negative consequences, such as impaired health-related quality of life [3]. Impaired health-related quality of life linked to postpartum anemia include depression, fatigue, and reduced cognitive abilities. All of these symptoms significantly interferes with mother-child interactions and impact a woman's ability to breastfeed [1].

Postpartum anemia should be treated by restoring iron stores. Although there is a number of treatment options for women with postpartum anaemia, the debate about iron supplementation and the ideal form of administration is ongoing and is not universal in all countries. Currently, common treatment includes iron supplementation administered orally or intravenouslly (IV). The traditional treatment for mild to moderate iron deficiency anaemia is oral supplementation of iron with iron sulfate perorally because of its low cost and simple use. There are advantages and disadvantages of either of the two approaches, which we will not go into detail here. Since the postpartum anaemia contributes to a major healthcare problem even in developed countries, it is important to treat it efficiently [7]. However, IV iron may be preferred because the non-compliance and absorption challenges of oral iron, but it includes increased drug costs and the need for supervised treatment in healtcare institutions. Recent robust studies have compared different iron preparations and there has been a network meta-analysis of different iron medications. However, no randomized clinical trial has directly compared intravenous derisomaltosie, intravenous carboxymaltose and peroral ferrous sulphate for treatment of postpartum anemia, including fatigue measurements.

In this paper, we address the question on predicting the postpartum anemia six weeks after childbirth. We look at three key parameters from blood tests that are related to anemia, namely

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Table 1: Dataset features.

Personal	Blood test
Age [years]	Haemoglobin [g/L]
Gestational age [weeks]	Serum iron [μmol/L]
Number of children born	TIBC [μgmol/L]
Number of total pregnancies	Transferrin saturation [%]
Number of total childbirths	Ferritin [μg/L]
Number of total abortions	Phosphate [mg/dL]
Type of childbirth	CRP [mg/L]
Transfusion	
Marital status	
Education	
BMI before childbirth	
BMI after childbirth	
Medication	

the ferritin, haemoglobin, and transferrin saturation. Using a database containing 296 patients that were diagnosed with anemia, we investigate the possibilities to predict these relevant blood test values using machine-learning models. We present the results of our initial studies.

2 DATA

The initial dataset included 296 patients that were diagnosed with anemia and 27 features that had some missing values. As this was our initial study, we did not perform any missing data inputation, but rather dropped the patients that had missing values in any of the columns. We were left with 224 patients that had data for all 27 features. Based on the medications that the patients were given during their treatment, they can be separated in three groups: 80 of the patients were treated with Iroprem, 75 were treated with Monofer, and 69 were treated with Tardyfer. Both Monofer and Iroprem are IV medications with iron, while Tardyfer is administered orally as tablets.

The data included personal data and blood test results. Blood tests were performed both right after the childbirth as well as six weeks after. The list of personal and blood test features is given in Table 1.

In the dataset, there are 13 personal features and $2 \cdot 7$ blood test features. Among personal features, gestational age corresponds the number of weeks since the last period. The type of childbirth is a categorical variable and can either be vaginal delivery, planned Cesarean section, or elective Cesarean section. Transfusion is a binary variable indicating whether a patient needed a blood transfusion after the childbirth or not. Marital status is a categorical variable and can either be lives alone, married, or non-marital partnership. Education is ordinal variable of 10 different values with the lowest representing elementary school education and the highest representing a doctoral degree. Lastly, BMI stands for body mass index.

In the blood test features, serum iron describes the amount of iron in the blood. TIBC stands for total iron binding capacity, which is a good indicator of the amount of iron in blood. If the iron level in blood is low, the TIBC is higher as the free capacity for binding of the iron is higher. Transferrin saturation is the value of serum iron divided by the TIBC of the available transferrin. The higher the transferrin saturation, the bigger the iron stores in the body. Lastly, CRP stands for C-reactive protein, which is high is there is inflammation in the body. Inflammation can also be cause as a consequence of an injury during childbirth or Cesarean section. Typically, CRP levels are increased after childbirth. If the high level of CRP (>8 mg/L) still persists after six weeks after the childbirth, this indicates inflammation.

3 METHODOLOGY

The aim of this initial study was to evaluate the performance of several machine learning (ML) models in predicting the values of haemoglobin, ferritin, and transferrin saturation levels in blood of the anemia patients six weeks after childbirth, as these parameters are related to anemia. The input of the models were personal features and the features of the blood test immediately after the childbirth. In each experiment, only one of the three quantities was the output. Thus, we ran three experiments with the same input and different outputs. Additionally, we ran additional separate experiments for each of the three medication groups. We compared our results with the baseline, which always predicted the mean output value of the training data.

4 RESULTS

Our dataset included 224 patients with 20 predictor features. We used mean absolute error (MAE), root mean squared error (RMSE), and mean absolute percentage error (MAPE) as the evaluation metrics, with MAE as the main metric of performance evaluation. Formulas for calculation of MAE, RMSE , and MAPE are given in equations (1), (2), and (3). Parameter y_i denotes predicted values, x_i denotes true values, and n denotes the total number of data points.

$$MAE = \frac{\sum_{i=1}^{n} |y_i - x_i|}{n} \tag{1}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (y_i - x_i)^2}{n}} \tag{2}$$

$$MAPE = \frac{1}{n} \sum_{i=1}^{n} \left| \frac{x_i - y_i}{x_i} \right| \tag{3}$$

We implemented nine ML regression models. Regression models predict a continuous variable(s). Linear regression (LR), Kernel Ridge (KR), and elastic net regression (EN) find linear correlations between the predictor features and the output. Bayesian ridge regression (BR) formulates linear regression using probability distributions rather than point estimates. Support vector regression (SVR) finds a hyper-plane in the feature space that has maximum number of data points. Gradient boosting regressor (GB), Light gradient boosting machine (LGBM), extreme grading boosting regressor (XGB), and CatBoost regressor (CB) are ensemble methods that combine the predictions of multiple decision tree regressors. A decision tree regressor uses a tree diagram for decision making, where each branch is partitioned based on a threshold for a predictor feature.

The models trained on the whole dataset were compared in a 10-fold cross validation with the folds stratified with respect to the medication. The models trained for separate medication only were compared in a 5-fold cross validation due to the smaller dataset size. For each of the output variables, we also show a histogram of values distribution along with the mean and standard deviation (SD).

The models' training and performance evaluation was done using Python 3.7 and libraries Numpy 1.18.5 [8], Scikit 0.24.2 [9], LightGBM 3.2.1 [10], XGBoost 1.4.2 [11], and CatBoost 0.26 [12].

4.1 Ferritin

Distribution of ferritin blood levels six weeks after childbirth is given in Figure 1. We see that the patients that were given medication Tardyfer had significantly lower levels than those that were given medications Iroprem or Monofer. The mean and SD values of the distribution are 185.88 μg/L and 141.31 μg/L, respectively. Results of the regression models are given in Table 2.

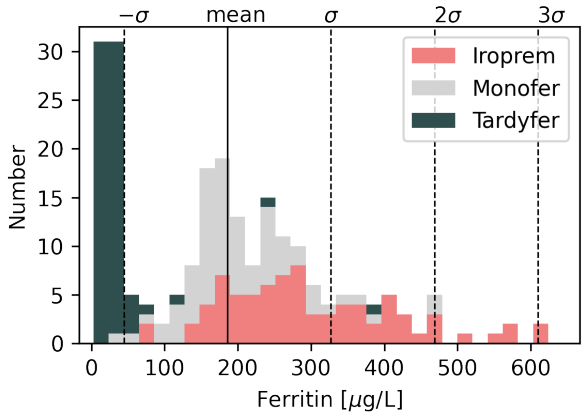

Figure 1: Distribution of ferritin blood levels in patients six weeks after childbirth.

Table 2: Results for the prediction of ferritin.

Model	MAE	RMSE	MAPE [10^{-2}]
CB	**61.96**	**87.44**	80.11
XGB	62.76	93.97	**61.23**
LGBM	63.07	88.31	65.88
GB	64.14	91.32	83.86
LR	68.42	89.45	86.26
KR	69.3	90.62	80.2
EN	79.64	99.56	158.81
BR	80.43	101.93	135.88
Baseline	111.81	138.88	272.51
SVR	112.91	140.25	260.76

We see that the best performing model according to both metrics was the CB. Except for the SVR, other models have had similar performances to that of CB. Additionally, we see that most of the models significantly outperform the baseline.

The results of the models performance of predictions for separate medications only are shown in Table 3. The models within each medication have similar performances. In the case of Monofer, all of the models' performances are worse than that of the baseline.

4.2 Haemoglobin

Distribution of haemoglobin blood levels six weeks after childbirth is given in Figure 2. We see that the distributions are very similar between all three medication groups. The mean and SD values of the distribution are 133.87 g/L and 8.10 g/L, respectively. Results are given in Tables 4 and 5.

Table 3: Results for the prediction of ferritin for each medication separately.

Model	Iroprem MAE	Monofer MAE	Tardyfer MAE
LR	93.65	70.85	41.33
LGBM	86.19	57.03	21.74
XGB	95.48	62.44	19.43
CB	**81.26**	58.78	20.48
KR	98.90	69.93	33.11
EN	92.76	63.77	31.81
BR	96.24	61.47	21.99
GB	88.37	70.00	25.69
SVR	97.41	58.20	**19.27**
Baseline	94.61	**55.87**	23.42

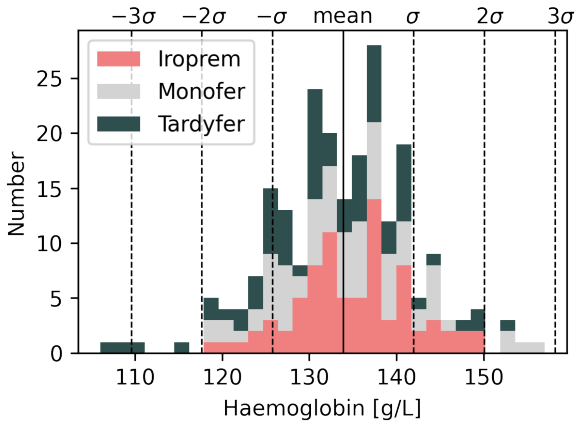

Figure 2: Distribution of haemoglobin blood levels in patients six weeks after childbirth.

Table 4: Results for the prediction of haemoglobin.

Model	MAE	RMSE	MAPE [10^{-2}]
Baseline	**6.11**	**8**	**4.62**
BR	6.31	8	4.77
SVR	6.33	8.01	4.80
EN	6.56	8.22	4.96
LR	6.67	8.41	5.03
CB	6.74	8.34	5.10
LGBM	7.16	8.93	5.41
XGB	7.2	9.19	5.44
GB	7.28	9.03	5.52
KR	7.43	9.45	5.59

We see that the models do not perform well in predicting haemoglobin, as they perform worse than the baseline for both the general case and the separate medication cases.

4.3 Transferrin saturation

Distribution of transferrin saturation in blood six weeks after childbirth is given in Figure 3. We see that the distributions are very similar between all three medication groups. The mean and SD values of the distribution are 33.56 % and 11.53 %, respectively. Results of the regression models are given in Table 6.

Table 5: Results for the prediction of haemoglobin for each medication separately.

Model	Iroprem MAE	Monofer MAE	Tardyfer MAE
LR	6.99	7.04	8.17
LGBM	5.46	6.41	8.21
XGB	6.38	6.58	9.20
CB	5.75	6.58	8.03
KR	7.65	7.13	8.63
EN	5.69	6.43	7.36
BR	5.31	6.45	7.33
GB	5.79	7.23	9.41
SVR	5.42	6.62	7.28
Baseline	**5.17**	**5.85**	**7.22**

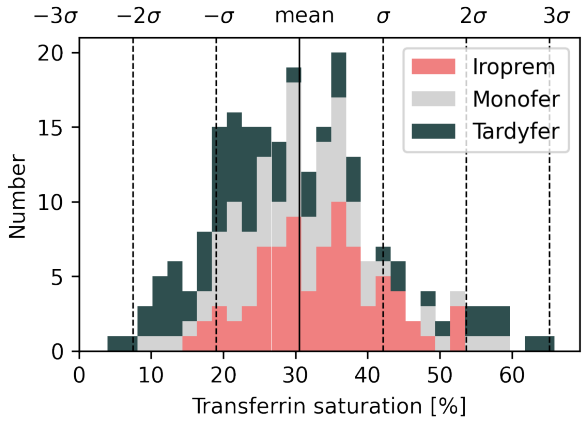

Figure 3: Distribution of transferrin saturation in blood of patients six weeks after childbirth.

Table 6: Results for the prediction of transferrin saturation.

Model	MAE	RMSE	MAPE $[10^{-2}]$
KR	**8.74**	**10.93**	**36.74**
LR	8.78	10.97	36.80
EN	8.82	11.14	38.45
Baseline	8.88	11.12	39.16
SVR	9.11	11.38	39.51
CB	9.11	11.31	38.81
BR	9.22	11.41	40.49
GB	9.51	11.89	40.20
LGBM	9.55	12.10	39.58
XGB	9.62	12.11	39.64

We see that the top three performing models outperform the baseline, with the best model being the KR. The results of the models performance of predictions for separate medications only are shown in Table 7. Unlike Monofer and Tardyfer, the models do not perform well in the case of Iroprem.

5 DISCUSSION AND CONCLUSION

We evaluated nine classic machine learning regression models for the prediction of three key parameters associated with anaemia collected from blood tests six weeks after childbirth: ferritin, haemoglobin, and transferrin saturation. We compared the results with the baseline model, which always predicted the output mean of the training data. We found that the models for ferritin and transferrin saturation had good predictive performance, whereas this was not the case for haemoglobin prediction, as all models were outperformed by the baseline model.

Table 7: Results for the prediction of transferrin saturation for each medication separately.

Model	Iroprem MAE	Monofer MAE	Tardyfer MAE
LR	7.68	9.4	11.84
LGBM	7.16	**7.59**	11.39
XGB	8.36	9.12	12.86
CB	7.2	7.87	11.44
KR	7.73	8.94	12.01
EN	7.16	8.54	**11.24**
BR	6.8	7.83	12.02
GB	7.88	8.78	11.61
SVR	6.94	7.62	11.62
Baseline	**6.49**	7.75	11.82

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REFERENCES

[1] Nils Milman. 2011. Postpartum anemia i: definition, prevalence, causes, and consequences. *Annals of hematology*, 90, 11, 1247–1253.

[2] Kathryn A. Lee and Mary Ellen Zaffke. 1999. Longitudinal changes in fatigue and energy during pregnancy and the postpartum period. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*, 28, 2, 183–191.

[3] Kiyoshi Ando et al. 2006. Health-related quality of life among japanese women with iron-deficiency anemia. *Quality of life research*, 15, 10, 1559–1563.

[4] Nils Milman. 2012. Postpartum anemia ii: prevention and treatment. *Annals of hematology*, 91, 2, 143–154.

[5] Andreas Greinacher, Konstanze Fendrich, Ralf Brzenska, Volker Kiefel, and Wolfgang Hoffmann. 2011. Implications of demographics on future blood supply: a population-based cross-sectional study. *Transfusion*, 51, 4, 702–709.

[6] Christian Breymann. 2005. Iron deficiency and anaemia in pregnancy: modern aspects of diagnosis and therapy. *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 123, S3–S13.

[7] Lisa M. Bodnar, Anna Maria Siega-Riz, William C Miller, Mary E Cogswell, and Thad McDonald. 2002. Who should be screened for postpartum anemia? an evaluation of current recommendations. *American journal of epidemiology*, 156, 10, 903–912.

[8] Charles R. Harris, Jarrod K. Millman, Stefan J. van der Walt, Ralf Gommers, Pauli Virtanen, and David Cournapeau. 2020. Array programming with numpy. *Nature*, 585, 357–362. DOI: https://doi.org/10.1038/s41586-020-2649-2.

[9] F. Pedregosa et al. 2011. Scikit-learn: machine learning in Python. *Journal of Machine Learning Research*, 12, 2825–2830. http://www.jmlr.org/papers/volume12/pedregosa11a/pedregosa11a.pdf.

[10] Guolin Ke, Qi Meng, Thomas Finley, Taifeng Wang, Wei Chen, Weidong Ma, Qiwei Ye, and Tie-Yan Liu. 2017. Lightgbm: a highly efficient gradient boosting decision tree. In *Proceedings of the 31st International Conference on Neural Information Processing Systems* (NIPS'17). Curran Associates Inc., Long Beach, California, USA, 3149–3157. ISBN: 9781510860964.

[11] Tianqi Chen and Carlos Guestrin. 2016. XGBoost: a scalable tree boosting system. In *Proceedings of the 22nd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (KDD '16). ACM, San Francisco, California, USA, 785–794. ISBN: 978-1-4503-4232-2. DOI: 10.1145/2939672.2939785.

[12] Liudmila Prokhorenkova, Gleb Gusev, Aleksandr Vorobev, Anna Veronika Dorogush, and Andrey Gulin. 2018. Catboost: unbiased boosting with categorical features. In *Proceedings of the 32nd International Conference on Neural Information Processing Systems* (NIPS'18). Curran Associates Inc., Montréal, Canada, 6639–6649.

Covid symptoms home questionnaire classification and outcome verification by patients

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ABSTRACT

Testing for Covid, in a time of pandemic, can put a lot of overhead on the medical and testing facilities. Moreso, in a pandemic crisis, people become more hypochondriacs and get tested even if a slightest symptom of Covid is detected. This leads to many people, infected and not infected, to gather at the medical facilities, thus increasing the possibility for not infected people to get Covid infection. Our application registers patients and, by using a medical survey, determines if the patient is supposed to get tested for Covid or even more severe measure are to be taken. Additionally, our application uses medical tests results from patients to determine the success rate of the prediction. The case study has shown that the application has 89% success rate of classification. Using this application, only people with the right symptoms will be advised to get tested, thus lowering the overload placed on the medical facilities and minimizing the virus spread.

KEYWORDS

analysis, classification, Covid, survey, symptoms, test cases

1 Introduction

Although world-wide pandemics are not that often, yet Covid pandemic hit the world fast, with many patients dying and doctors not being able to understand the cause in time. The aftereffect of the pandemic has left many people with health issues with more and more people becoming hypochondriacs. Technology was and is still used to alleviate the hit from the virus and help prevent the spread of the corona virus and maintain the current lifestyle as much as possible. On the other side, technology was used to help fight against the virus and return life to its original form.

A lot of research has been done on the Covid virus and Corona outbreak, including image processing, machine learning and so on. In [1], they give a summary of the different machine learning techniques to predict and classify covid-19 cases. They are using mathematical models and machine learning to predict Covid-19 cases. The authors in [2], have further used machine learning and image processing to determine the cause of pneumonia in covid-19 infected patients. They are using X-rays and CT images to create a software to determine how to classify patients based on pneumonia and Covid-19 images.

The machine learning approach is also used in most papers but in [3], authors are trying to investigate the best possible options and weight distribution in the ML techniques to get the best results when working with Covid-19 data. They are using different approaches to get the best results when combining ML and Covid. Furthermore, [4] is again using CT scans and ML to classify patients as infectious or not, which would be useful to decrease infection spread amongst the population.

Much like in [1], authors in [5] are helping other authors with an overview of the ML techniques. Additionally, they are offering data sets to help with the further investigation. The research done in [1] and [5], coupled with the research in [6], gives authors the means, the knowledge, the data set and the information on how to proceed with the research for covid and ML. The research in [6] evaluates all the data and the publishing process of papers regarding Covid and ML and how the publication process changes the initial paper submission.

Further analysis is done in [7] about covid detection and CT images using a pre-trained data set that can help classify the new data set before training and testing using deep learning and multi-layered convolution algorithms. This way, the data set can be increased and overcome the persisting problem of ML with not having enough data to perform the training and testing. The overall analysis of all the research in ML and data set is concluded by the authors in [8], where they give a detailed analysis of the functions and usage of ML and Covid.

There is a lot of research of Machine Learning/Deep Learning techniques to detect Covid using medical images. Our approach is simpler and uses medical questionnaires and human input to improve the detection of Covid 19 in patients. The architecture of our Covid Medical App system is described in Section 2, whereas the behavior and case scenarios are described in Section 3. Section 4 concludes the paper and gives information about further development.

2 Architecture of the system

The Covid Medial Application is designed to help patients and the health system by classifying patients into six categories. These categories range from the patient not having Covid (or the least suspect of a Covid infection), to an almost certain Covid infection (requires isolation and medical treatment). The users of the applications are taking a short survey (questionnaire) about their wellbeing and symptoms, and the result of the questionnaire is the classification of the user into one of categories [9]. The application accesses the survey from an API that is standardized and provided by the InferMedica Medical Platform, implemented and approved by World Health Organization (WHO). The API contains all sorts of Covid data that can be retrieved and many surveys the users can take, our application utilizes only the API for classification of Covid, which is done based on symptoms and patient's wellbeing.

Besides all the Covid recommendations and information that is displayed in the application, the users can take the survey and find out,

based on their symptoms, in which category they belong. The categories are:

- No risk – the patient is the least likely to have Covid
- Self-monitoring – the patient should continue to monitor the symptoms but is not likely to have Covid
- Call a doctor – there is an infection, but it is not Covid-related
- Quarantine – the patient is advised to quarantine himself from the environment and perform Covid tests
- Isolation call – the person should isolate themselves from the environment with high probability for Covid infection
- Isolation ambulance – the person has high probability for Covid infection and should call for ambulance since the symptoms are severe.

The architecture and the organization of the application is presented on Figure 1.

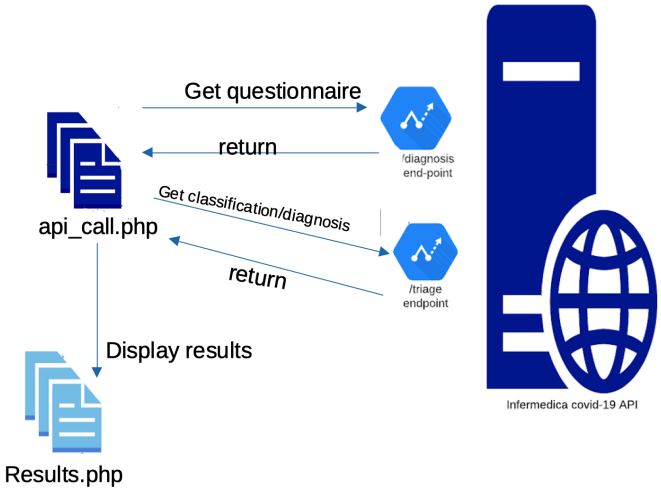

Figure 1 Organization of the application

On Figure 1 we can see that our application is a wrapper around the API provided from InferMedica, which first and foremost, provides a human readable survey that patients can take and classify their symptoms into a category. The questionnaire helps patients with symptoms of Covid to determine the best possible action to take, in case they are suspecting Covid infection. Users of the application access it via web link, where users can get Covid-related information, access their profile and take the questionnaire. The questionnaire taken from a patient is packed, formatted and sent to the API, the API returns the result, which is displayed back to the patient.

As presented on Figure 1, we can see that the application uses two APIs from InferMedica. The first API is diagnosis endpoint, that we use to obtain the questions to form the questionnaire. These questions are predetermined, can easily be translated into any language, and be adapted if the questionnaire changes from the endpoint. The second API is the triage endpoint that is used to perform the diagnosis and classification of the patient. Also, the result returns a short info status that is presented to the patient with information about how to proceed with the diagnosis and recommendations. This information can also be easily translated and wrapped.

Patients that might have higher risk of Covid infection (placed in that category by the API) can isolate themselves in time to prevent others to be infected. Furthermore, the entire pandemic made many patients hypochondriacs and suspect Covid symptoms even for a small cough. Thus, by using this application, if they get classified in no Covid infection categories, uninfected patients can avoid going to the hospitals for unnecessary Covid tests, and reducing the possibility to get infected in the testing areas.

On the figure below (Figure 2), we can see a part of the survey interface and the questions that the users have to answer to be classified in the categories.

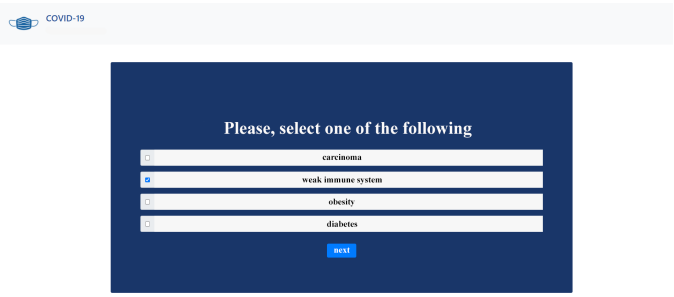

Figure 2 Questions from the survey (multipart)

The series of questions can vary from input fields for body temperature measured or blood pressure, to multiple choice questions and Yes/No questions. The requirements from the questionnaire are simple and easily understandable that every patient can answer even if with severe health issues. The interface is adjusted and simplified as to not impose any incorrect information that could lead to a faulty classification.

On Figure 3 we can see a list of results that the patient received, as a result of the survey. From Figure 3, we can see that the information is presented in different color based on the severity of the classification, followed by a short information summary intended for the classification. The patient can take the questionnaire multiple times, and each result is marked and presented to the user with the date and time of the questionnaire taken and the result.

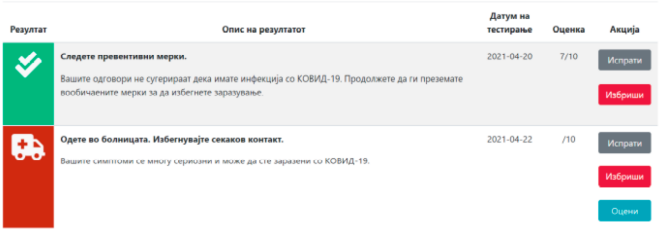

Figure 3 Result of the classification

On the other hand, medical personnel also have access to these classifications, but only to patients that they have been assigned to. Based on the outcome of the classification, the medical personnel can schedule an appointment for testing or send an ambulance to the appointed address. The panel of the medical personnel is similar to the

one of the patient's, except it additionally displays the information of the patient that took the survey and contact information.

3 Evaluation of the system

Each medical classification system cannot guarantee a faultless classification method, so there is always a chance that the classification might not be correct. If there are numerous of medical tests and findings, a different doctor might give a different diagnosis and classification of a patient's condition. Even more so in our case, where we are using a questionnaire to classify a patient in a six different Covid categories, it gives a rough classification as a basic step of the diagnosis. The questionnaire, as stated before, is taken from Infermedica, which was previously issued by the WHO, but it is not something that can be used with absolute certainty and fully depended upon. That is why, in this section of the paper, we are also making an evaluation of the results of the questionnaire.

Our medical application allows users to take a Covid survey based on their symptoms and be classified into categories of high to low Covid infection. Alongside with the classification, a short information is presented on how to proceed with their result and how to minimize further infection on other patients. The survey, as stated before, is intended to keep patients with low risk of infection to visit Covid testing places in order to avoid getting infected. Also, by advising patients with low possibility of Covid infection to not get tested, reduces crowding the medical facilities and Covid test centers, thus reducing overhead of the medical system. However, patients can still ignore the results from our application and get tested to make sure if they have Covid or not.

The case study of the API and our application was conducted with 20 patients who already have been tested with Polymerase Chain Reaction (PCR) test for Covid in the past. More than half of the patients (15 of them) have been tested twice for Covid, thus the total number of test cases is 35. The patients already had the diagnosis for Covid from their PCR test before the survey was taken on our application. After which, we have compared the results from the survey with the results from the PCR tests of the patients. The results from the case study are presented on Figure 4.

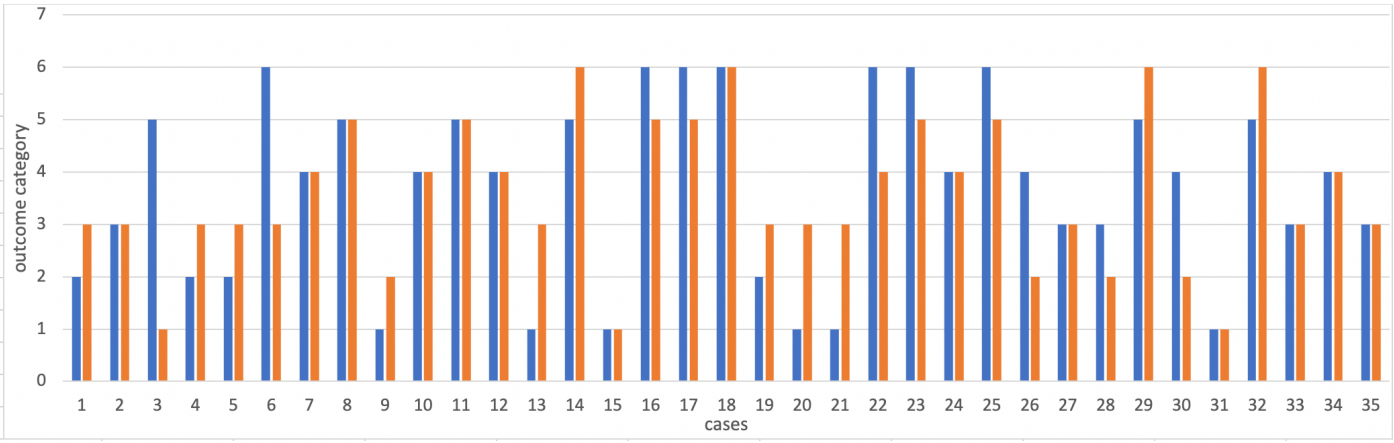

Figure 4 Results from the case study of our application with 35 tests

On Figure 4 we can see the results from our application (shown with blue bars) and the results from the PCR tests (shown with orange bars). As we can see from the results, the PCR and the application bars are mostly the same. The deviation in the PCR and the application results are mostly in categories one, two and three. The most common error is when the API suggests category one, but the PCR shows category three. This error is minimal since the first three categories are linked with low to no infection. The next frequent error is in the last two categories, when the API suggests category five, but the PCR suggests category six and vice versa. If we put the results of the questionnaire in binary form (the patient has Covid or the patient doesn't have Covid), the first three categories will form the result that the patient doesn't have Covid, whereas the last three categories will form the result that the patient has Covid. If the categories are binary, the error between the API and the PCR is close to zero. The minimal diversion is detected in the subcategories presented by the questionnaire. Also, the PCR gives information as to whether the patient has or hasn't got Covid, the subcategorizing is done based on hospitalization of the patient and the recommendations received from their doctor.
If we consider the six categories offered by the API, the overall success rate of the API, compared with the PCR tests is at 85% of accurate prediction and classification. If we consider the binary classification, the success rate of the API is increased to 89%.

4 Conclusion

Our application tends to use a simplified system for online diagnosis of Covid patients that uses questionnaire designed to give initial diagnosis of the patient. This initial diagnosis is used to give patients information as to whether they have Covid or not and to suggest testing and medical care, only if necessary, thus reducing the overhead on the testing places and the medical facilities from patients that are with low risk or no infection at all. The case study in section III shows that the questionnaire is accurate enough to give initial diagnosis and sufficient enough to determine if the patient has Covid or not with 89% accuracy.

For future work we propose testing the system with patients before they go to the hospital or testing facilities for Covid. The user can update the results of the API with the results from the medical/test facilities. This can be done by result category, and the system can present the accuracy of the API result next to the result. Thus, users can get classified into the categories, but also receive accuracy information provided by users of the application that have been classified and afterwards tested.

References

[1] Swapnarekha, H, Behera, S., Nayak, J., Naik, B., Role of intelligent computing in COVID-19 prognosis: A state-of-the-art review, Chaos, Solitons & Fractals, Volume 138, 2020, ISSN 0960-0779

[2] Bharati, S., Podder, P., Mondal, R. H, Prasath, S., Medical Imaging with Deep Learning for COVID- 19 Diagnosis: A Comprehensive Review, arXiv:2107.09602

[3] Mohammed, M., Abdulkareem, K., Al-Waisy, A., Benchmarking Methodology for Selection of Optimal COVID-19 Diagnostic Model Based on Entropy and TOPSIS Methods, IEEE Access, May 2020, 10.1109/ACCESS.2020.2995597

[4] Subhalakshmi, R.T., Appavu, S, Sasikala, S., Deep learning based fusion model for COVID-19 diagnosis and classification using computed tomography images, oncurrent Engineering: Research and Applications 2022, Vol. 30(1) 116–127

[5] Chadaga, K., Prabhu, S., Vivekananda, B., Battling COVID-19 using machine learning: A review, Cogent Engineering, 8:1, 1958666, DOI: 10.1080/23311916.2021.1958666

[6] Jemioło, P.; Storman, D.; Orzechowski, P. Artificial Intelligence for COVID-19 Detection in Medical Imaging—Diagnostic Measures and Wasting—A Systematic Umbrella Review. *J. Clin. Med.* **2022**, *11*, 2054. https://doi.org/10.3390/ jcm11072054

[7] Mehboob, F., Rauf, A., Jiang, R. *et al.* Towards robust diagnosis of COVID-19 using vision self-attention transformer. *Sci Rep* **12**, 8922 (2022). https://doi.org/10.1038/s41598-022-13039-x

[8] Swapnarekha, H., Behera,H., Nayak, J., Naik, B., Role of intelligent computing in СнOVID-19 prognosis: A state-of-the-art review, Chaos, Solitons & Fractals,Volume 138,2020,ISSN 0960-0779,https://doi.org/10.1016/j.chaos.2020.109947.

[9] Infermedica Medical Platform, Covid-19 survey API, https://developer.infermedica.com/docs/api

Piloting ICT Solutions for Integrated Care

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ABSTRACT

The SI4CARE project is aiming to develop a strategy and action plans to improve health and social care in the Adriatic-Ionian region. It started with surveying the state of affairs in the region, identifying needs and challenges, as well as best practices that can answer them. Based on these, wishes for improvement were formulated. The paper describes the methodology of this process and the key findings. Some of the best practices are being piloted to support the development and monitoring of the policy actions. In the paper, we describe nine pilots that involve pervasive health technology and otherwise strongly leverage ICT to benefit senior users. Most employ wearables and other sensing devices to monitor the users and provide health and care services, or provide telehealth and care through web and mobile technology.

KEYWORDS

Social innovation, integrated care, telehealth, telecare, transnational strategy, action plan

1 INTRODUCTION

The population of Europe and the rest of the developed world is rapidly aging. In the last 20 years, the old-age dependency ratio of working-age population vs. seniors in Europe decreased from 4 : 1 to 3 : 1, and it is projected to further decrease to 1.75 : 1 by 2050 [1]. This will result in a range of problems, including a lack of people who can support the seniors once they can no longer live independently. These problems will have to be tackled from multiple angles: with demographic policies, increases in retirement age, and social and technological innovations that can improve the care for the seniors and their quality of life.

The SI4CARE project [2] aims to create a transnational ecosystem for social innovation in integrated care with a focus on ICT technology. It started with surveying the status quo of health and social care in the Adriatic-Ionian region, identifying needs and challenges, as well as best practices that can answer them. It then formulated wishes and actions for improved health and social care, which will eventually result in a transnational strategy and national/regional action plans.

To gain a deeper insight into the benefits of the identified best practices and ways of implementing them, the project started 13 pilots in seven countries. We describe the nine that involve pervasive health technology and otherwise strongly leverage ICT to benefit senior users. Most employ wearables and other devices to monitor the users and provide health and care services, or provide telehealth and care through web and mobile technology.

2 SI4CARE PROJECT: FROM STATUS QUO TO ACTION

The SI4CARE project used a systematic and evidence-based approach for devising a strategy and actions to improve integrated care via social and technological innovation, with the aim of presenting solid arguments to decision makers.

2.1 Status Quo of Health and Social Care

The first step was to survey the status quo (the state of affairs) in health and social care in the Adriatic-Ionian region, comprising Slovenia, Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Greece and Italy. Four key activities were done:

- We surveyed the literature, such as statistical reports, national and regional policy documents and legislation.
- We conducted semi-structured interviews with high-level stakeholders such as highly placed employees at relevant

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ministries, non-governmental organizations and educational institutions. The interviews included 26 questions on the healthcare system, financial and physical accessibility of healthcare services, future challenges and other topics. 31 stakeholders were interviewed in total. Qualitative analysis of the answers was performed, focusing on the main points raised among the participants.

- We administered a questionnaire to various people employed in health and social care services. The questionnaire included 29 items on the use of healthcare services by seniors, their accessibility, the ability to obtain information on healthcare, and the status of seniors in the society and their social care. A subset of these questions was asked specifically about people with memory impairment or dementia. We received responses from 222 health and social care staff.
- We administered the same questionnaire to seniors. We received responses from 619 people.

Our finding was that in general, the provision of healthcare services is moderately good, with a lack of human resources cited as a key problem. Rehabilitation was noted to be less available than other services, and people with dementia face more problems than the general elderly population. A significant problem is that seniors are poorly informed about healthcare.

Even though healthcare is mostly covered by insurance, many seniors face significant financial problems, mainly due to low pensions. In part, this appears to be because, despite the insurance, they sometimes still need to resort to private services. Waiting times are a common issue, which may explain the use of private services. Physical accessibility is also a major issue – the seniors have significant difficulties using public transport. Secondary healthcare for people living in rural areas was also found to be difficult to access.

Seniors have a low digital literacy and find anything involving the internet (e.g., booking an appointment) a major problem. High-level stakeholders feel that new technologies have not been successfully integrated in the healthcare system, and this is even more true for the questionnaire respondents. Most stakeholders believe such technologies are important, though, validating the objectives of the SI4CARE project.

2.2 Best Practices

The SI4CARE project identified and documented 115 best practices in social and technological innovation to improve the care and quality of life of seniors, selected based on their effectiveness as demonstrated by experience.

Since SI4CARE emphasizes the use of ICT technologies in integrated care, most of the identified best practices are technology-based. The largest group involve pervasive health technology, such as wearables to monitor users, either to help them manage their health or to provide functions such as fall detection. Some also use sensing integrated in fitness devices or 3D cameras to support rehabilitation. There are also web and mobile platforms that support various activities interesting to seniors (e.g., gardening, cognitive training), facilitate communication and social inclusion. A few best practices are intended for hospitals and other care organizations (e.g., for management of health records).

Some of the best practices – less relevant to this paper but otherwise just as important – are non-technological. Examples include providing information and training to seniors about health(care), particularly dementia, and digital technology; promotion of social inclusion; and organizing provision of (health)care (e.g., via mobile medical units).

2.3 Wishes to Improve Care and Quality of Life

Based on the analysis of status quo (Section 2.1) and inspired by the best practices (Section 2.2), the SI4CARE project formulated a number of wishes that – if fulfilled – would leverage social and technological innovation to improve the care and quality of life of seniors. These were developed for each of the involved countries, and validated in a focus group involving stakeholders.

Since the analysis of the status quo found a strong need for the introduction of new technologies, and many technology-based best practices were identified, it is not surprising that various initiatives aimed at increasing the use of telehealth and telecare comprise the largest group of wishes. They had different focus: rehabilitation (where the current availability is particularly poor), cost-effectiveness (which is a prerequisite for institutional funding), non-pharmacological interventions (that tend to be neglected), applications that do not require institutional support (which are typically inexpensive and non-pharmacological) … Activities to improve digital skills of seniors were also wished for, as well as better digital infrastructure.

Unlike best practices, most wishes were not technological. This is perhaps because wishes are about goals, whereas technology in health and social care is often a means of achieving these goals. The non-technological wishes include increases in human resources (which were found to be a key reason for the inadequacies of healthcare provision), improved overview of the state of care and solutions for improvement (essentially activities similar to SI4CARE's but put on a more sustainable basis), improvements in home care, training and better policies.

2.4 Transnational Strategy and Action Plans

The preparation of the transnational strategy and national/regional action plans – one for each country involved – is still in progress. The strategy is organized in five pillars:

- Digital transitions are concerned with pervasive health technologies and other ICT-based innovations exemplified by the pilots presented in this paper.
- Digitalization process will support digital transitions by providing the required infrastructure and knowledge.
- Economic and financial implications deal with appropriate funding for healthcare and other aspects of long-term care.
- Governance and policies address sustainable and geographically appropriately distributed provision of care, ensuring its quality and properly trained staff.
- The SI4CARE community will ensure the sustainability of the project via organizations that will exist after the end of the funding period.

The national/regional action plans aim at implementing this strategy in individual countries. Their main components are specific actions, which essentially fulfill the wishes discussed in Section 2.3. These wishes are being validated by stakeholders in events organized in each country, one of which is also taking place at the Information Society 2022 multiconference. Afterwards, the action plans will be presented to high-level decision makers.

3 PILOTS OF ICT SOLUTIONS FOR INTEGRATED CARE

3.1 Mobile Application for Self-management of Heart Failure

Heart failure is a common and debilitating disease among seniors, and a leading cause of hospitalizations. It requires complex management difficult for many seniors. Healthcare institutions provide only periodic checkups and cardiac rehabilitation, the latter not to all who would benefit. Resources to provide more support are hard to come by, so a mobile application to assist self-management is an attractive solution.

The HeartMan application [3] provides a personalized exercise program and nutrition advice, support for measurement of vital parameters, medication reminders, mindfulness exercises intended to improve the patients' mental health and wellbeing, and cognitive behavioral techniques to improve the adherence to the application's advice. The first step of the pilot was to make the application easier to deploy and to remove physiological monitoring as input for its decisions, as this is a barrier from the usability and regulatory perspective. The user experience was also improved. The ongoing second step is a feasibility study with 20 patients using the application and 10 controls.

The lesson learned so far is that designing an application for heart-failure patients is difficult due to the complex topic and poor digital and health literacy of this group. Our solution was to guide less advanced users by simple automatic prompts, and not require them to do much on their own initiative.

3.2 ICT Solution for Monitoring the Health of Patients after Returning Home

Special Hospital Merkur is a secondary health institution in Serbia specializing in diabetes. Upon discharge, patients often return to bad habits, and diabetes complications occur. In addition, they face problems when they need to see a doctor.

The main aim of the pilot was to investigate the integration of modern communication technology in diabetes treatment to facilitate better coordination between stakeholders. The patients were trained to use the SmartCare mobile application, and to input the necessary data (insulin, sugar, mass, blood pressure, temperature, etc.). Merkur's medical team had insight into the patient's condition and intervened as needed. In addition, patients were trained to contact doctors for consultations from home.

The combined effect of the involvement of patients in their health condition, and the remote intervention of doctors, proved to reduce the risk of diabetes complications. The pilot demonstrated the feasibility of remote treatment in Serbia, which can also lead to significant financial savings. It should be repeated on a larger sample on a national level to provide a basis for the introduction of telemedicine in the health system.

3.3 ICT to Enable Accessibility to Health Systems by the Elderly

In the Italian healthcare system, regional governments are responsible for ensuring the delivery of a health benefits package through a network of health management organizations. There is a remarkable difference among regions, with northern regions providing better services, resulting in migration of patients from south to north. In 2018, healthcare mobility in Calabria amounted to approx. € 310 million. This is particularly relevant for small towns and villages where people suffer from a lack of general medicine and efficient public transportation to regional hubs.

Due to some recent programs, many rural areas in Calabria have good internet connections. In this pilot, with the help of UCCP del Reventino (a team of physicians), we are evaluating the use of tele-assistance and remote monitoring of chronic patients (elderly people and people affected by dementia).

The developed services are particularly useful for patients who require a re-evaluation of an already known clinical picture, people suffering from rare diseases, and frail people who require constant contact with health facilities. Teleadvice also proved of great utility in the context of COVID-19.

3.4 Specialized Outpatient Clinic for Memory, Dementia and Parkinson's Disease

Approximately 20% of the population above the age of 65 are affected by mild cognitive impairment or dementia. As the status quo analysis indicated, these people have limited access to specialized healthcare. This is more pronounced in remote areas. Greece has many small and isolated islands with a high percentage of elderly inhabitants and understaffed health centers.

The Aeginition Hospital of the National and Kapodistrian University of Athens developed an outpatient clinic pilot through the National Telemedicine Network, in collaboration with the 2nd Regional Healthcare Administration of Piraeus and the Aegean Islands. Through this clinic, patients with cognitive or movement disorders living in remote Aegean islands are examined by a specialized healthcare team (neurologist, psychiatrist and neuropsychologist) through video-conferencing.

Based on the questionnaires from 58 telemedicine visits, all stakeholders are highly satisfied with this telemedicine service, mentioning improved care, better health, and convenience, reduced transportation and cost. The low number of cases compared to the available capacity points to the need to better disseminate the information about the availability of telemedicine in the area by involving local health professionals and other telemedicine services in Greece.

3.5 Tele-exercise for the Elderly and Patients with Cognitive Disorders/Dementia

Physical activity is a well-established non-pharmaceutical intervention for health improvement in the elderly. It improves mobility, fitness, and cognitive function, prevents falls, improves functionality and quality of life as well as increases socialization.

The Aeginition Hospital of the National and Kapodistrian University of Athens in collaboration with the Medical School of Athens developed a tele-exercise pilot to provide specialized online physical activity programs for the elderly. Small groups of about 10 individuals receive aerobic and resistance training with a frequency of 2–5 times/week and duration of 40 min per intervention, guided in real-time via video-conference by specialized healthcare professionals. The elderly involved were trained to use the tablets though which they are participating.

All participants report high satisfaction rates and improved functionality in everyday life. Key lessons learned are that tele-exercise is feasible and effective non-pharmacological treatment that enhances social interaction, and that effective collaboration

between healthcare providers is necessary. The elderly face difficulties in the use of new technologies and training is needed.

3.6 Individualized Training Based on Biomechanical Measurements

The importance of physical activity was already discussed in the previous pilot description. The status quo analysis in Slovenia showed that the availability of physical exercising and rehabilitation services is not adequate. Resorting to the private sector may result in lower quality of services as they might be provided by people without the necessary knowledge and skills.

We prepared a pilot in which training was based on initial screening of the participants by an orthopedist and experienced coaches, followed by biomechanical measurements of lower extremities. Isometric measurement of peak torque and tensiomyography were used along with a body composition measurement. 24 participants performed training 2 times per week for 3 months under two conditions: half of the participants exercised in a gym, while the other half online. In the in-person scenario, participants were divided in small groups. The focus was proper posture and exercise execution. Only after absorbing proper technique, the training increased intensity.

Both conditions were warmly accepted by participants, with the in-person one slightly preferred. Working in small groups not only enabled individual training, but also group cohesion, resulting in socialization after exercising in the nearby café.

3.7 Nursing by Monitoring

The pilot carried out in Split, Croatia, was motivated by the well-established issue of inadequate resources to provide quality care to seniors who cannot live independently.

The pilot used monitoring technology that requires minimal interactions with senior users, since they are not familiar with digital technology. 10 medically non-certified wristbands, equipped with LoRaWAN radio, ensure data delivery to large distances without using mobile phones as a gateway. The wristbands enable 10-minute acquisition of heart rate, GPS location, steps, calories, and wrist temperature, as well as having alarms for low heart rate and falls, and a help button. The data is received by a system called IoT Wallet, which allows future expansion since it supports adding add more wristbands.

LoRaWAN technology turned out to provide broad coverage with a relatively low power consumption.

3.8 Access to Public Social Services by Telemedical Monitoring (Click for Life)

Seniors represent a high percentage of the population of Region of Central Macedonia (RCM) in Greece (22% are over 65), with a significant proportion of them living alone (approx. 100,000). They face difficulties in access to public social services, especially in high-density urban places and remote rural areas.

The RCM regional authority launched the pilot project 'Click for Life', offering telemedicine/homecare assistance to seniors with a low income living alone. Approx. 3000 users participate so far. They are provided: (1) 24-hour monitoring via devices with fall detection and a panic button. The panic button enables communication with a call center 24 hours/day. (2) Medical history is accessible to relatives and health professionals, and the users can receive notifications from the relatives. (3) Behavioral assessment service interprets movement and activity data from devices in the user's home. The aim is to automatically detect abnormal behaviors that may indicate an emerging disease.

The lesson learned so far is that there is a need for a more systematic coordination of the call center with public health care units, doctors, social care workers and emergency units.

3.9 Accessibility to Integrated Long-term Care

In the pilot project we analyzed both spatial accessibility and accessibility of information. Slovenia is rural country. Older people in rural Slovenia face poor access to public services and especially to health facilities. In terms of spatial accessibility, we identified the locations of buildings where seniors live alone. In 2021, there were 42,344 seniors living alone in houses (27,136 aged 65–79 and 15,208 aged 80 and older) in Slovenia.

There are a number of elderly care services advertised online, but the offer is scattered and searching for such information is time-consuming. To avoid these obstacles, we set up a web platform where different providers (formal and informal) are presented in one place. We included all formal providers in Slovenia in the database. We enabled self-registration of service providers and spatial representation of providers via the web.

We highlighted areas with poor accessibility to health and social care services, and will present them to local decision-makers and caregivers to improve integrated long-term care and transport for them. We will also present them our web app.

4 CONCLUSION

The paper presented the SI4Care project and its methodology to bring social innovation to integrated care. The focus was on the presentation of the pilots that address the identified needs and wishes in the region. The fact that most, nine out of thirteen, of the piloting activities within the SI4Care project involve some sort of pervasive health technology testifies to the importance of such technologies also for integrated care. Preliminary results from most pilots show benefits for stakeholders and good acceptance. However, digital literacy is a significant barrier, and in some cases also infrastructure, organizational readiness and legislation. Pervasive technology clearly cannot be introduced in isolation, which is why our strategy consists of five pillars, only one of which is concerned with pervasive technology.

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REFERENCES

[1] Eurostat, 2021. *Eurostat Regional Yearbook* (2021 edition). DOI: 10.2785/894358

[2] SI4CARE – Social Innovation for integrated health CARE of ageing population in ADRION Regions. https://si4care.adrioninterreg.eu/

[3] M. Luštrek, M. Bohanec, C. Cavero Barca, M. C. Ciancarelli, E. Clays et al., 2021. A personal health system for self-management of congestive heart failure (HeartMan): Development, technical evaluation, and proof-of-concept randomized controlled trial. JMIR Med. Inform. 9, 3, e24501. DOI: 10.2196/24501

Network Anomaly Detection using Federated Learning for the Internet of Things

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ABSTRACT

The widespread use of IoT devices has contributed greatly to the continuous digitisation and modernisation of areas such as healthcare, facility management, transportation, and household. These devices allow for real-time mobile sensing, use input and then simplify and automate everyday tasks. However, like all other devices connected to a network, IoT devices are also subject to anomalous behaviour primarily due to security vulnerabilities or malfunction. Apart from this, they have limited resources and can hardly cope with such anomalies and attacks. Therefore, early detection of anomalies is of great importance for the proper functioning of the network and the protection of users' personal data above all. In this paper, deep learning and federated learning algorithms are applied in order to detect anomalies in IoT network traffic. The results obtained show that all the models achieve high accuracy, with the FL models providing slight worse results compared to the DL models. However, with the increase in the amount of user data, the model based on federated learning is expected to have better results over time.

KEYWORDS

federated learning; deep learning; malware; internet of things; anomaly detection

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1 INTRODUCTION

In the last decade, a significant increase in the usage of Internet of Things (IoT) devices has been observed. The ability to connect various kinds of devices from different manufacturers to a network wirelessly and share data has proven beneficial to nearly every domain where this technology is involved, including household, industry, infrastructure, transportation, and healthcare[3]. Additionally, the actions that end users can take are increasing everyday and vary from changing ambient parameters of a home or car setting easily and on-the-go to remotely and securely controlling a manufacturing process inside a smart factory setting. Implementing these devices into an ambient assisted living (AAL) setting has proven to be beneficial both for the patients and for the medical staff, as it can improve monitoring and medical assistance (if needed), as well as medication dose adjustment[7].

However, the diversity of IoT devices, accompanied by wireless networking and a slow standardisation process, have led to many issues regarding the privacy and security of data and also the processes based on that data. The occurrence of various cyber attacks on networks composed of IoT devices, but also on individual IoT devices performing specific tasks, is becoming more common [8]. By disabling, reconfiguring or reprogramming such devices, attackers can manipulate the network, obtain private data illegally and maybe even induce a life-threatening situation, especially in the e-health domain. Therefore, it is significantly important to detect potential attacks and anomalies that occur in an IoT setting.

This paper examines the detection of anomalies in IoT network traffic by using deep learning and federated learning algorithms. The remainder of this paper is structured as follows. Section

2 gives an overview of the approaches tackling IoT network anomaly detection using deep and federated learning algorithms. Section 3 describes the used dataset and gives an insight into the importance of the features. The experiments done in this research and the discussion of the results obtained are presented in Section 4, while Section 5 gives a brief summary and provides further research directions.

2 RELATED WORK

One of the most popular approaches when tackling network anomaly detection is the usage of network intrusion detection systems (NIDS). By examining network data flow patterns (signatures), the NIDS can track inconsistencies (also called anomalies) and resolve them in a timely manner. However, directly analysing the behaviour of the IoT devices has proven to be more beneficial in detecting newer and unknown types of attacks, in spite of the overall lower detection accuracy and higher computational cost [6].

Using machine learning (ML) techniques has had a big impact on the development of NIDS and malware anomaly detection systems in general. Lin et al. [9] propose a combination of Support Vector Machines (SVMs) and Artificial Fish Swarm algorithms for IoT botnet detection. A combination [5] using different ML algorithms, also including an SVM has been done to evaluate the accuracy in detecting Mirai DDoS attacks. The authors in [16] used Convolutional Neural Networks (CNN) with binary visualisation to provide fast zero-day malware detection. However, some of the datasets used in these research papers provide only network traffic flow from conventional networks and have little to do with the attacks which target IoT networks. A further issue is that using traditional ML techniques increases the security risk, as data has to be moved away from the network and the data source to a powerful system performing the ML training.

Federated learning (FL) has emerged as a new decentralised way of training models on privately held datasets that can or should not be shared for security and privacy reasons. The training process consists of a central server and several clients, where the former facilitates the training and the latter possess the private data. In each round of federated training, the server randomly selects a subset of clients who receive the current model parameters. Then, local training is performed by each of the clients, keeping the local data on-site. The updated model parameters are then sent back to the server, where the global server model is updated. Opposed to centralised ML or classical decentralised techniques, FL can work with both independent and identically distributed (IID) and non-IID datasets. [10]

Several approaches have been using this decentralised technique in order to detect anomalies in IoT networks. The DIoT approach [2] uses federated learning to aggregate profiles of IoT network behaviour. It was evaluated in real-world conditions and reported no false alarms. Saharkhizan et al. [14] used a recurrent neural network with ensemble learning to detect cyberattacks on IoT devices. The evaluation of the model was performed on a Modbus dataset of network traffic. Some of the approaches even used a combination of FL and a distributed ledger (blockchain) [12, 17] in order to detect anomalies in networks. In [13], the federated deep learning model created for zero-day botnet attacks on IoT devices outperformed traditional decentralised approaches, as well as both localised deep learning (DL) and distributed DL methods. In [15], a novel privacy-by-design FL model using a stacked long short-time memory (LSTM) model is introduced for tackling anomaly detection in smart buildings. The results showed twice as fast convergence during training, compared to the centralised LSTM.

3 DATASET AND EXPLORATORY DATA ANALYSIS

For the purpose of this research we used the publicly available dataset N-BaIoT [11]. It is a dataset created by a group of researchers from the University of California, Irvine, School of Information and Computer Sciences in the USA. The dataset addresses the lack of public botnet datasets, especially for the IoT domain. It is composed of real-time network traffic data gathered from nine commercial IoT devices, including a baby monitor, security cameras, a webcam, doorbells, and a thermostat, which have been infected by the most common families of botnet attacks: Mirai and Bashlite [1].

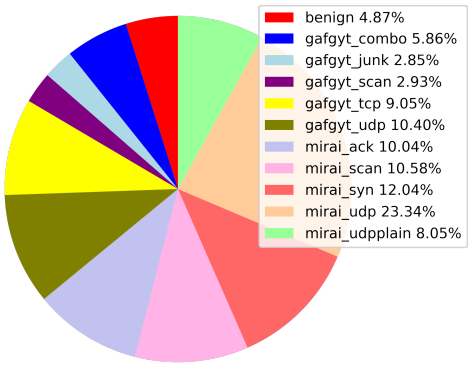

Figure 1: N-BaIoT dataset distribution by class

The N-BaIoT dataset consists of 7,062,606 entries with 115 different features, which are further divided into 10 attack categories: gafgyt_combo, gafgyt_junk, gafgyt_scan, gafgyt_tcp, gafgyt_udp, mirai_ack, mirai_scan, mirai_syn, mirai_udp, mirai_udpplain and one benign category, which contains the normal traffic flow of the observed devices. As it can be seen from Figure 1, which shows the distribution of the dataset used in the upcoming experiments, only a portion (509,149 entries) is considered for the model training in both DL and FL experiments. For the DL experiments, the dataset is further divided into a train and test partition including 80% and 20% of the data, while maintaining the distribution intact. As for the FL experiments, the data is divided into 50 IID datasets which include a train and test subsets. They represent the 50 clients which will take part in the FL process.

Table 1: Most important dataset features

Number	Feature
1	H L0.01_mean
2	Ml_dir_L0.01_mean
3	Ml_dir_L0.01_variance
4	H_L0.01_variance
5	H_L0.1_mean

After preprocessing the data, an exploratory analysis was done in order to obtain the features which have the greatest

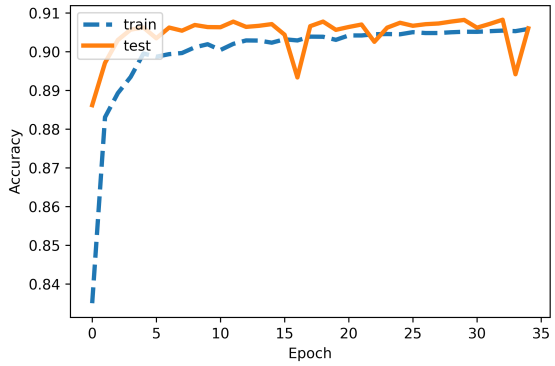

Figure 2: DL model using the five layer NN - accuracy

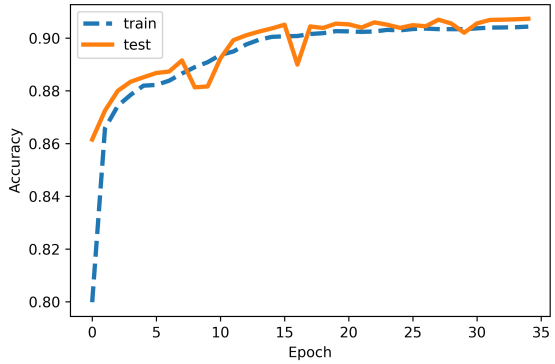

Figure 3: DL model using the three layer NN - accuracy

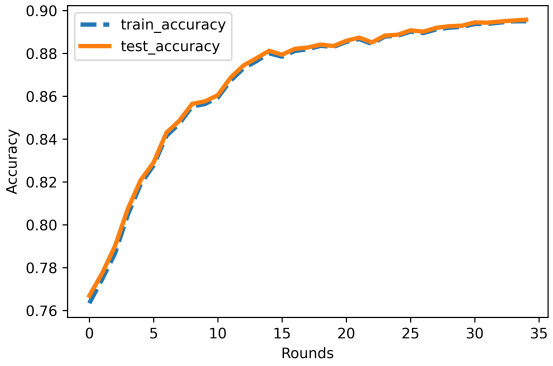

Figure 4: FL model using the five layer NN - accuracy

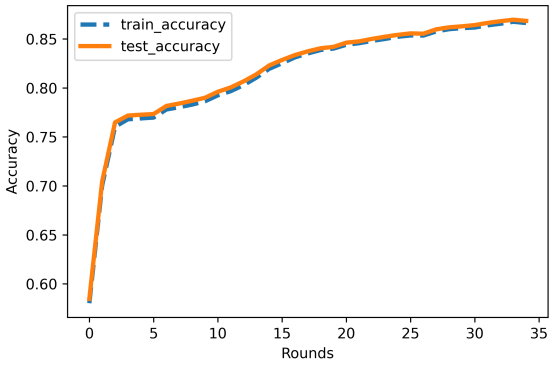

Figure 5: FL model using the three layer NN - accuracy

influence. The mutual dependence between the features and the class was determined with the help of Mutual Information Gain. From Table 1, it can be noticed that the five features with the greatest importance are H L0.01_mean, Ml_dir_L0.01_mean, Ml_dir_L0.01_variance, H_L0.01_variance and H_L0.1_mean.

4 EXPERIMENTS AND DISCUSSION

This paper compares two DL and two FL models for network anomaly detection, which are able to distinguish anomalous behaviour or a deviation from the normal traffic flow of IoT devices. After performing the training, all models were evaluated in order to see their accuracy in detecting anomalies. In the first experiment, a feed-forward neural network with 5 layers, an input layer, 3 hidden layers and an output layer was used. In the second experiment, a simple feed-forward neural network with one hidden layer was used. In both cases, the output layer has 11 neurons, which represent all the classes in the dataset.

Both models have the same hyperparameters. We used the Adam optimiser with a learning rate of 0.001, which works well for many use cases and models. Since the model performs a multi-class prediction task, we minimised the categorical cross entropy loss during training. The DL experiments were performed using the TensorFlow framework and the FL experiments were performed using the Flower [4] framework and TensorFlow Federated, applying the FedAvg aggregation strategy [10] on the server. In the FL experiments 35 rounds were performed, which corresponds to approximately 35 epochs in the DL experiments.

As previously mentioned, two DL models, the first one using a NN with multiple layers and the second one using a simple NN were trained and tested. From Figures 2 and 3 we can notice that the accuracy between the two models is very similar - the first model obtained an accuracy of 90.75% on the test data, while the second model obtained an accuracy of 90.18%. Furthermore, if the confusion matrices of both DL models are analysed, it can be noted that both models make the same mistake - predicting class 4 (gafgyt_scan) as class 5 (gafgyt_tcp).

When it comes to the results obtained from the FL process after 35 rounds it can be seen that the first model obtained an accuracy of 88% (Figure 4). As for the second simplified model, the accuracy is 86% (Figure 5). This means that even though a simpler NN was used, the second model actually performed similarly in terms of FL. We can also observe the minor differences in accuracy (1-5%) between the DL and FL models, which means that although the DL models performed slightly better, the FL models can also accurately predict anomalies.

From Figures 6 and 7 we can analyse the SHAP (SHapley Additive exPlanations) force plot, which shows the contribution of each feature in making a prediction. We can see that the features 69, 25, 75, 87, 56 and 101 (HH_jit_L3_mean, H_L0.1_mean, HH_jit_L0.1_mean, HpHp_L3_weight, HH_L0._covariance and HpHp_L0.1_weight) have the greatest influence in making the prediction. The features 69, 25 and 75 have a positive impact on

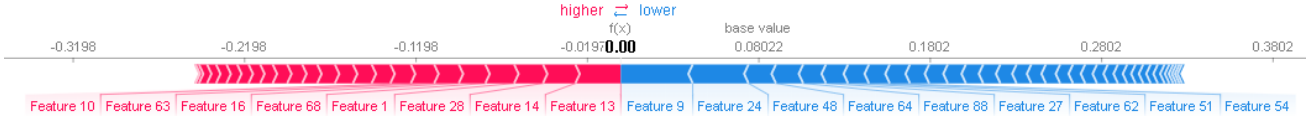

Figure 6: SHAP force plot for DL model using the five layer NN.

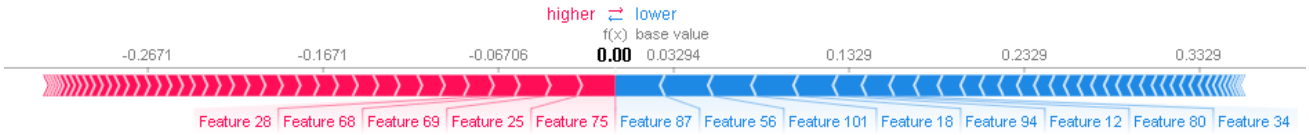

Figure 7: SHAP force plot for DL model using the three layer NN.

decision-making, i.e. prediction, while the features 87, 56 and 101 affect negatively on the performance. When we compare Figures 6 & 7 and Table 1, we can see that the most important features are different. This is because the SHAP method deals with the model and its output, while Mutual Information Gain deals with the preprocessed data.

5 CONCLUSION AND FUTURE WORK

This paper compares two models of DL and FL for accurate anomaly detection purposes in IoT networks. The FL model distributes the learning process to several clients, thus preserving data privacy and security. Both models achieve high accuracy, with the FL models providing similar results to the DL models.

Future work will include implementing some security mechanisms to the FL models and evaluating the trade-off between privacy and accuracy. Also, these models can be further tested and improved by being provided with new substantial datasets which may combine similar categories of attacks and/or include novel attacks on IoT networks. New federated learning algorithms can also be tested and evaluated on the same and new datasets, which can lead to a novel federated learning algorithm for anomaly detection purposes.

ACKNOWLEDGMENTS

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REFERENCES

[1] Abdelmuttlib Ibrahim Abdalla Ahmed. 2020. Systematic Literature Review on IoT-Based Botnet Attack. *IEEE Access* 8 (12 2020). https://doi.org/10.1109/ACCESS.2020.3039985

[2] Ulrich Matchi Aïvodji, Sébastien Gambs, and Alexandre Martin. 2019. IOTFLA : A Secured and Privacy-Preserving Smart Home Architecture Implementing Federated Learning. In *2019 IEEE Security and Privacy Workshops (SPW)*. 175–180. https://doi.org/10.1109/SPW.2019.00041

[3] Saurabh Bagchi, Tarek F. Abdelzaher, Ramesh Govindan, Prashant Shenoy, Akanksha Atrey, Pradipta Ghosh, and Ran Xu. 2020. New Frontiers in IoT: Networking, Systems, Reliability, and Security Challenges. *IEEE Internet of Things Journal* 7, 12 (2020), 11330–11346. https://doi.org/10.1109/JIOT.2020.3007690

[4] Daniel J. Beutel, Taner Topal, Akhil Mathur, Xinchi Qiu, Javier Fernandez-Marques, Yan Gao, Lorenzo Sani, Kwing Hei Li, Titouan Parcollet, Pedro Porto Buarque de Gusmão, and Nicholas D. Lane. 2020. Flower: A Friendly Federated Learning Research Framework. https://doi.org/10.48550/ARXIV.2007.14390

[5] Rohan Doshi, Noah Apthorpe, and Nick Feamster. 2018. Machine Learning DDoS Detection for Consumer Internet of Things Devices. In *2018 IEEE Security and Privacy Workshops (SPW)*. 29–35. https://doi.org/10.1109/SPW.2018.00013

[6] Satish Kumar, Sunanda Gupta, and Sakshi Arora. 2021. Research Trends in Network-Based Intrusion Detection Systems: A Review. *IEEE Access* 9 (2021), 157761–157779. https://doi.org/10.1109/ACCESS.2021.3129775

[7] Isabel Laranjo, Joaquim Macedo, and Alexandre Santos. 2012. Internet of Things for Medication Control: Service Implementation and Testing. *Elsevier Procedia Technology* 5 (10 2012), 777–786. https://doi.org/10.1016/j.protcy.2012.09.086

[8] In Lee. 2020. Internet of Things (IoT) Cybersecurity: Literature Review and IoT Cyber Risk Management. *Future Internet* 12 (09 2020), 157. https://doi.org/10.3390/fi12090157

[9] Kuan-Cheng Lin, Sih-Yang Chen, and Jason Hung. 2014. Botnet Detection Using Support Vector Machines with Artificial Fish Swarm Algorithm. *Journal of Applied Mathematics* 2014 (04 2014), 1–9. https://doi.org/10.1155/2014/986428

[10] H. Brendan McMahan, Daniel Ramage, Kunal Talwar, and Li Zhang. 2017. Learning Differentially Private Language Models Without Losing Accuracy. *CoRR* abs/1710.06963 (2017). arXiv:1710.06963 http://arxiv.org/abs/1710.06963

[11] Yair Meidan, Michael Bohadana, Yael Mathov, Yisroel Mirsky, Asaf Shabtai, Dominik Breitenbacher, and Yuval Elovici. 2018. N-BaIoT—Network-Based Detection of IoT Botnet Attacks Using Deep Autoencoders. *IEEE Pervasive Computing* 17, 3 (2018), 12–22. https://doi.org/10.1109/MPRV.2018.03367731

[12] Yisroel Mirsky, Tomer Golomb, and Yuval Elovici. 2020. Lightweight collaborative anomaly detection for the IoT using blockchain. *J. Parallel and Distrib. Comput.* 145 (06 2020). https://doi.org/10.1016/j.jpdc.2020.06.008

[13] Segun I. Popoola, Ruth Ande, Bamidele Adebisi, Guan Gui, Mohammad Hammoudeh, and Olamide Jogunola. 2022. Federated Deep Learning for Zero-Day Botnet Attack Detection in IoT-Edge Devices. *IEEE Internet of Things Journal* 9, 5 (2022), 3930–3944. https://doi.org/10.1109/JIOT.2021.3100755

[14] Mahdis Saharkhizan, Amin Azmoodeh, Ali Dehghantanha, Kim-Kwang Raymond Choo, and Reza M. Parizi. 2020. An Ensemble of Deep Recurrent Neural Networks for Detecting IoT Cyber Attacks Using Network Traffic. *IEEE Internet of Things Journal* 7, 9 (2020), 8852–8859. https://doi.org/10.1109/JIOT.2020.2996425

[15] Raed Abdel Sater and A. Ben Hamza. 2021. A Federated Learning Approach to Anomaly Detection in Smart Buildings. *ACM Trans. Internet Things* 2, 4, Article 28 (aug 2021), 23 pages. https://doi.org/10.1145/3467981

[16] Robert Shire, Stavros Shiaeles, Keltoum Bendiab, Bogdan Ghita, and Nicholas Kolokotronis. 2019. Malware Squid: A Novel IoT Malware Traffic Analysis Framework Using Convolutional Neural Network and Binary Visualisation. In *Internet of Things, Smart Spaces, and Next Generation Networks and Systems*, Olga Galinina, Sergey Andreev, Sergey Balandin, and Yevgeni Koucheryavy (Eds.). Springer International Publishing, Cham, 65–76.

[17] Devrim Unal, Mohammad Hammoudeh, Muhammad Asif Khan, Abdelrahman Abuarqoub, Gregory Epiphaniou, and Ridha Hamila. 2021. Integration of Federated Machine Learning and Blockchain for the Provision of Secure Big Data Analytics for Internet of Things. *Comput. Secur.* 109, C (oct 2021), 14. https://doi.org/10.1016/j.cose.2021.102393

Zbornik 25. mednarodne multikonference

INFORMACIJSKA DRUŽBA – IS 2022

Zvezek I

Proceedings of the 25th International Multiconference

INFORMATION SOCIETY – IS 2022

Volume I

Srednjeevropska konferenca o uporabnem teoretičnem računalništvu
Middle-European Conference on Applied Theoretical Computer Science

Uredniki / Editors

Andrej Brodnik, Gábor Galambos, Branko Kavšek

http://is.ijs.si

13.-14. oktober 2022 / 13-14 October 2022
Koper, Slovenija

PREDGOVOR

Leta 2019 – ko smo organizirali 3. MATCOS konferenco – smo trdno verjeli, da smo vzpostavili tradicionalni dogodek v Kopru. V naslednjih letih smo bili osredotočeni na premagovanje covida. Ob tem smo spoznali možnosti uporabe domačih pisarne in sodelovanja na spletnih izvedbah konferenc. Vsemu navkljub smo prepričani, da ostaja konferenca, na kateri pride do osebnega stika in pogovora, nenadomestljiva.
Zato smo pričeli s pripravo naslednje konference MATCOS, 4. po vrsti. Pri organizaciji in izvedbi smo imeli srečo, da so člani tako organizacijskega kot programskega odbora večinoma sprejeli tudi letošnje povabilo ter izdatno prispevali k organizaciji in izvedbi konference.
Vabljeno predavanje je običajno eden osrednjih dogodkov konference. Letos bo to predavanje Györgyja Turána z University of Illinois at Chicago (USA) z naslovom »Interpretability of deep-learned error-correcting codes«. Predavanje nam bo posredovalo uvid v vpliv sodobne UI na načrtovanje klasičnih kod za popravljanje napak.
Poleg vabljenega predavanja bo na konferenci predstavljen še izbor člankov iz širokega področja računalništva in informatike vključno s primeri uporabe.
Tradicionalno prihaja na konferenco večina prispevkov in avtorjev iz Madžarske in Slovenije. Vendar je naš napor letos obrodil sad, saj so se jim na naše veliko zadovoljstvo pridružili avtorji še iz sedmih drugih držav in predstavili svoje delo.
Člani tako organizacijskega kot programskega odbora so v zadnjih nekaj mesecih opravili odlično delo. Zato vsem, ki so pomagali pri organizaciji in izvedbi konference MATCOS-22, iskrena zahvala.
Zaključujemo z željo, da boste te dni uživali v Kopru in da vzpostavite nove profesionalne stike na konferenci MATCOS-22.

V imenu organizatorjev
Andrej Brodnik in Gábor Galambos
sopredsedujoča

FOREWORD

In 2019 – when we organized the 3rd MATCOS conference – we strongly believed that we established a new tradition here in Koper. Then, the next few years we had to concentrate to win over the covid. We got acquainted with the possibilities of home offices and the organization of online conferences became current. But we are sure that a conference with personal interviews and discussions are irreplaceable.

So, this year we started to organize the next MATCOS conference, the 4th one. Fortunately, the former members of the Organizing Committee and the Program Committee accepted our invitation and took part actively in organization.

The invited talk is a central point while you organize a conference. This year György Turán from the University of Illinois at Chicago (USA) will present a talk on "Interpretability of deep-learned error-correcting codes", and so, we can take a look the influence of modern AI research to the design of classical error-correcting processes.

Selecting among the submitted papers we sorted out those ones that came from a wide range of the computer science and its applications.

Following the "traditions" most of the participants come from Hungary and Slovenia, but it is really a great pleasure to see that our efforts have been successful: the authors represent new research results from 7 countries.

The members of PC and OC did an excellent job during the last few months. Thanks to everybody who helped to organise the MATCOS-22.

We hope you will enjoy these days in Koper and you can establish new professional contacts during the MATCOS-22 conference.

On behalf of the organisers
Andrej Brodnik and Gábor Galambos
co-chairs

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A Neural Network Based Classification Algorithm for Asthma Using Capnography

[Extended Abstract]

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ABSTRACT

This article presents a neural network-based method to help physicians diagnose and monitor asthma and other chronic respiratory diseases. The method is based on capnography, using measurement data from a specially developed hand-held device.

After proper preparation, various parameters are calculated on the capnographic curve from which healthcare professionals can conclude the condition of the patient's respiratory system.

Another purpose of using the calculated parameters is to serve as a learning base for an artificial intelligence application that can be used in the decision support of physicians. The shape of the capnogram obtained from the gas sample exhaled by the patient and thus the parameters calculated from it are different for healthy people and those with respiratory diseases.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Decision Support; J.3 [**Computer Applications**]: LIFE AND MEDICAL SCIENCES—*Capnography*

General Terms

Applications

Keywords

Decision support, Neural networks, Capnography

1. INTRODUCTION

Capnography is a non-invasive method for the numerical and graphical analysis of exhaled CO_2 concentration. Time-based capnography is part of routine daily patient monitoring during mechanical ventilation and anesthesia. For spontaneously breathing patients, the method has the advantage that it does not require the patient to carry out any special breathing maneuvers, the measurement is easy to perform, and therefore requires minimal cooperation. It also holds the potential for the diagnosis of obstructive airway disease, as bronchospasm severity can be quantitatively assessed [4, 6]. The feasibility of non-invasive examinations is essential in pediatrics, so it also opens up new areas of application for capnography [7, 9, 10]. Although the analysis of capnogram shape parameters is not yet a standard part of patient monitoring, it appears promising in the monitoring of chronic respiratory diseases, as it provides useful information on the pathophysiological processes of pulmonary ventilation, such as airway patency and lung recoil tendency.

In capnographic studies, the carbon dioxide content of exhaled air can be considered as a function of time or plotted against the exhaled gas volume. In the former case, we are

talking about *time-based*, while in the latter case we are talking about *volumetric capnography*.

In the first part of the article, we examine the formal properties of time-based capnograms. Possible parameters describing the shape of the curve are presented. In the second part we introduce a neural network based method that uses these parameters to help physicians in diagnosing patients.

2. THE CAPNOGRAMS AND THEIR PARAMETERS

The capnogram curve plots the partial pressure of the CO_2 content of the exhaled gas against time or volume. The partial pressure of a given gas in a gas mixture is the pressure that a gas in question would create alone if it filled the available space alone. The partial pressure of CO_2 is denoted by PCO_2.

The capnogram consists of an exhalation segment and an inhalation segment. In this study we focused only on the shape indices of the exhalation section. The three phases of the exhalation segment (Phases 1-3) contain different slopes, angles and other parameters which are described in many articles and textbooks (e.g. [2, 3, 8]).

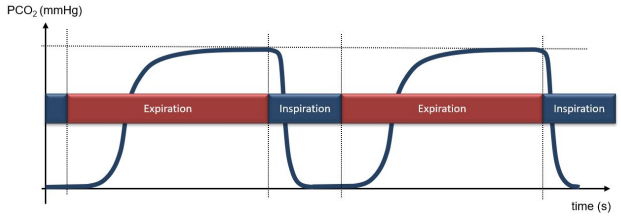

Figure 1: General form of time-based capnograms

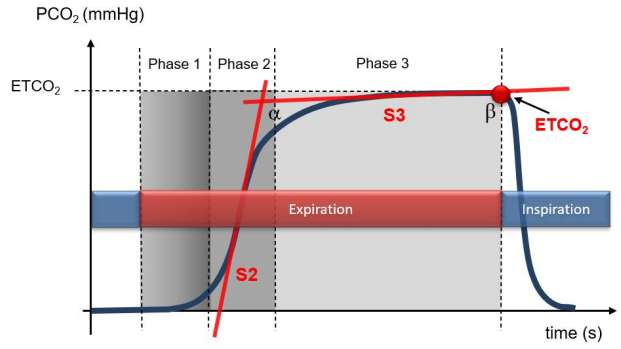

Figure 2: Phases of a capnogram with End-tidal $CO_2 (ETCO_2)$

2.1 The calculated parameters

The various morphological parameters are calculated using mathematical methods, which are presented in this subsection. The resulting capnographic indices - in the knowledge of the patients' condition - provide an opportunity to assess the characteristics of healthy and chronic respiratory patients (see [12] for more details). We aim to calculate these parameters as accurately and objectively as possible. This creates the opportunity to apply learning algorithms and automatically determine the condition of the patients studied. As a first step, faulty respiratory cycles were filtered out based on physiological rules that were supported by measurement techniques.The parameter calculator smoothed the points of the raw curve using the moving average method. In this case, each point was replaced by an average calculated from a specified number of adjacent points. For the 100Hz sampling frequency used for recording, we found the 9-point moving average to be the most suitable. Then, for each point of the smoothed curve, we calculated the first-order derivatives using the standard differential quotient. Since the curve containing the first derivatives can also be slightly noisy, we performed the previous smoothing algorithm for this as well. Then, following the same method, we calculated the curve containing the second derivative and its smoothed version. Finally, using the smoothed derivative 2 curve, the starting point of Phase 2 (local maximum) and the end point of Phase 3, i.e. the end of exhalation (local minimum) can be determined. It should be noted that the starting point of the exhalation cannot be precisely determined only from the time capnogram curve. However, before the start of Phase 2, we can find the point where the curve still takes approximately a value of 0, and then this point can be considered as the starting point of the fitting algorithm described below. We then fit a function to the exhalation sections obtained as previously described using the method introduced by Tusman et al. in [11]. The beginning of Phase 2 and the end of Phase 3 have already been determined as described above, and its post-fitting correction is not necessary. However, after fitting, the first, second, and third derivatives must be re-determined (now on the fitted curve). The end point of Phase 2 (the starting point of Phase 3) is obtained from the local maximum of the calculated third derivative.

2.1.1 *The slopes of Phases 2 and 3 (S2, S3)*

To determine the inflection point of Phase 2, we use the first-order derivative values, which mathematically represent the slope of the line drawn at a given point on the curve. The slope at the inflection point will be the largest. The slope of Phase 2 (S2) is the maximum slope that can be read at this inflection point [11]. The slope of Phase 3 (S3) is the slope of the line fitted to the middle third of Phase 3, which is a simplified but not significantly different modification of the method used by Tusman et al [11].

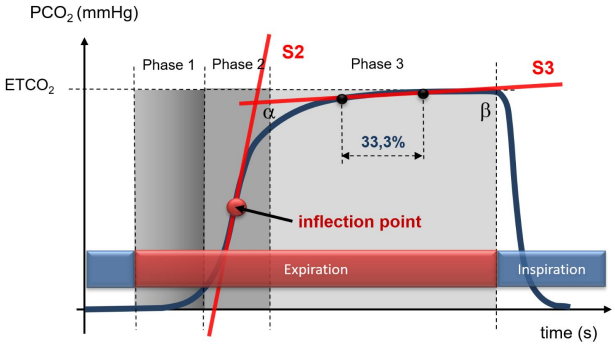

Figure 3: The slopes of time-based capnograms

2.1.2 *End-tidal CO_2 $(ETCO_2)$*

The carbon dioxide concentration increases throughout Phase 3, so it normally peaks at the end of the phase. This is the final exhalation CO_2 concentration ($ETCO_2$, $PETCO_2$), which is equal to the carbon dioxide partial pressure read at the end of Phase 3.

2.1.3 The normalized slopes of Phases 2 and 3 (Sn2, Sn3)

The normalized slopes of Phase 2 (Sn2) and Phase 3 (Sn3) are obtained by dividing the slopes of the second and third phases (S2, S3) by the value of $ETCO_2$.

2.1.4 Sn3/Sn2

The quotient of the Sn3 and Sn2 values.

2.1.5 D2min and D2max

The maximum and minimum of the second derivative, the rate of change of the start and end points of Phase 2 (the lower and upper curves).

2.1.6 The α angle (Q)

The angle enclosed by the slopes of Phases 2 and 3.

2.1.7 The area ratio (AR)

The area ratio in the section between the inflection point and the beginning of Phase 3 is the quotient of the area under the curve and the area of the entire rectangle. It is practically the shape of the transition from Phase 2 to Phase 3.

2.1.8 Squared difference (R2SUM)

The sum of the squares of the differences between the points of the raw, original curve and the fitted one. As previously described, the original capnogram curve contains higher frequency noises, which may have physiological reasons. Therefore, these sums of squares are used to examine the differences in the curves of the patients in each group.

2.1.9 Respiratory rates (RR)

In the absence of flow data, the exact length of respiratory cycles cannot be determined from the time capnogram alone. Thus, the length of the given respiratory cycle can be estimated from the combined length of Phases 2 and 3. Examining the measurements in parallel with the flow measurement, we found that the combined length of Phases 2 and 3 is about 65 percent of the respiratory cycle. Currently, we use this ratio to estimate respiratory length, from which we calculate the actual respiratory rate.

3. THE INPUT DATA AND THE STRUCTURE OF THE NETWORK

The data used for teaching the network were as follows:

- All time-based parameters calculated from mainstream measurements: S2T, S3T, $ETCO_2$, Sn2, Sn3, Sn3/Sn2, D2min, D2max, Q, AR, R2SUM, RR (Separate records for each breathing cycle).
- Gender of the patient.
- Class of the patient's age at the time of examination. (The patient's age was divided into 10-year-long classes. For example: 13 years old, 17 years old -> class: 1, 33 years old -> class: 3, 60 years old, 62 years old -> class: 6, etc. This was necessary because without classification only a few measurements would belong to some ages, which would impair the effectiveness of learning.)
- Class of the patient's body weight at the time of examination. (The patient's body weight was divided into classes of 10 kilograms, in the same way as for age.)

We used one label for teaching, which was a manual medical diagnosis of the patient for the test. (One test could include several measurements. One measurement could only belong to one test. One test could only have one diagnosis.) We only used measurements with a "healthy" or "asthmatic" diagnosis. We omitted from teaching the load measurements and the measurements marked as incorrect.

The method was implemented in Java and relied on the Deeplearning4j library [1]. The training of the neural network and the diagnosis prediction with the trained neural network ran on the following configuration: Intel Core i7 10700K CPU, 32GB DDR4 RAM, 256GB SSD, 2TB HDD, Nvidia GeForce 8500 GT video card.

The neural network had 3 hidden layers, each with 50 neurons. For each hidden layer, the activation function was the TANH function. The activation function of the output layer was the SIGMOID function. We gave 6000 epochs for teaching, but according to the log files, no significant learning took place after the 652nd epoch. The training was performed on a record of 3141 healthy and 16670 asthmatic breathing cycles, which lasted 2169 seconds on the configuration given above.

4. RESULTS

Since the training was done per respiratory cycle (the parameters are also calculated separately for each cycle), the diagnosis prediction with the trained neural network is also done per respiratory cycle. For each measurement, we calculated how many cycles of the measurement were "healthy" and how many cycles were "asthmatic". (The prediction is not performed for cycles marked as incorrect.) If the number of healthy predictions is lower than the number of asthmatic predictions, then the entire measurement is considered asthmatic. Otherwise, the entire measurement is considered healthy. The number of measurements used in the prediction was 648. Considering the "asthmatic" diagnosis as positive and the "healthy" diagnosis as negative we found the followings:

- True positive (TP): 517 (79.78%)
- True negative (TN): 107 (16.51%)
- False positive (FP): 23 (3.55%)
- False negative (FN): 1 (0.15%)

TP: The number of measurements for which the manual diagnosis of the test is "asthmatic" and the diagnosis obtained with the neural network is also "asthmatic". TN:

The number of measurements for which the manual diagnosis of the test is "healthy" and the diagnosis obtained with the neural network is also "healthy". FP: The number of measurements for which the manual diagnosis of the test is "healthy", but the diagnosis obtained with the neural network is "asthmatic". FN: The number of measurements for which the manual diagnosis of the test is "asthmatic", but the diagnosis obtained with the neural network is "healthy".

The metrics calculated from these are:

- Accuracy: 0.96,
- Precision: 0.96,
- Recall: 1.00,
- F1 Score: 0.98.

Here we used the usual metrics of classifiers, based on the following formulas [5]: Accuracy: (TP + TN) / (TP + FP + TN + FN) Precision: TP / (TP + FP) Recall: TP / (TP + FN) F1 score: 2* precision * recall / (precision + recall)

All of the above metrics must fall within the interval [0.0, 1.0]. The closer the value is to 1.0, the better the result. The total running time of the diagnosis prediction was 240 seconds for 1361 measurements, so the prediction takes an average of 0.1763 seconds per measurement. Comments:

1. The evaluation is somewhat distorted by the fact that we have fewer healthy subjects than asthmatics.

2. It is similarly distorted by the fact that we used all the measurements of all asthmatic and healthy tests from the database for teaching. This is due to the limited number of measurements. In the case of several measurements, we could use only a small part of the measurements during teaching, and test the neural network on the larger part. That way we would get more objective test results.

5. CONCLUSIONS

In this research we developed a neural network based application that uses capnography measurements to help the diagnosis of asthma. Possible future works are the followings:

1. Training the neural network with the raw measurement data as well, not only with the calculated parameters. This is expected to require more hardware resources and time. An advantage may be that the neural network can also learn useful information that is lost during the parameter calculation.
2. Training the neural network with the volumetric parameters or together with volumetric and time-based parameters. The disadvantage here may be that there are no volumetric parameters for purely time-based measurements without flow data.
3. Teaching the neural network for the different severities of asthma, and using the trained neural network to distinguish between them.
4. Teaching the neural network for other diseases, e.g. COPD (and its sub-conditions), ACOS (and its sub-conditions), COVID, etc. Distinguishing these diseases with the help of a trained neural network.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Deeplearning4j Suite Overview. `https://deeplearning4j.konduit.ai/`. [Accessed 16-Jul-2022].

[2] K. Bhavani-Shankar, A. Y. Kumar, H. S. L. Moseley, and R. Ahyee-Hallsworth. Terminology and the current limitations of time capnography: A brief review. *Journal of Clinical Monitoring*, 11(3):175–182, May 1995.

[3] K. Bhavani-Shankar and J. H. Philip. Defining segments and phases of a time capnogram. *Anesthesia & Analgesia*, 91(4):973–977, Oct. 2000.

[4] J. B. Chambers, P. J. Kiff, W. N. Gardner, G. Jackson, and C. Bass. Value of measuring end tidal partial pressure of carbon dioxide as an adjunct to treadmill exercise testing. *BMJ*, 296(6632):1281–1285, may 1988.

[5] D. Chicco and G. Jurman. The advantages of the matthews correlation coefficient (MCC) over f1 score and accuracy in binary classification evaluation. *BMC Genomics*, 21(1), jan 2020.

[6] C. Chopin, P. Fesard, J. Mangalaboyi, P. Lestavel, M. C. Chambrin, F. Fourrier, and A. Rime. Use of capnography in diagnosis of pulmonary embolism during acute respiratory failure of chronic obstructive pulmonary disease. *Critical Care Medicine*, 18(4):353–357, apr 1990.

[7] N. Eipe and D. R. Doherty. A review of pediatric capnography. *Journal of Clinical Monitoring and Computing*, 24(4):261–268, jul 2010.

[8] J. S. Gravenstein, M. B. Jaffe, N. Gravenstein, and D. A. Paulus, editors. *Capnography*. Cambridge University Press, Mar. 2011.

[9] B. D. Guthrie, M. D. Adler, and E. C. Powell. End-tidal carbon dioxide measurements in children with acute asthma. *Academic Emergency Medicine*, 14(12):1135–1140, dec 2007.

[10] S. Kunkov, V. Pinedo, E. J. Silver, and E. F. Crain. Predicting the need for hospitalization in acute childhood asthma using end-tidal capnography. *Pediatric Emergency Care*, 21(9):574–577, sep 2005.

[11] G. Tusman, A. Scandurra, S. H. Böhm, F. Suarez-Sipmann, and F. Clara. Model fitting of volumetric capnograms improves calculations of airway dead space and slope of phase III. *Journal of Clinical Monitoring and Computing*, 23(4):197–206, June 2009.

[12] B. You, R. Peslin, C. Duvivier, V. D. Vu, and J. Grilliat. Expiratory capnography in asthma:. *European Respiratory Journal*, 7(2):318–323, Feb. 1994.

Online Bin Covering with Exact Advice*

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ABSTRACT

We show a 2/3-competitive strategy for the bin covering problem using $O(b + \log n)$ advice, where b is the number of bits used to encode a rational value and n is the length of the input sequence.

Categories and Subject Descriptors

500 [**Theory of computation**]: Online algorithms

1. INTRODUCTION

In the bin covering problem, we are given a set of items of different sizes in the range $]0, 1]$ and the goal is to find a maximum number of covered bins where a bin is covered if the sizes of items placed in it is at least 1. It has been shown that is NP-hard [1]. The covering problem has applications in various situations in business and in industry, from packing snack pieces into boxes so that each box contains at least its defined net weight, to such complex problems as redistribution tasks/items to a maximum number of factories/bins, all working at or beyond the minimal feasible level. The problem is, as mentioned, maximizing the number of covered bins, and is NP-hard [9]. The bin covering problem was studied in-depth in Assmann's Ph.D. thesis [2]. In the online version, items are delivered successively (one-by-one) and each item has to be packed, either in an existing bin or a new bin, before the next item arrives. The quality of online strategies is measured by their *competitive ratio*, the minimum ratio between the quality of the strategy's solution and that of an optimal one. The first known online strategy that has been proposed for the problem is *Dual Next Fit* (DNF), analogous to Next Fit for the bin packing problem. A competitive ratio of DNF is 1/2 proved by Assmann *et al.* [1]. A few years later, Csirik and Totik [8] prove that no online algorithm can achieve a competitive ratio better than 1/2. Further lower bounds ar given by Balogh *et al.* [3]. Thus, the only way to improve on the competitive ratio is to change the computational model. Boyar *et al.* [4] look at bin covering using extra advice provided by an oracle through an advice tape that the strategy can read. If the input sequence consists of n items, they show that with $o(\log \log n)$ bits of advice, no strategy can have better competitive ratio than 1/2. They also provide a strategy with $O(\log \log n)$ bits of advice having competitive ratio 8/15 and then show that a linear number of bits of advice is necessary to achieve competitive ratio greater than 15/16.

We show a 2/3-competitive strategy for the one-dimensional bin covering problem using $O(b + \log n)$ advice, where b is the number of bits used to encode a rational value in the input sequence and n is the length of the input sequence.

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2. PRELIMINARIES

The *online bin covering problem* we consider is, given an input sequence $\sigma = (v_1, v_2, \ldots)$, of rational values $v_i \in [0, 1]$, find the *maximum* number of unit sized bins that can be covered online with items from the input sequence σ. The bin covering problem is a dual version of the *bin packing problem*.

We define the *load* of a bin B to be

$$\mathrm{ld}(B) \stackrel{\text{def}}{=} \sum_{v \in B} v. \tag{1}$$

We can similarly define the load of a sequence σ to be $\mathrm{ld}(\sigma) \stackrel{\text{def}}{=} \sum_{v \in \sigma} v$.

A *covering* is a partitioning of the items into bins $B_1, B_2, \ldots$ such that for each bin B_j

$$\mathrm{ld}(B_j) \geq 1 \tag{2}$$

and our objective is to find the maximum number of bins that satisfy Inequality (2). In contrast to the bin packing problem, a strategy can open any number of bins at any time. However, only those that are filled to a load of at least 1 are counted in the solution.

We measure the quality of an online maximization strategy by its *competitive ratio*, the maximum bound R such that

$$\big|A(\sigma)\big| \geq R \cdot \big|\mathrm{OPT}(\sigma)\big| - C, \tag{3}$$

for every possible input sequence σ, where $A(\sigma)$ is the solution produced by the strategy A on σ, $\mathrm{OPT}(\sigma)$ is a solution on σ for which $|\mathrm{OPT}(\sigma)|$ is minimal, and C is some constant.

Of particular interest is the Dual Next Fit strategy (DNF), where DNF maintains one active bin B, and packs the items into B until it is covered. It then opens a new empty bin as

the active bin and continues the process. Assmann *et al.* [1] prove that DNF has a competitive ratio of 1/2 and Csirik and Totik [8] prove that no online algorithm can achieve a competitive ratio better than 1/2.

If we know some further structure of the input sequence, we can do slightly better as is shown in the next lemma that we will make extensive use of in the sequel.

LEMMA 1. *The online strategy* DNF *for the bin covering problem on an input sequence σ_α where the items have weights bounded by $\alpha < 1$ has cost*

$$\big|\mathsf{DNF}(\sigma_\alpha)\big| > \frac{1}{1+\alpha}\big|\mathrm{OPT}(\sigma_\alpha)\big| - \frac{1}{1+\alpha}.$$

PROOF. Assume that DNF opens $m+1$ bins when accessing the sequence σ_α, m of which are covered. Since every item has weight at most α, it means that each of the m covered bins are filled at most to a total weight of $1+\alpha$. A bin not obeying this limit would have been covered already before DNF places the last item in it, a contradiction. Thus the total load of the sequence σ is

$$(1+\alpha)m + 1 > \mathrm{ld}(\sigma_\alpha) \geq \big\lfloor \mathrm{ld}(\sigma_\alpha) \big\rfloor \geq \big|\mathrm{OPT}(\sigma_\alpha)\big|,$$

whereby $|\mathsf{DNF}(\sigma_\alpha)| = m > |\mathrm{OPT}(\sigma_\alpha)|/(1+\alpha) - 1/(1+\alpha)$ as claimed. □

Another strategy of interest is Dual Harmonic (DH_k), where the strategy subdivides the items by sizes into k groups,

$$]0, 1/k[,\ [1/k, 1/(k-1)[, \ldots, [1/3, 1/2[,\ [1/2, 1[,$$

and packs items in each group, maintaining k groups, according to DNF. Evidently, DH_k is at best 1/2-competitive using the same argument as in Csirik and Totik [8].

In certain situations, the complete lack of information about future input is too restrictive. In a sense, the online strategy plays a game against an all-powerful adversary who can construct the input sequence in the worst possible manner. To alleviate the adversary's advantage, we consider the following *advice-on-tape* model [6]. An *oracle* has knowledge about both the strategy and the full input sequence from the adversary, it writes information on an *advice tape* of unbounded length. The strategy can read bits from the advice tape at any time, before or while the requests are released by the adversary. The *advice complexity* is the number of bits read from the advice tape by the strategy. Since the length of the advice bit string is not explicitly given, the oracle is unable to encode information into the length of the string, thereby requiring some mechanism to infer how many bits of advice the strategy should read at each step. This can be done with a self-delimiting encoding that extends the length of the bit string only by an additive lower order term [5].

A bit string s is encoded as $e(s) = u(s) \circ b(s) \circ s$ ($\circ$ denotes concatenation), where $b(s)$ is a binary encoding of the length of the string s and $u(s)$ consists of $\big|b(s)\big|$ ones followed by a single zero, thus indicating how many bits the strategy needs to read in order to obtain the length of the string s. The encoding has length at most $\big|e(s)\big| = |s| + 2\lceil \log(|s|+1)\rceil + 1$. We henceforth assume that all advice information is encoded in this way. An integer m can thus be encoded exactly using $O(\log m)$ bits and a rational value m_e/m_d, where m_e and m_d are integers can be encoded using $O(\log m_e + \log m_d)$ bits. If the rational value lies in the interval $[0,1]$, then $m_e \leq m_d$ and the encoding can be made using $O(\log m_d)$ bits.

We will base our strategy on DH_k with added advice to improve on the competitive ratio, as do Boyar *et al.* [4].

3. AN EXACT ADVICE STRATEGY FOR BIN COVERING

Each item v corresponds to a rational value $0 < v < 1$, since any v above or equal to 1 will cover a bin and the optimum solution can be assumed to place v alone in a bin to cover it. Also, values of size 0 could be placed in the first covered bin without loss of generality.

Fix an integer $k \geq 2$. We will subdivide the set of items into k subsets, such that $1/t \leq v < 1/(t-1)$ for each integer $2 \leq t \leq k$, the *t-items*, and items $v < 1/k$, the *small items*.

Consider a fixed optimal covering $\mathrm{OPT}(\sigma)$ for the input sequence σ. We can partition the solution $\mathrm{OPT}(\sigma)$ into groups, $\mathcal{G}_{t_1 t_2 \cdots t_j}$, where the index $t_1 t_2 \cdots t_j$, with $2 \leq t_1 \leq t_2 \leq \cdots \leq t_j \leq k$, denotes that each bin in group $\mathcal{G}_{t_1 t_2 \cdots t_j}$ contains one t_1-item, one t_2-item, etc, multiplicity denoting the number of times each item type occurs in the bin in addition to the small items needed to fill it. We say that a bin in group $\mathcal{G}_{t_1 t_2 \cdots t_j}$ is *easy*, if $\sum_{t \in \{t_1, t_2, \ldots, t_j\}} 1/t \geq 1$ and we can assume without loss of generality that easy bins contain no small items. Furthermore, we assume that if the bins in $\mathcal{G}_{t_1 t_2 \cdots t_j}$ are easy, then any bin group $\mathcal{G}_{t_1 t_2 \cdots t_j t_{j+1}}$ is empty, if $t_1 t_2 \cdots t_j$ is a subsequence of $t_1 t_2 \cdots t_{j+1}$, as the t_{j+1}-item in a bin in $\mathcal{G}_{t_1 t_2 \cdots t_j t_{j+1}}$ can be moved to other bins while we still maintain coverage in the bin. We also say that a bin in $\mathcal{G}_{t_1 t_2 \cdots t_j}$ is a *gap bin*, if $\sum_{t \in \{t_1, t_2, \ldots, t_j\}} 1/(t-1) < 1$, as each of these bins must contain small items to the amount of more than $1 - \sum_{t \in \{t_1, t_2, \ldots, t_j\}} 1/(t-1)$ to be covered. Lastly, we denote the group of bins that are only covered by small items by $\mathcal{G}_S$.

As an example, $\mathcal{G}_{22}$ are those bins that each contain two 2-items (bins in $\mathcal{G}_{22}$ are easy), $\mathcal{G}_2$ are those bins that each contain one 2-item and some small items, and $\mathcal{G}_3$ are those bins that each contain one 3-item and some small items (bins in $\mathcal{G}_3$ are gap bins since they require small items to the amount of more than 1/2 to be covered).

The size of the optimal solution is given by

$$|\mathrm{OPT}(\sigma)| = \sum_{\forall t_1 t_2 \cdots t_j} |\mathcal{G}_{t_1 t_2 \cdots t_j}| + |\mathcal{G}_S|, \tag{4}$$

for all valid index combinations $t_1 t_2 \cdots t_j$.

We modify the Dual Harmonic strategy to operate on advice and describe this strategy, denoted DH_k^a, dependent on the parameter k, the number of item types used to partition the items into. The superscript a indicates that the strategy admits advice. Let $x_1, \ldots, x_n$, $n = |\sigma|$, be an ordering of the items in σ, such that $x_i \geq x_{i+1}$, for $1 \leq i \leq |\sigma|$. The oracle provides the strategy with an integer m and the value x_m through a self-delimiting encoding.

The strategy DH_k^a initially reads the parameters m and x_m and opens m bins that we call *critical bins* and that will each be covered with one of the m largest items of the input sequence σ together with small items. Initially, each critical bin is assumed to have a *virtual load* of x_m. When an item of size $\geq x_m$ is placed in a critical bin, its virtual load

is increased to the actual value of the item. The strategy further opens a *t-bin* for every item type $t \in \{2, \ldots, k\}$, and a *small bin* for the small items. As the next item v of the input sequence arrives, it is handled as follows:

1. if $x_m \leq v$, place v in the next critical bin that does not yet contain a large item and update the virtual load of the critical bin,
2. if $1/k \leq v < x_m$ is a t-item, place v in the corresponding t-bin using DNF. If the bin becomes covered, close it and open a new t-bin,
3. if $v < 1/k$ is small, place v in the next critical bin that does not contain small items up to a virtual load of at least 1 and update the virtual load of this critical bin. If all critical bins are filled up to a virtual load of 1, place v in the small bin using DNF. If the small bin becomes covered, close it and open a new small bin.

LEMMA 2. *Assume that the strategy DH_4^a has access to the exact values of m and x_m, then it has competitive ratio*

$$\big|\mathsf{DH}_4^a(\sigma)\big| \geq \frac{2}{3}\big|\mathrm{OPT}(\sigma)\big| - \frac{173}{60}$$

for serving any sequence σ of size n.

PROOF. Note that the number of t-items, for $t = 2$, 3, and 4, in the instance is

$$T_2 = |\mathcal{G}_2| + 2|\mathcal{G}_{22}| + |\mathcal{G}_{23}| + |\mathcal{G}_{24}| + |\mathcal{G}_{233}| + |\mathcal{G}_{234}| + |\mathcal{G}_{244}|, \quad (5)$$

$$T_3 = |\mathcal{G}_3| + |\mathcal{G}_{23}| + 2|\mathcal{G}_{33}| + |\mathcal{G}_{34}| + 2|\mathcal{G}_{233}| + |\mathcal{G}_{234}| + 3|\mathcal{G}_{333}| + 2|\mathcal{G}_{334}| + |\mathcal{G}_{344}| + 2|\mathcal{G}_{3344}|, +|\mathcal{G}_{3444}|, \quad (6)$$

$$T_4 = |\mathcal{G}_4| + |\mathcal{G}_{24}| + |\mathcal{G}_{34}| + 2|\mathcal{G}_{44}| + |\mathcal{G}_{234}| + 2|\mathcal{G}_{244}| + |\mathcal{G}_{334}| + 2|\mathcal{G}_{344}| + 3|\mathcal{G}_{444}| + 2|\mathcal{G}_{3344}| + 3|\mathcal{G}_{3444}| + 4|\mathcal{G}_{4444}|. \quad (7)$$

For each non-easy bin group $\mathcal{G}_2, \ldots, \mathcal{G}_{444}$ (there are eleven of them), let $S_{t_1 \cdots t_4}$ denote the weight of the small items that the optimum solution packs in the bins of group $\mathcal{G}_{t_1 \cdots t_4}$. In addition, we denote by $S_S = \sum_{B \in \mathcal{G}_S} \mathrm{ld}(B)$ the total load of the small items covering the bins in $\mathcal{G}_S$.

We consider first some arbitrary set of covered bins $\mathcal{G}$, where each bin only contains small items. Assume that these bins have a total load of $S = \sum_{B \in \mathcal{G}} \mathrm{ld}(B) \geq |\mathcal{G}|$ and that the input sequence restricted to these small items is σ_S. From Lemma 1 we have that

$$\big|\mathsf{DNF}(\sigma_S)\big| > \frac{4}{5}S - \frac{4}{5} \geq \frac{4}{5}\big|\mathcal{G}\big| - \frac{4}{5} \quad (8)$$

We can analyze the competitive ratio of the critical bins by first considering a decreasing ordering of the bins $B_1, \ldots, B_{|\mathcal{G}_2|}$ in $\mathcal{G}_2$ by the weight of their 2-item, w_i. We let $u_i = \mathrm{ld}(B_i) - w_i$ be the weight of the small items in B_i, whereby $S_2 \geq \big(|\mathcal{G}_2| - m\big) \cdot \big(1 - w_m\big)$ for arbitrary choice of $m \leq |\mathcal{G}_2|$ since $B_{m+1}, \ldots, B_{|\mathcal{G}_2|}$, each contains at least $1 - w_m$ amount of small items; see Figure 1. The critical bins, C_i, $1 \leq i \leq m$, each contains one 2-item of weight a_i, a small item of weight z_i that was the last small item placed in C_i by our strategy, and small items to the weight of $y_i = \mathrm{ld}(C_i) - a_i - z_i$. Again, by construction, $y_i \leq 1 - w_m$ for each $1 \leq i \leq m$.

Consider next the gap bins in the optimal solution. These are the bins in groups $\mathcal{G}_3$, $\mathcal{G}_4$, $\mathcal{G}_{34}$, and $\mathcal{G}_{44}$. Each bin in these groups is guaranteed to have small items to the amount of at least 1/2, 2/3, 1/6, and 1/3, respectively. Thus, for each of those groups we have $S_3 \geq |\mathcal{G}_3|/2$, $S_4 \geq 2|\mathcal{G}_4|/3$, $S_{34} \geq |\mathcal{G}_{34}|/6$, and $S_{44} \geq |\mathcal{G}_{44}|/3$.

For each group of non-easy bins $\mathcal{G}_2, \ldots, \mathcal{G}_{444}$, let $\mathcal{I}_{t_1 \cdots t_4}(m) \subseteq \{1, \ldots, m\}$ be the set of indices i such that the last small element (of weight z_i) that was placed in critical bin C_i was placed by the optimal solution in a bin from bin group $\mathcal{G}_{t_1 \cdots t_4}$. Easy bins are assumed, without loss of generality, to not contain any small items. Also, let $\mathcal{I}_S(m) = \big\{1, \ldots, m\big\} \setminus \big(\bigcup_{t_1 \cdots t_4 \notin Easy} \mathcal{I}_{t_1 \cdots t_4}(m)\big)$ be the set of remaining indices. The possible values of m range between $0 \leq m \leq m^+ = \big\lfloor (|\mathcal{G}_2| - |\mathcal{I}_2(m^+)|)/2 \big\rfloor$, where m^+ is the largest integer such that $2m^+ + |\mathcal{I}_2(m^+)| \leq |\mathcal{G}_2|$, since the strategy needs to guarantee that it can cover all the critical bins.

The oracle reveals $m = m^+ = \big\lfloor (|\mathcal{G}_2| - |\mathcal{I}_2(m^+)|)/2 \big\rfloor$ and $x_m = x_{m^+}$, the m^{th} largest item in the input sequence σ, so our strategy constructs m critical bins, $\big\lfloor (T_2 - m)/2 \big\rfloor$ 2-bins, $\big\lfloor T_3/3 \big\rfloor$ 3-bins, $\big\lfloor T_4/4 \big\rfloor$ 4-bins, and some bins corresponding to the amount of unused small items, giving us

$$\begin{aligned}
\big|\mathsf{DH}_4^a(\sigma)\big| &> m + \left\lfloor \frac{T_2 - m}{2} \right\rfloor + \left\lfloor \frac{T_3}{3} \right\rfloor + \left\lfloor \frac{T_4}{4} \right\rfloor + \frac{4}{5}\Bigg(S_S \\
&\quad + S_2 + S_3 + S_4 + S_{34} + S_{44} - \left(\sum_{i=1}^{m} y_i + z_i\right)\Bigg) - \frac{4}{5} \\
&\geq \frac{m}{2} + \frac{T_2}{2} + \frac{T_3}{3} + \frac{T_4}{4} + \frac{4}{5}\left(S_S - \sum_{i \in \mathcal{I}_S(m)} z_i\right) + \frac{4}{5}\left(S_3 - \sum_{i \in \mathcal{I}_3(m)} z_i\right) \\
&\quad + \frac{4}{5}\left(S_4 - \sum_{i \in \mathcal{I}_4(m)} z_i\right) + \frac{4}{5}\left(S_{34} - \sum_{i \in \mathcal{I}_{34}(m)} z_i\right) + \frac{4}{5}\left(S_{44} - \sum_{i \in \mathcal{I}_{44}(m)} z_i\right) \\
&\quad + \underbrace{\frac{4}{5}\left(S_2 - \sum_{i=1}^{m}(1 - w_m) - \sum_{i \in \mathcal{I}_2(m)} z_i\right)}_{\geq 0} - \frac{163}{60} \\
&\geq \frac{m}{2} + \frac{T_2}{2} + \frac{T_3}{3} + \frac{T_4}{4} + \frac{2}{3}\left(S_S - \sum_{i \in \mathcal{I}_S(m)} z_i\right) \\
&\quad + \frac{2}{3}\left(S_3 - \sum_{i \in \mathcal{I}_3(m)} z_i\right) + \frac{5}{8}\left(S_4 - \sum_{i \in \mathcal{I}_4(m)} z_i\right) \\
&\quad + \frac{1}{2}\left(S_{34} - \sum_{i \in \mathcal{I}_{34}(m)} z_i\right) + \frac{1}{2}\left(S_{44} - \sum_{i \in \mathcal{I}_{44}(m)} z_i\right) - \frac{163}{60} \\
&\geq \frac{m}{2} + \frac{T_2}{2} + \frac{T_3}{3} + \frac{T_4}{4} + \frac{2S_S}{3} - \frac{|\mathcal{I}_S(m)|}{6} + \frac{2S_3}{3} - \frac{|\mathcal{I}_3(m)|}{6} \\
&\quad + \frac{5S_4}{8} - \frac{5|\mathcal{I}_4(m)|}{32} + \frac{S_{34}}{2} - \frac{|\mathcal{I}_{34}(m)|}{8} + \frac{S_{44}}{2} - \frac{|\mathcal{I}_{44}(m)|}{8} - \frac{163}{60} \\
&\geq \frac{m}{2} + \frac{T_2}{2} + \frac{T_3}{3} + \frac{T_4}{4} + \frac{2S_S}{3} - \frac{m}{6} + \frac{|\mathcal{I}_2(m)|}{6} + \frac{|\mathcal{I}_3(m)|}{6} \\
&\quad + \frac{|\mathcal{I}_4(m)|}{6} + \frac{|\mathcal{I}_{34}(m)|}{6} + \frac{|\mathcal{I}_{44}(m)|}{6} + \frac{2S_3}{3} - \frac{|\mathcal{I}_3(m)|}{6} \\
&\quad + \frac{5S_4}{8} - \frac{5|\mathcal{I}_4(m)|}{32} + \frac{S_{34}}{2} - \frac{|\mathcal{I}_{34}(m)|}{8} + \frac{S_{44}}{2} - \frac{|\mathcal{I}_{44}(m)|}{8} - \frac{163}{60} \\
&> \frac{m}{3} + \frac{T_2}{2} + \frac{T_3}{3} + \frac{T_4}{4} + \frac{|\mathcal{I}_2(m)|}{6} + \frac{2|\mathcal{G}_S|}{3} + \frac{|\mathcal{G}_3|}{3} + \frac{5|\mathcal{G}_4|}{12} \\
&\quad + \frac{|\mathcal{G}_{34}|}{12} + \frac{|\mathcal{G}_{44}|}{6} - \frac{163}{60}
\end{aligned}$$

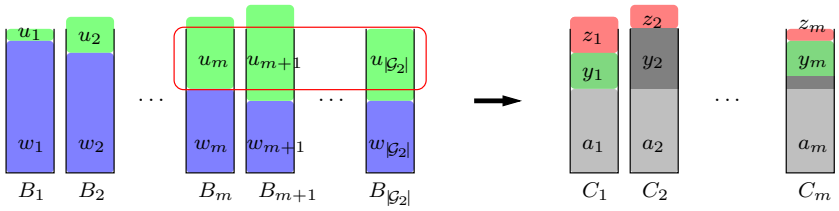

Figure 1: The critical bins and their relationship to the $\mathcal{G}_2$-bins in the optimal covering. In the $\mathcal{G}_2$-bins, blue are 2-items and light green are the small items. In the critical bins, red represents the last small items in the bin, dark green are the remaining small items, grey items are the 2-items, and dark grey represents the overlap between the virtual and actual load of the 2-item.

$$
\begin{aligned}
&= \frac{2|\mathcal{G}_2|}{3} + \frac{2|\mathcal{G}_3|}{3} + \frac{2|\mathcal{G}_4|}{3} + \frac{2|\mathcal{G}_{33}|}{3} + \frac{2|\mathcal{G}_{34}|}{3} + \frac{2|\mathcal{G}_{44}|}{3} + \frac{2|\mathcal{G}_S|}{3} \\
&\quad + \frac{3|\mathcal{G}_{24}|}{4} + \frac{3|\mathcal{G}_{444}|}{4} + \frac{5|\mathcal{G}_{23}|}{6} + \frac{5|\mathcal{G}_{344}|}{6} + \frac{11|\mathcal{G}_{334}|}{12} + |\mathcal{G}_{22}| \\
&\quad + |\mathcal{G}_{244}| + |\mathcal{G}_{333}| + |\mathcal{G}_{4444}| + \frac{13|\mathcal{G}_{234}|}{12} + \frac{13|\mathcal{G}_{3444}|}{12} + \frac{7|\mathcal{G}_{233}|}{6} \\
&\quad + \frac{7|\mathcal{G}_{3344}|}{6} - \frac{173}{60} \qquad \geq \qquad \frac{2}{3}|\mathrm{OPT}(\sigma)| - \frac{173}{60}
\end{aligned}
$$

bins, by applying Equalities (5)–(7) in the second to last step, while using that each $z_i < 1/4$, that $S_S \geq \sum_{i \in \mathcal{I}_S(m)} z_i$ and $S_{t_1 \cdots t_4} \geq \sum_{i \in \mathcal{I}_{t_1 \cdots t_4}(m)} z_i$, for each bin group $\mathcal{G}_{t_1 \cdots t_4}$, that critical bin C_i can be covered by a large item of size at least w_m plus the small items from a bin among the last bins $B_{m+1}, \ldots, B_{|\mathcal{G}_2|}$ in $\mathcal{G}_2$ and one extra small item from a non-easy bin in the optimal solution; see Figure 1, and that $m = |\mathcal{I}_S(m)| + \sum_{t_1 \cdots t_4} |\mathcal{I}_{t_1 \cdots t_4}(m)|$, for any m. The competitive ratio is the smallest coefficient of any of the terms corresponding to bin groups, since an adversary can ensure that the groups with larger coefficient contain no bins. This gives a competitive ratio of $2/3 \approx 0.6666\ldots$. □

For completeness sake we mention that using the same proof technique it is possible to show that $|\mathsf{DH}_2^a(\sigma)| \geq 3|\mathrm{OPT}(\sigma)|/5 - 19/15$, where $3/5 = 0.6$ and $|\mathsf{DH}_3^a(\sigma)| \geq 9|\mathrm{OPT}(\sigma)|/14 - 173/84$, where $9/14 \approx 0.64285\ldots$, if these strategies are given the exact values for m and x_m.

The two advice values $m \leq n$ and x_m can be represented by $O(\log n)$ bits and $O(b)$ bits respectively, where b is the number of bits required to represent the integer denominator of the rational value x_m, since $x_m < 1$. We have the following immediate theorem.

THEOREM 1. *The strategy DH_4^a receives $O(b + \log n)$ bits of advice and has competitive ratio*

$$|\mathsf{DH}_4^a(\sigma)| \geq \frac{2}{3}|\mathrm{OPT}(\sigma)| - \frac{173}{60}$$

for serving any sequence σ of size n, where b is the number of bits required to represent any rational value in σ.

One could venture to think that strategy DH_k^a, for $k > 4$, would give improved competitive ratio, or even that extending the strategy with more sets of critical bins could improve it further. However, this is not possible, since an adversary can simply provide an instance where all bin groups except $\mathcal{G}_2$ in an optimal solution are empty. Thus, the instance consists of only 2-items and small items. Any critical bin-based strategy must solve this instance and does so, even if the adversary provides all the small items first and the 2-items last, by choosing $m = \lfloor |\mathcal{G}_2|/3 \rfloor$, since the index set is $\mathcal{I}_2(m) = \{1, \ldots, m\}$, for all m, to guarantee that all critical bins are covered, thus opening m critical bins, and packing the remaining 2-items in pairs to cover $\lfloor (|\mathcal{G}_2| - m)/2 \rfloor$ bins. The strategy covers

$$
\begin{aligned}
m + \left\lfloor \frac{|\mathcal{G}_2| - m}{2} \right\rfloor &= \left\lfloor \frac{|\mathcal{G}_2|}{3} \right\rfloor + \left\lfloor \frac{|\mathcal{G}_2| - \lfloor |\mathcal{G}_2|/3 \rfloor}{2} \right\rfloor \\
&\leq \frac{|\mathcal{G}_2|}{3} + \frac{|\mathcal{G}_2|}{3} + \frac{1}{3} \leq \frac{2}{3}|\mathrm{OPT}(\sigma)| + \frac{1}{3} \qquad (9)
\end{aligned}
$$

bins, proving that our analysis in Lemma 2 is asymptotically tight.

4. REFERENCES

[1] Susan Fera Assmann, David S. Johnson, Daniel J. Kleitman, and Joseph Y-T. Leung. On a dual version of the one-dimensional bin packing problem. *Journal of Algorithms*, 5(4):502–525, 1984.

[2] Susan Fera Assmann. *Problems in discrete applied mathematics*. PhD thesis, Massachusetts Institute of Technology, 1983.

[3] János Balogh, Leah Epstein, and Asaf Levin. Lower bounds for online bin covering-type problems. *Journal of Scheduling*, 22(4):487–497, 2019.

[4] Joan Boyar, Lene M. Favrholdt, Shahin Kamali, and Kim S. Larsen. Online bin covering with advice. *Algorithmica*, 83(3):795–821, 2021.

[5] Joan Boyar, Shahin Kamali, Kim S. Larsen, Alejandro López-Ortiz. Online bin packing with advice. *Algorithmica*, 74(1):507–527, 2016.

[6] Hans-Joachim Böckenhauer, Dennis Komm, Rastislav Královič, Richard Královič, Tobias Mömke. On the advice complexity of online problems *Proc.* 20th *ISAAC*, LNCS 5878, pages 331–340, 2009.

[7] Edward G. Coffman Jr., Joseph Y-T. Leung, and D.W. Ting. Bin packing: Maximizing the number of pieces packed. *Acta Informatica*, 9(3):263–271, 1978.

[8] János Csirik and Vilmos Totik. Online algorithms for a dual version of bin packing. *Discrete Applied Mathematics*, 21(2):163–167, 1988.

[9] Michael R. Garey and David S. Johnson. *Computers and intractability*, volume 174. Freeman San Francisco, 1979.

Subsets without arithmetic subsequences: computational experiments and unsatisfiable cores

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ABSTRACT

A reduction to satisfiability of a combinatorial problem of minimal saturated subset without arithmetic subsequences is given in this paper. We conduct an empirical evaluation and present previously unknown optimal solutions for certain instances of the problem. The results also show where the limits for computing the optimal solutions are. Finally, we present a new possibility for solving such combinatorial problems, namely the unsatisfiable cores of the SAT expressions, which could give new insights to mathematicians and possibly new methods for solving the problem computationally.

Categories and Subject Descriptors

G.2.2 [**Mathematics of Computing**]: Discrete Mathematics—*combinatorics*

Keywords

satisfiability, solvers, modelling

1. INTRODUCTION

The problem of satisfiability has been at the center of computer science for more than half a century. It has been widely used to show some of the most important results in computational complexity and it is used as a showcase problem of a hard computational problem. But on the other hand, there has been a huge interest in developing better and better algorithms that can solve impressively large instances. The main driving force of this development is the annual SAT competition [5], spawning a huge research field and resulting in an enormous improvement in the speed and efficiency of these solvers in the past decade.

In this paper, we are exploring the possibilities of solving a set of instances of a hard combinatorial problem with the final goal of getting some new insights into the problem with such an empirical exploration. One way to implement this search could be to hand-tailor an efficient solver for this particular problem, but from our experience, we established that it takes a huge effort to construct a competitive solver which could outperform a state-of-the-art SAT solver. So instead of putting the effort into a custom-made solver, we construct a reduction to SAT and explore where are the limits of this approach.

The paper is structured as follows. The next section gives a short definition of the combinatorial problem and the reduction of this problem to SAT. Furthermore, we show what the reduced expressions look like for the instances that we are interested in. Section 3. describes the computational results, namely what are the optimal solutions for our problem and what are the times required to obtain them. This will give us some insight into what are the feasible sizes that can be solved with any kind of solver. Section 4. describes an interesting concept that can be obtained with SAT solvers and could be a new approach to solving this problem, either theoretically or empirically.

2. PROBLEM DEFINITION AND REDUCTION TO SAT

2.1 Problem definition

Definition 1 (Arithmetic triple)**.** *A set $\{a, b, c\}$ (assuming $a < b < c$) is an arithmetic triple if $b - a = c - b$.*

The set of all arithmetic triples of a set A will be denoted as

$$arith(A) = \{\{a, b, c\} \subseteq A | \{a, b, c\} \text{ is an arithmetic triple}\}$$

.

Definition 2 (Non-arithmetic set)**.** *A set A is said to be non-arithmetic if $arith(A) = \emptyset$.*

With these two definitions in place, we can define our optimization problems.

Definition 3 (MinNArith)**.** *Given a set $A = \{1 \dots n\}$, what is the smallest non-arithmetic subset $A' \subseteq A$, which is also maximal (or saturated), i.e. it is not possible to enlarge this set without creating an arithmetic triple, formally:*

$$\forall i \in A \setminus A' : arith(A' \cup \{i\}) \neq \emptyset$$

In our case, we are mostly interested in the size of such a set, given a particular value of n.

Example:. Let us say the set $A = \{1, \ldots, 16\}$, one saturated set that does not contain any arithmetic triple is $A' = \{6, 7, 10, 11\}$. It can be easily checked that by adding any other number from A, we create an arithmetic triple. We will see that this is also the smallest such subset of A.

What is known about this problem? [7, 6]
1. it seems to be a hard mathematical problem
2. for $n = 4^k$ there exists a construction of such a set of size $\sqrt{n}$,i.e., 2^k
3. it is conjectured that this is the smallest possible such set
4. It has been proven that this is indeed the case for $n = 4, 16,$ and 64.

The goal of this work is to push this boundary further, as much as possible, with the final goal to explore the feasibility of computing the size of the minimal set for $n = 256$. Since we already know such a set of size 16, the goal is to prove that there is no such set of size 15.

2.2 Reduction to SAT

In principle, this is a minimization problem, but we will use a decision version of this problem to reduce to SAT.

Definition 4 (MinNArithDEC). *Given a set $A = \{1, \ldots, n\}$ and a number k, does a saturated non-arithmetic subset $A' \subseteq A$ exist, such that $|A'| \leq k$.*

In what follows, we give a reduction $MinNArithDEC \rightarrow SAT$. The input to this problem are two numbers n and k, the reductions construct a logical expression (in CNF form) that is satisfiable if there exists a saturated non-arithmetic subset of $A = \{1 \ldots n\}$ with the size $\leq k$.

Each element in $i \in A$ has a corresponding logical variable x_i, which is true if $i \in A'$. To describe the problem $MinNArithDEC$, we introduce three types of constraints on this set of logical variables.

1. Cardinality constraint, i.e., at most k of the variables x_i can be true. We will denote this constraint as $CARD$.
2. In order for the set of true variables to describe a non-arithmetic subset, we have to check every arithmetic triplet $\{a, b, c\} \in arith(A)$ and assure that not all three elements are in A':
$$\overline{x_a \wedge x_b \wedge x_c}$$
. We will denote this type of constraint as $NARITH$.
3. And the third type of constraints assure the saturation of the set A'. For every element, $a \in A$, either a is already in the chosen subset, or there exists an arithmetic triplet where both of the other two elements are in the set. We will denote this type of constraint as $SATUR$.

The final expression is the conjunction of these three constraints:

$$E(n, k) = CARD \wedge NARITH \wedge SATUR$$

The $NARITH$ constraints have already been described (if we apply DeMorgan's rule it is already in CNF form), now we need to define more precisely how $CARD$ and $SATUR$ constraints are written as logical expressions.

Cardinality constraints. The problem of encoding cardinality constraints in SATs is a research topic on its own, and many different approaches are known. The main issue we are addressing in this problem is how to enforce that at most a certain number of variables are set to true. The most researched version of this problem is known as at-most-one (AMO) constraint [9]. Generalizations (at-most-k constraints) have been explored and are now part of most standardized SAT modeling toolboxes. It is also well-known [12] that different encodings can have varying effects on the execution times of different solvers.

In order to explore this impact, we tested 4 different standard encodings: Sequential counting [10], Sorting network [2], Cardinality network [1], and k-modulo totalizer [8].

Saturation constraints. For each element $i \in A$, we have to express that either it is in the set A', or that there exists an arithmetic triple $\{i, j, k\} \in arithA$ such that $j, k \in A'$.

This is straightforwardly transformed into a logical expression:

$$x_i \vee (\bigvee_{(i,j,k) \in arith(A)} (x_j \wedge x_k))$$

However, there is a technical difficulty with this expression. Namely, it is not in CNF, which is a typical requirement of SAT solvers. A straightforward transformation to CNF would result in exponentially large expressions, which would quickly make them practically unusable. Luckily, there exists a transformation, called the Tseitin transform [11], that transforms any logical expression into CNF, and the final expression is linear in the size of the original expression. The downside of this transformation is that also introduces a linear number of new variables.

2.3 Sizes of instances

To give an impression of the sizes of the reduced problem, the number of clauses and the number of variables for different n and k are given in Table 1.

Two different parameters describe the size of the expression, those are the number of variables and the number of clauses in the expression.

The table gives these two sizes for three different expressions, $E(16, 3), E(64, 7), E(256, 15)$. These are the expressions at $n = 4^k$ since we are testing the hypothesis that the solution at this n is 2^k and these expressions should all be unsatisfiable based on this hypothesis. We also show the difference in sizes if different cardinality encodings are used. We can see that the encoding does not greatly influence the entire size of the expression, since the largest difference is only a few percent.

Table 1: Sizes of reduced problems

n, k	CC	# of vars	# of clauses
(16,3)	seqcount	391	1168
	cardnet	440	1213
	sortnet	416	1265
	kmtotalizer	397	1182
(64,7)	seqcount	6415	19760
	cardnet	6600	19789
	sortnet	7102	20542
	kmtotalizer	6251	19598
(256,15)	seqcount	101407	316576
	cardnet	101248	314305
	sortnet	105470	320638
	kmtotalizer	98712	312147

But that does not describe the entire picture of the structure of these expressions. A more detailed view is given in Figure 1 which shows the percentage of clauses and new variables introduced by each type of constraint. The first graph shows how the ratio of the three types of clauses. It can be seen that the $SATUR$ constraint contributed to the vast majority of clauses. As n grows, the dominance of the $SATUR$ clauses gets even bigger. A similar situation can be seen on the right graph that shows the ratio of the newly introduced variables. First, notice that $NARITH$ constraints do not introduce any new variables and are thus omitted from this graph. Again, the vast majority of newly introduced variables originate from the $SATUR$ constraints.

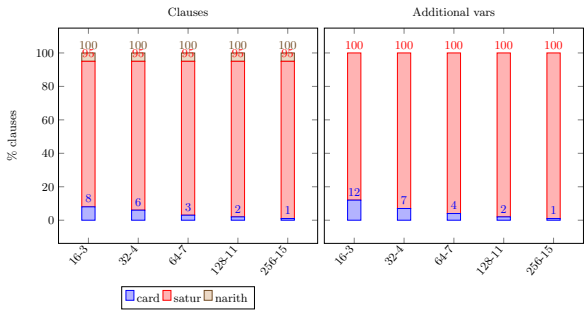

Figure 1: The structure of the SAT expression.

3. COMPUTATIONAL RESULTS

These generated SAT expressions have been given to the state-of-the-art solver. We used currently the fastest solver kissat [3], which won the 2020 and 2021 SAT competitions.

The minimal size of the set is obtained by finding a number k, such that $E(n, k)$ is satisfiable and $E(n, k-1)$ is unsatisfiable. In the evaluation description, we will be mostly describing the unsatisfiable expressions, since these expressions are usually much harder for the SAT solvers.

Figure 2 shows the sizes of minimal saturated subsets. The black plot is $\sqrt{n}$, i.e., the hypothesized lower bound. The results give further empirical evidence for this hypothesis to be true since the $\sqrt{n}$ lower-bound is reached only at points $n = 4^k$, which makes it more plausible that the proposed construction of such sets is also optimal.

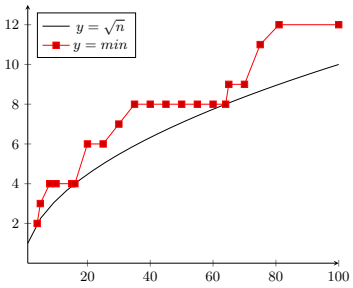

Figure 2: The plot of the minimal saturated set sizes. The black plot shows the lower bound which was reached only at the points $n = 4^k$.

An even more important aspect of our empirical test is the running times to prove the optimality for a certain n. Figure 3 shows the measurements for 4 different cardinality constraint encodings. The first chart gives the running times (y axis is log scale) and it can be seen that all four encodings follow the same trend. Nonetheless, some differences cannot be seen on this log-plot, so we show the results for $E(75, 10)$ and $E(81, 11)$ which shows that that k modulo totalizer has a significant advantage over the other three encodings.

4. UNSATISFIABLE CORES

Based on the results described above, it seems unlikely that we could solve the expression $E(256, 15)$ in a reasonable amount of time. This also gives little hope for solving the problem using some other reductions or even hand-crafted solvers for this particular problem.

However, there could be a different path, using the byproduct of SAT solvers. Namely, these solvers produce proof that their claim (satisfiable or unsatisfiable) is true. For satisfiable expressions, the proof is simply the variable assignment that yields a true value of the expression. But for unsatisfiable expressions, the proof is the trace of the execution of the solver.

The trace of the execution is very large, but a more compact proof can be extracted from it, and that is the unsatisfiable core [4] of the expression. Unsatisfiable cores are subexpressions that are unsatisfiable, but if we remove any clause, the expression becomes satisfiable. This can thus be viewed as the core "reason" why this expression is unsatisfiable.

As an example, let us examine the unsatisfiable core of the expression $E(16, 3)$. The entire expression has 397 variables and 1182 clauses (k modulo totalizer), but the unsatisfiable core has only 399 clauses. We can brake down the structure of the unsatisfiable core even further:

- original size of the $CARD$ expression is 102 and the core contains only 73,
- $NARITH$ has 56 clauses, but the core only contains 19 of these,
- and $SATUR$ has 1024 clauses, but the core only 307.

These results show that there is a more compact reason for

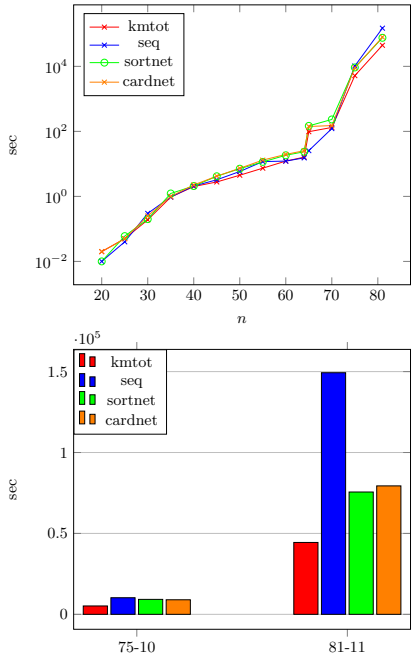

Figure 3: Run times for solving the problem $E(n, k)$, by varying n and k being the largest value where the expression is unsatisfiable. The left plot shows the log plot of the time for four different encodings of the cardinality constraint. The right plot shows only the times for $E(75, 10)$ and $E(81, 11)$ to show a more significant difference between different encodings.

the impossibility of the existence of a saturated set of size 3. There are two possible usages of these unsatisfiable cores:

- reverse engineering the unsatisfiable core to obtain the rules and find a general pattern and thus the proof for the lower bound as it is currently hypothesized.
- knowing the shape of the unsatisfiable cores, we could solve the problem by explicitly finding such a substructure in the entire expression, e.g. $E(256, 15)$. This would require a search for a known substructure, which is a computationally simpler problem than proving that a certain structure does not exist.

5. CONCLUSIONS

In this paper, we described a reduction of the problem of finding a minimal saturated non-arithmetic subset. This is a hard mathematical problem and empirical results could shed some new light on this problem, giving potential insights for future exploration of the problem.

The current hypothesis is, that the lower bound for the size of such a set is $\sqrt{n}$ and it can be reached for values $n = 4^k$. Our initial hope was to be able to reach $n = 256$, where a known set is of size 16 and we need to prove or disprove that this is the smallest possible one.

Using state-of-the-art solvers, we attacked this problem and obtained optimal solutions for values up to 100. All the results are in favor of the current hypothesis, but there is also a pessimistic result that it seems unlikely to obtain optimal results for a much larger n without a significant new insight into this problem.

But the reduction to SAT also has another potentially useful side-effect, namely the unsatisfiable cores. These subexpressions that can be obtained by SAT solvers carry some new insight into the problem and the study of their structure and reverse-engineering the rules for their creation might lead to discoveries in this and maybe other similar problems as well.

6. REFERENCES

[1] R. Asín, R. Nieuwenhuis, A. Oliveras, and E. Rodríguez-Carbonell. Cardinality networks and their applications. In O. Kullmann, editor, *Theory and Applications of Satisfiability Testing - SAT 2009*, pages 167–180, Berlin, Heidelberg, 2009. Springer Berlin Heidelberg.

[2] K. E. Batcher. Sorting networks and their applications. In *Proceedings of the April 30–May 2, 1968, Spring Joint Computer Conference*, AFIPS '68 (Spring), page 307–314, New York, NY, USA, 1968. Association for Computing Machinery.

[3] A. Biere, K. Fazekas, M. Fleury, and M. Heisinger. CaDiCaL, Kissat, Paracooba, Plingeling and Treengeling entering the SAT Competition 2020. In T. Balyo, N. Froleyks, M. Heule, M. Iser, M. Järvisalo, and M. Suda, editors, *Proc. of SAT Competition 2020 – Solver and Benchmark Descriptions*, volume B-2020-1 of *Department of Computer Science Report Series B*, pages 51–53. University of Helsinki, 2020.

[4] A. Cimatti, A. Griggio, and R. Sebastiani. A simple and flexible way of computing small unsatisfiable cores in sat modulo theories. In J. Marques-Silva and K. A. Sakallah, editors, *Theory and Applications of Satisfiability Testing – SAT 2007*, pages 334–339, Berlin, Heidelberg, 2007. Springer Berlin Heidelberg.

[5] N. Froleyks, M. Heule, M. Iser, M. Järvisalo, and M. Suda. Sat competition 2020. *Artificial Intelligence*, 301:103572, 2021.

[6] E. Győri. personal communication, 2022.

[7] S. J. Miller. Combinatorial and additive number theory problem sessions: '09–'19, 2014.

[8] A. Morgado, A. Ignatiev, and J. Marques-Silva. Mscg: Robust core-guided maxsat solving. *J. Satisf. Boolean Model. Comput.*, 9:129–134, 2014.

[9] V.-H. Nguyen, V.-Q. Nguyen, K. Kim, and P. Barahona. Empirical study on sat-encodings of the at-most-one constraint. In *The 9th International Conference on Smart Media and Applications*, pages 470–475, 2020.

[10] C. Sinz. Towards an optimal cnf encoding of boolean cardinality constraints. In P. van Beek, editor, *Principles and Practice of Constraint Programming - CP 2005*, pages 827–831, Berlin, Heidelberg, 2005. Springer Berlin Heidelberg.

[11] G. S. Tseitin. On the complexity of derivation in propositional calculus. In *Automation of reasoning*, pages 466–483. Springer, 1983.

[12] N.-F. Zhou. Yet another comparison of sat encodings for the at-most-k constraint, 2020.

Exact time measuring challenges

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ABSTRACT

In this paper, we focus on implementations of the BubbleSort algorithm in three different programming languages: Java, C, and x86 assembler. Using the ALGator system we execute these implementations with different inputs and perform an empirical evaluation of the results. We discuss the importance of test repetition for achieving accurate timing results. We show that the Java and the C implementations achieve similar efficiency and that the quality order depends on the type of input data.

Categories and Subject Descriptors

F.2 [**Analysis of algorithms and problem complexity**]: Reliability and Testing; D.2.8 [**Software Engineering**]: Metrics—*complexity measures, performance measures*

General Terms

Algorithm Engineering

Keywords

empirical algorithm analysis, time measuring, accuracy, reliability, comparing Java and C

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1. INTRODUCTION

The theoretical complexity analysis of algorithms is a very important part of the algorithm design process. This analysis usually estimates the amount of resources (e.g. time or memory storage) that is going to be utilized during the algorithm execution [4]. The result of the analysis depends on the selected computation model [3] which implies the execution environment and its limitations. Roughly, the results of such theoretical analysis are used to distinguish between fast (i.e. polynomial) and slow (exponential) algorithms. But in practice these results are of limited value especially if the two algorithms compared have the same (theoretical) time complexity. The model that is used in theoretical study does usually not take into account all the peculiarities of the real execution environment (like memory caching, paging, branch prediction, etc.), which are revealed only during the execution of the algorithm on a real computer. Therefore, for practical comparison of actual algorithms' capacity theoretical analysis has to be replaced with empirical measurements of resource usage during the algorithms' executions on various types of input data [5]. In order to provide quality results, these measurements have to be performed carefully since many factors impact the measured data. In this paper we focus on some of them and present results of our measurements that highlight the importance of each of them. Namely, we use three programming languages and present the impact of language selection on the speed of execution. Furthermore, we present the importance of repetition of tests, especially when the size of the input (and therefore the execution time) is small. In addition, we discuss how the type of input data can affect the algorithms' quality rankings.

2. TESTING ENVIRONMENT SETUP

For all our tests in this research we will use the BubbleSort [1] algorithm for sorting arrays of integers. Since this is a very well known and a simple algorithm we are able to perform a precise theoretical analysis and provide very accurate (theoretical) forecast for the time complexity of its implementations. The algorithm is so simple that we can count the number of operations performed during the execution for different inputs. Thus we will be able to compare theoretical predictions with the empirical results.

One of the goals of this research was to analyse the impact of the selected programming language on the efficiency of algorithm execution. Therefore we used three programming languages (namely the Java, the C and the x86 assembler) to implement BubbleSort. Due to the simplicity of the algorithm we managed to write the three implementations in such a way that they provide semantically identical code. For further reference, we named implementations `BubbleJ`, `BubbleC` and `BubbleA`, where the last letter denotes the programming language used (J for Java, C for C and A for x86 assembler). When executing these implementations on the same inputs they will perform the same number of each programming-language-dependant atomic operations. Any differences in the execution speed will thus reflect the differences in the execution speed of these operations in the selected programming language. The C implementation was compiled with the `gcc` compiler in two ways: without op-

timization (the `-O0` flag) and with full optimization (the `-O3` flag). In this way we got two distinct implementations (namely `BubbleC0` and `BubbleC3`). In the following we will analyze the impact of this optimization to the speed of execution.

To facilitate the empirical evaluation in our research we used the ALGator system [2]. We used its tools to configure the Sorting project, to provide the test sets of input data and implementations and to execute the algorithms' implementations in a controlled environment. For the execution machine we used the Intel(R) Core(TM) i7-6700 CPU @ 3.40GHz computer with 32GB RAM and with the Linux Ubuntu operating system installed.

The inputs for our algorithms consist of arrays of integers prearranged in three different orders: random order (RND), sorted order (SOR) and inversely sorted order (INV). These three distributions of input data are well manageable from a theoretical point of view, since we know for all three the number of operations that will be performed during the sorting process. In all three case BubbleSort will perform exactly $n(n-1)/2$ comparisons, and $n^2/4$, 0, $n(n-1)/2$ swaps for RND, SOR, INV respectively. Note that all the numbers of operations are exact, except for the number of swaps in RND case - here we only have the expected (instead of exact) number of swaps, since the sequence is randomly mixed. Since BubbleSort performs only comparisons and swaps (and some auxiliary increments of indices to maintain the loops) we could expect that, for example, sorting RND array will be faster than sorting INV array of the same size. But as we will see in the following this in not the case.

In the ALGator project inputs (i.e. test cases) are grouped into test sets. Each test case has its own identifier (Test ID), so the results can also be compared on the test-basis. To provide accurate results each test case is executed several times (each execution of the test case has its identifier, Repetition ID). Besides a list of all execution times of a test case ALGator provides two information, the time of the first execution (Tfirst) and the time of the fastest execution (Tmin) of this test case. The first execution is usually much slower than other executions since (this is true especially for the java environment) the execution machine needs to warm up. As we will see in the following the Tfirst time can even be twice as big as the Tmin time.

To measure the time in Java we can only use the wall-clock (Java does not provide any processor usage information). To minimize the unreliability of the measured time (which is due to the fact that the process may spend time waiting for I/O or for other processes that are also using the CPU) we use a "clean" computer which is dedicated only for execution of the algorithms. Besides that, we usually take the Tmin time as a reference data, since this is a time in which the computer is capable of solving the problem (the number of disturbing factors is minimal). For he algorithms implemented in the C programming language we use the CPU time obtained by the `clock()` function (which returns the number of clock ticks used by the process). By calling this function before and after the algorithm execution and subtracting the returned values we get the total amount of time a process has actively used a CPU. The time measured this way is much more reliable and accurate quality indicator.

3. THE MEANING OF TEST REPETITION

In our first experiment we would like to find out the meaning of several repetitions of a given test case execution. For this we used a test set consisting of three groups of test cases: in each group there are 50 identical tests of sizes 500, 5000 and 20000. All the input arrays in these test cases were ordered in inverse order (to ensure the identical number of operations during the sort process). We executed each test case 50 times. By analysing the results we noticed that the (absolute) difference between Tfirst and Tmin is approximately the same for all three groups of test cases. The relative difference is therefore smaller for bigger measured times. We can conclude that the measurement of both Tfirst and Tmin is important for small inputs and that the importance of distinguishing between Tfirst and Tmin decreases with increasing input size. Measurements have shown that something similar to the Java's "Tfirst phenomenon" also happens with C, except that in this case "warming up the machine" adds significantly less to the overall time complexity, so the differences in speed between Tfirst and Tmin are noticeable only in experiments that take very little time. From Table 1, which shows the relationship between the average first and the minimum execution time of a test case, $f = \frac{\overline{T}_{first}}{T_{min}}$ it can be seen that for small n the ratio is similar in both implementations, but for larger n the difference between Tfirst and Tmin is almost negligible for the `BubbleC3`, while for the `BubbleJ` the value decreases significantly more slowly. At $n = 20000$ the difference is still more than 5%.

The difference in measured times of multiple executions of the `BubbleJ` and `BubbleC3` implementations is depicted in Fig. 1. Here we used 50 inversely ordered arrays of size 5000, each test case was repeated 50 times. On the graph, the time of the first execution of the test case is shown in gray (Tfirst, Repetition ID=0), the first 20 repetitions are shown in orange, and the next 30 in red. With `BubbleJ`, we see that the first times (Tfirst) deviate considerably from the other measured times; the Tfirst times are somewhere between 18k and 22k, and the other times are much smaller (between 12k and 14k), which corresponds to the factor of 1.4 from Table 1. Other measured times on this graph does not show much fluctuation, as the scale of the display is reduced due to the large Tfirst times; we see that some Tfirst times are almost 100% larger than the smallest measured times. With `BubbleC3`, all times are quite similar to each other; the graph shows some variations, but everything is between 14.6k and 15.6k; the differences between measured times are relatively small (approx. 6%).

For the conclusion: is it important to repeat the algorithm execution for several times to find the minimum time? As

N	*BubbleJ*	*BubbleC3*
500	1.98	1.80
5000	1.40	1.02
20000	1.05	1.01

Table 1: The ratio $f = \frac{\overline{T}_{first}}{T_{min}}$ between the average of the first and the minimal measured times

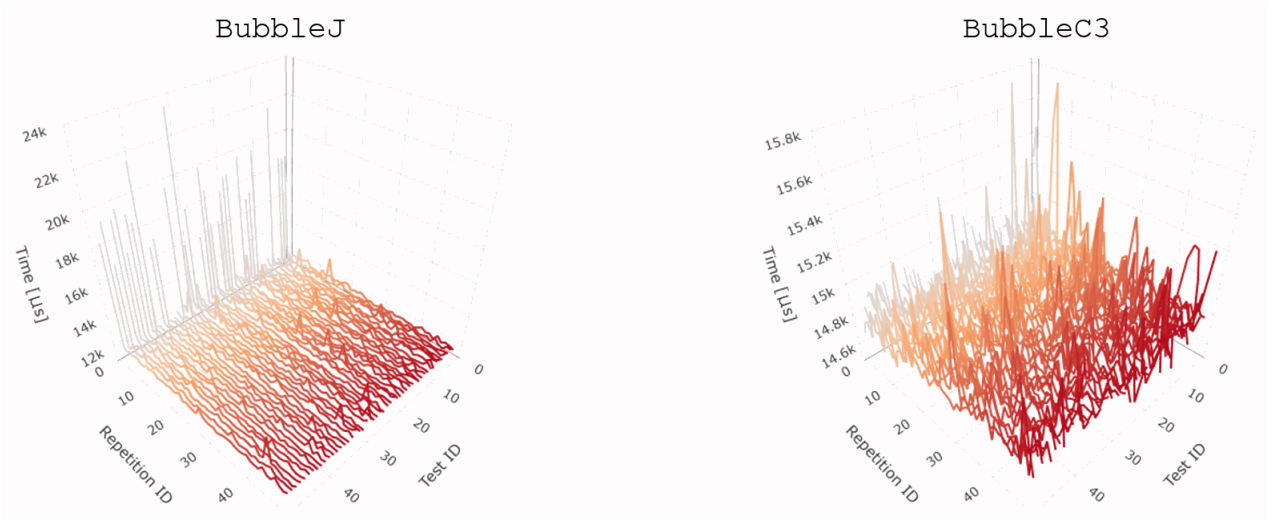

Figure 1: Times of execution of 50 identical test cases (50 repetitions of each test case) with `BubbleJ` and `BubbleC3`

the measurements show, the answer depends on the size of the input - the smaller the input, the more measurements are unreliable, so we need to take more measurements to get a good result.

Bar charts in Fig. 2 depict the proportion of measurements that differ from the smallest measurement by the given percentage range. The measurements on small inputs for the `BubbleJ` vary a lot. More than 36% of all measurements differ from the minimal time more than 10%. For the `BubbleC3` on the other hand only 17% of the measurements are that bad. When increasing the size of the input the results for both algorithms improve. For n=20000, for example, more than 73% (98%) of measurements differ from the minimal measurements for less than 1% for `BubbleJ` (`BubbleC3`) implementation.

The relative standard deviations of all measured times for `BubbleJ` are 21%, 7% and 1% for n=500, 5000 and 20.000 respectively. This confirms the claim that as the size of the input increases, the importance of multiple tests decreases. Since the relative standard deviations are even smaller for `BubbleC3` (namely 15%, 1%, 0.24%), the importance of a large number of measurements is even smaller here.

4. THE IMPACT OF THE PROGRAMMING LANGUAGE

We compared the times of execution of four implementations (`BubbleJ`, `BubbleA`, `BubbleC0` and `BubbleC3`) on randomly ordered sequences (RND) of length 500 to 50000 (step 500). Each test was executed 30 times. Fig. 3 shows the minimum measured times Tmin of all four algorithms.

We expected the `BubbleC3` to be the best, which was also proven with the measurements. The difference between `BubbleC0` and `BubbleC3` is somewhat surprising. Since BubbleSort is a simple algorithm, one would expect that the speedup resulting from the optimization would not be that great. But this is not the case, the difference is almost 2 times for large n. The relationship between `BubbleJ` and `BubbleA` is interesting. In a battle between fast implementations, Java turned out to be the slowest, although the differences in speed are not so great. Fitting all measurements with a quadratic functions results in the following:

`BubbleC0`:	$T_{min}(n) = 2.438n^2\ \mu s$
`BubbleJ`:	$T_{min}(n) = 1.372n^2\ \mu s$
`BubbleA`:	$T_{min}(n) = 1.311n^2\ \mu s$
`BubbleC3`:	$T_{min}(n) = 1.246n^2\ \mu s$

The ratio between the best (`BubbleC3`) and the worst (`BubbleC0`) implementation is 1 : 1.956, which we also noticed from the graph. More interesting is the ratio between the optimized C3 and Java implementation: `BubbleC3` : `BubbleJ` = 1 : 1,101. This means that for sorting random sequences Java is 10% slower than C. To find out, how good this conclusion is, lets calculate and depict the relative error

$$Error = \frac{|BubbleC3.T_{min} - 1.1 * BubbleJ.T_{min}|}{BubbleJ.T_{min}} * 100\%$$

Fig. 4 shows that for small inputs ($n < 5000$) the error is very big (as big as 1200%), but for larger inputs ($n > 10000$) the error is always less than 5% and it seems that it decreases when n increases.

As the last experiment we compared the times of execution of four implementations on inversely ordered sequences (INV) of length 500 to 50,000 (step 500). The results that are presented in Fig. 5 are somehow surprising.

The quality ranking of algorithms when sorting INV data changes comparing to the ranking on RND data. While `BubbleC0` remains the worst implementation, on the first place there is a swap - `BubbleC3` gives way to `BubbleA` and `BubbleJ`. Something similar happens with the sorted (SOR) data. This change in ranking is hard to explain, but according to our other research results which shown that the processor's branch predictor has a great impact to the execution time, we could speculate that the code generated by JVM is less suitable for branch prediction. With INV (and

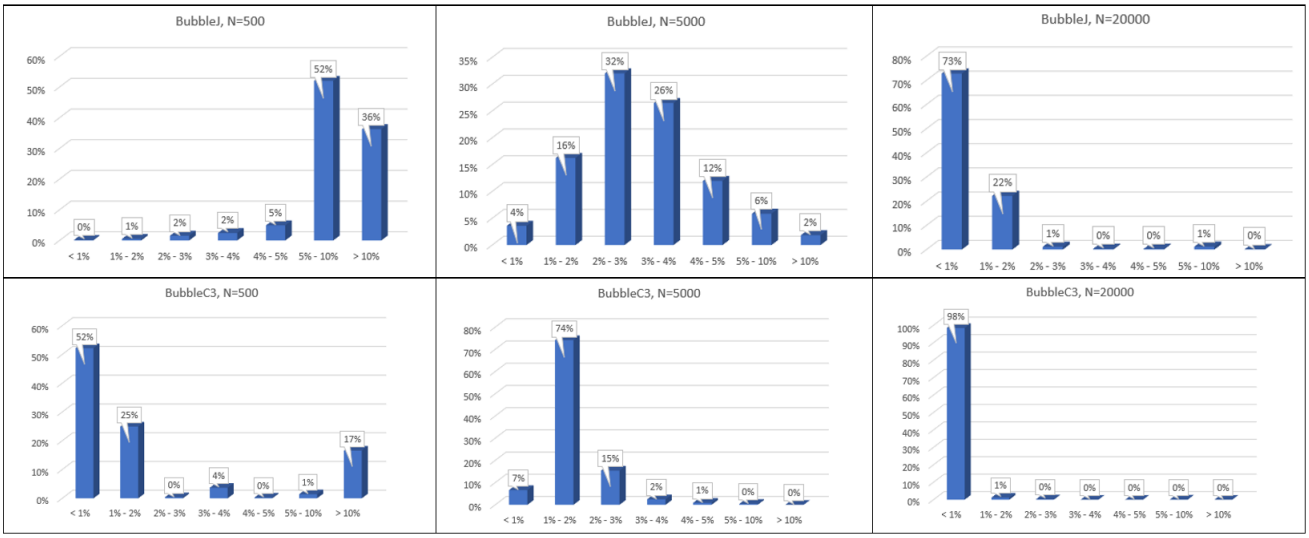

Figure 2: The proportion of measurements that differ from the smallest measurement by the given percentage range.

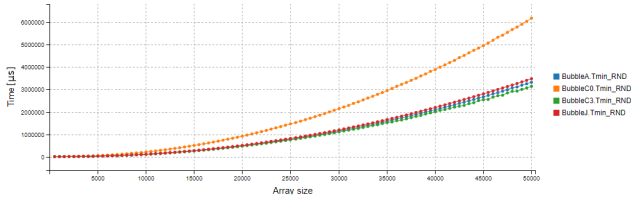

Figure 3: Tmin, RND data, $n = 500, ..., 50000$

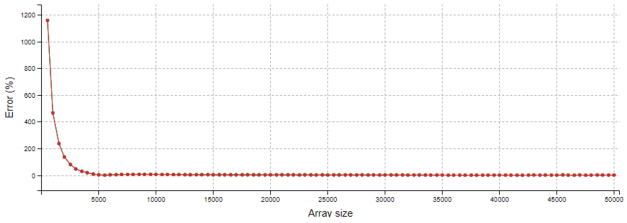

Figure 4: Relative error of estimating `BubbleJ`.Tmin with 1.1*`BubbleC3`.Tmin

SOR) data the code predictor is always correct, which could reflect in better performance. Anyway, the results unequivocally shows that the type of the input has a great impact on the quality of implementation. While with random data `BubbleC3` implementation was faster than `BubbleJ`, for inversely ordered data (and sorted, as we also found out) the Java implementation is the fastest.

5. CONCLUSIONS

The results presented in this paper show that there are many factors that have impact to the execution time of the algorithms. We have shown that despite a carefully controlled environment, deviations occur in measurements. The deviations are particularly pronounced in Java, since the way of measuring time here is significantly more sensitive to the influence of the environment than in C. We have seen that repeated execution of algorithms is especially important for

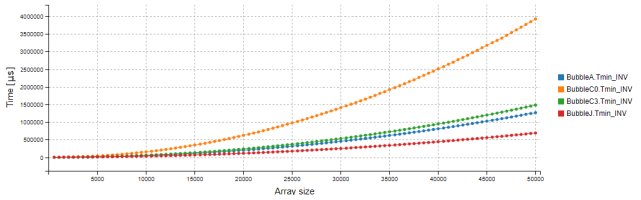

Figure 5: Tmin, INV data, $n = 500, ..., 50000$

small inputs. We also compared the differences between the programming languages. We showed that the difference between Java and C is not very big and that it depends on the type of input data - for randomly sorted arrays, the C implementation was faster, while for inversely ordered and already sorted data, Java took the first place in the ranking. In the future we could provide similar results for some other problems (to see if the results can be generalized), we could use another popular programming language (like Python) and we could investigate the real impact of the branch predictor the final results.

6. REFERENCES

[1] T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein. *Introduction to Algorithms*. The MIT Press, 2nd edition, 2001.

[2] T. Dobravec. Algator — an automatic algorithm evaluation system. *Advances in Computers*, 116(1):65–131, 2019.

[3] M. Fernández. *Models of Computation, An Introduction to Computability Theory*. Springer, 2009.

[4] B. Swathi. A comparative study and analysis on the performance of the algorithms. *International Journal of Computer Science and Mobile Computing*, 5(1):91–95, Januar 2016.

[5] M. Tedre and N. Moisseinen. Experiments in computing: A survey. *The Scientific World Journal*, 2014(1):1–11, 2014.

Systematic generation of precedence based MILP models with P-graphs for multipurpose scheduling problems

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ABSTRACT

Scheduling of various processes is a widely researched topic in the literature. Different fields have their own specific constraints and parameters, thus, specialized approaches often emerge to tackle these needs efficiently. Solution methods have many flavors from general mathematical models such as mathematical programming, constraint programming; through general purpose heuristics, e.g., genetic algorithms, ant colony optimization; to problem specific tools like the S-graph framework.

A general aim of any newly developed method is to perform efficiently, and provide the optimal solution quickly, preferably faster than existing approaches. However, each tool has its strengths and weaknesses, and even for a well defined problem class, it is often not trivial to select the best approach for a problem instance in advance. This work focuses on a prerequisite of this dilemma: having the set of approaches to consider.

The aim of the paper is to present a modeling approach which enables the systematic generation of sound MILP models for a problem class. To illustrate this approach, a well known scheduling problem class from the batch process industry is considered, and the investigation is limited to only a specific type of MILP formulations, namely the general precedence models.

Keywords

scheduling, model generation, precedence, P-graph, MILP

1. INTRODUCTION AND LITERATURE

In general, the goal of scheduling is to time processes and often to allocate resources wisely in order to achieve a plan that meets all requirements or to find the best one among them. Due to its general nature, scheduling has been investigated in many different fields of science. In this work, the focus is on the production industry, where machines or equipment units are used to produce a certain set of goods. More specifically, makespan minimization for multipurpose batch processes is investigated, which has been addressed with various techniques over the last few decade, such as Mixed-Integer Linear Programming (MILP), S-graph framework, Linearly-Priced Timed Automata, and others[1, 7]. Even among MILP models, several different branches have emerged, the two main categories are precedence based and time discretization based formulations[2].

A lot of effort has been invested into the testing various models on case studies, benchmark examples, or a large number of randomly generated examples. When such a study is carried out, the examiner has to make a decision about the models to be included. This is not a straight forward decision even for only MILP models, as there is a huge number of them, often developed for a slightly different problem classes, and usually have several variants. Moreover, even with expert knowledge on the field, one can only include models that have already been published.

The aim of this work is to introduce a modeling approach, that results in a mathematical model enabling systematic generation of possible general precedence based models, including the ones published in the literature. Such a method would ensure for a comparative study, that it is not limited on manually hand-picked models, but consider all options within a given set of limitations. For the sake of simplicity and the illustration if this approach, this work focuses only on precedence based MILP models with general precedence variables for the most basic multipurpose batch scheduling problems without any common real life requirements such as changing- and setup times, storage limitations, etc. It would have been too ambitious for this study to include a a wider range of model types or a more complex scheduling problem class. This is left to future research. It is not the aim of this paper to provide any comparative results between the various MILP models, neither is to present the list of the numerous MILP formulations generated. The key messages of this study are the concepts and techniques used for building this model.

For the aforementioned purposes, the P-graph framework was utilized. P-graphs have been originally introduced as combinatorial models of process networks[3], that allows the developed algorithms to find feasible or optimal solution structures to synthesis problems[5, 4]. Since then, the models and the algorithms of the framework have been widely

applied in different areas of science from renewable supply chain optimization through polygeneration plant modeling to mobile workforce optimization[8, 6, 9].

The paper is structured as follows: Section 2 provides the definition of the scheduling problem class selected for illustration. Different modeling techniques among precedence based MILP formulations are briefly discussed in Section 3. Due to space limitations, completeness is not the aim of this section, only the showcasing of variations. To facilitate understanding, the utilized parts of the P-graph framework are briefly introduced in Section 4. The P-graph formulation of precedence based MILP models is illustrated in 5, again without the aim of completeness. Concluding remarks are shared in 6 along with possible directions of further research.

2. PROBLEM DEFINITION

The goal of the considered problem class is to minimize makespan of producing a set of products P with the set of equipment units: J. The production recipe of each product $p \in P$ is linear, and $n_p \in \mathbb{Z}^+$ denotes the number of steps. A derived set, $I = \{(p,n) \mid p \in P, n \in \{1,2,\ldots,n_p\}\}$ denotes the set of all tasks to be carried out. For simpler notation, a task is denoted by i instead of (p,n) when that level of detail is unnecessary. $I_j \subseteq I$ refers to the tasks that can be carried out by unit $j \in J$, and for all $i \in I_j$, the execution time is denoted by pt_{ij} in that unit. J_i is used to refer to units that can perform $i \in I$, i.e., $J_i = \{j \in J \mid i \in I_j\}$.

Each task is uninterruptible, must be assigned to exactly one unit, and a unit may not work on two tasks at the same time. Other common timing parameters for setups, changeovers, etc., are neglected, and intermediate materials can be stored at any amounts for any duration of time, i.e., Unlimited Intermediate Storage (UIS) Policy is considered. [1]

3. VARIATIONS FOR GENERAL PRECEDENCE BASED MILP MODELS

Precedence based models for the described problem class usually rely on decision variables about the assignment, sequencing, and starting time of tasks.

Assignment is generally modeled by a binary variable, Y_{ij} denoting whether unit $j \in J$ is assigned to task $i \in I$. Similarly, the exact starting time of task $i \in I$ is modeled by a continuous variable $S_i \in \mathbb{R}^{0+}$. The models also always define the makespan, MS as a target variable to be minimized.

This is the point, where models start to diverge. Some dedicate a continuous variable C_i for the completion time of each task, similar to S_i. The largest difference, however, appears in the sequencing variables, usually denoted by X. In some models, $X_{iji'}$ takes the value of 1 if and only if both tasks i and i' are assigned to unit j and the decision has been made to perform i before i'. With such a variable, the constraint to properly sequence tasks can be expressed by the following inequality, where M is a sufficiently large number:

$$S_{i'} \geq S_i + pt_{ij} - M \cdot (1 - X_{iji'}) \qquad \forall j \in J,\, i, i' \in I_j$$

This formulation, however, requires an unnecessarily large number of binary variables, thus models often employ another variable, $X_{ii'}$ that takes the value of 1 if tasks i and i' are assigned to the same unit, and the decision has been made that i is performed before i'. With such variables, the constraint above can be replaced with another:

$$S_{i'} \geq S_i + pt_{ij} - M \cdot (3 - X_{ii'} - Y_{ij} - Y_{i'j}) \qquad \forall j \in J,\, i, i' \in I_j$$

Note, that the value of $X_{ii'}$ is irrelevant if i and i' are assigned to different units. If that feature is ensured by another constraint, and a separate completion variable is defined, sequencing can be enforced via the following simple constraint:

$$S_{i'} \geq C_i - M \cdot (1 - X_{ii'}) \qquad \forall i, i' \in I,\, J_i \cap J_{i'} \neq \emptyset$$

Again, this constraint does not require $X_{ii'}$ to be 0 if the tasks are assigned to different units, it only needs them to be allowed to be 0.

Following similar thinking, other variants of the X variables and their corresponding constraints can be derived. Such further discussion is omitted here, however, there other ways how different model variants can be generated. For example, $X_{ii'}$ variables could either be defined for all i, i' pairs in both directions or only for $i < i'$ if a total ordering is defined. Or, when C_i is introduced, it may be required to be the exact time when i finishes, or just any time point after that, as discussed in a bit more detail in Section 5. Also, if the same requirement of the problem class can be expressed in various ways, only one can be selected or even several of them redundantly. The latter may seem unreasonable, however, testing experience often shows, that redundant constraints may affect the search space in such a way, that MILP solvers and their heuristics can find better solutions or bounds.

4. BRIEF INTRODUCTION TO P-GRAPHS

The P-graph framework was introduced to provide a rigorous and efficient framework to generate feasible process networks [3], or find the optimal one among them[5, 4]. This work relies only on the original P-graph model (without any extensions or additional parameters) and the SSG (Solution Structure Generator) algorithm, that generates all combinatorially feasible solution structures.

A P-graph is an (M, O) pair, where M denotes the set of materials, and O the set of operating units. Each operating unit $o \in O$ is a pair of material sets: its (mandatory) inputs and outputs. A Process Network Synthesis (PNS) problem is defined by a triple $(\mathsf{P}, \mathsf{R}, \mathsf{O})$ where

P is the set of product materials that must be produced by at least one operating unit.

R is the set of raw materials that can be consumed without being produced by an operating unit.

O is the set of possible operating unit to be included in the network.

[1] In this simplified form, the problem class is reduced to Flexible Job Shop Scheduling. However, as the research was motivated by the batch production industry, its terminology is kept along with its standard notation, that has less conflicts with that of the P-graph framework.

The SSG algorithms takes (P, R, O) as its input, and generates all of the feasible subsets of O that satisfy the 5 axioms for feasible solution structures.

5. SYSTEMATIC MODEL GENERATION

In many industrial applications of the P-graph framework, the original meaning of operating units and materials is extended to broader concepts. Materials often represent logical states, and operating units may model transportation, etc. This application of P-graphs follows the same idea. There are, however, terms like intermediates, product, unit, etc., that both appear in the underlying process to be scheduled and in the P-graph model, that is used to generate MILP models. To avoid confusion, the elements of the P-graph model will be referred to as M-, P-, I-,R- and O-nodes.

5.1 P- and R-nodes

The R-nodes of the proposed model are the variable declarations with their domain, such as:

- $S_i \in \mathbb{R}^{0+} \quad \forall i \in I$
- $C_i \in \mathbb{R}^{0+} \quad \forall i \in I$
- $Y_{ij} \in \{0,1\} \quad \forall j \in J, i \in I$
- $X_{ii'} \in \{0,1\} \quad \forall i, i' \in I,\ i < i', J_i \cap J_{i'} \neq \emptyset$
- $X_{ii'} \in \{0,1\} \quad \forall i, i' \in I,\ i > i', J_i \cap J_{i'} \neq \emptyset$
- $X_{iji'} \in \{0,1\} \quad \forall j \in J, i, i' \in I_j, i < i'$
- $X_{iji'} \in \{0,1\} \quad \forall j \in J, i, i' \in I_j, i > i'$

The P-nodes are the feasibility constraints of the scheduling problem:

P1 Each task must be carried out.

P2 Production steps of a product must be in order.

P3 Tasks assigned to the same unit can not overlap.

P4 The shutdown of the facility must happen after all of the products are produced.

These are the results that has to be produced (ensured) from the R-nodes. To do so, O-nodes are available.

5.2 O- and I-nodes

One type of O-nodes are the possible constraints in a precedence based MILP model.

As an example, the following constraint is an O-node, that consumes the R-node representing Y and generates P1:

$$\sum_{j \in J} Y_{ij} = 1 \quad \forall i \in I$$

As another example, the following constraint is another O-node that generates P2:

$$S_{(p,n+1)} \geq C_{(p,n)} \quad \forall p \in P, n \in \{1, 2, \ldots, n_p - 1\}$$

The inputs of this O-node are less obvious and worth a short discussion. Seemingly there should be two of them, the R-nodes representing the S_i and C_i variables. However, that is not correct, as the R-nodes only represent the availability of those variables, but don't ensure additional semantic features. Namely, the R-node for C_i only ensures that there is a variable named C but nothing about its timing. For the O-node above to produce P2, such a C variable is needed, whose value is ensured to be greater or equal than the completion time of the task. This semantically correct C variable is different from the R-node above, and can be represented by an I-node. In turn, this I-node can be produced by the following O-node:

$$C_i \geq S_i + \sum_{j \in J_i} Y_{ij} \cdot pt_{ij} \quad \forall i \in I$$

or by another O-node:

$$C_i \geq S_i + Y_{ij} \cdot pt_{ij} \quad \forall i \in I, j \in J_i$$

Both O-nodes require the R-nodes for C and S variables as inputs. Again, the R-node representing the Y variables is not an input, as it does not hold the semantic meaning, that one unit is assigned to a task. This is represented by P1.

An observant reader may point out that the first suggested O-node above should have had equality:

$$C_i = S_i + \sum_{j \in J_i} Y_{ij} \cdot pt_{ij} \quad \forall i \in I$$

This constraint, of course is a valid, and a different O-node in the proposed model. However, the output of this node is not the same, as in this case, it is ensured that C_i is exactly the finishing time of a task, not a time point at least that much. Some O-nodes may require this more specific version of C, others the previous one. On the other hand, if this new I-node for the C variables with exact timing is available, the other I-node is also implied. This implication is also represented by an O-node, that has no constraint assigned to it.

Thus, I-nodes in the proposed model are concepts similar to the P-nodes, albeit more specific to the variables of the model. O-nodes represent either constraints or logical implications.

5.3 Illustration

Figure 1 illustrates the part of the model that in the previous section.

It is easy to see, that there are 7 feasible solution structures (3 of them without redundancy) to just this small part of the P-graph model. Generating the model from a solution structure is straight forward, the constraints and variable declarations corresponding to included O-nodes and R-nodes compose the MILP model together with the objective function to minimize the makespan.

Note, however, that there could be other O-nodes producing P2, further increasing the number of possible models. For example:

$$S_{(p,n+1)} \geq S_{(p,n)} + \sum_{j \in J_{(p,n)}} Y_{(p,n)j} \cdot pt_{(p,n)j} \quad \forall (p,n) \in I$$

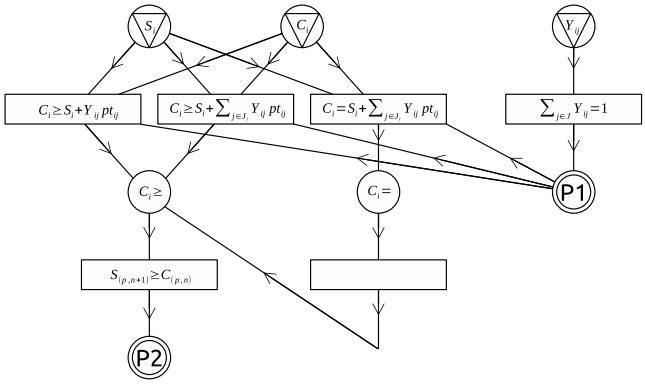

Figure 1: Part of the proposed P-graph model

5.4 Remarks on extendability

The rest of the model could be formulated in a similar fashion. Naturally, the presented model only considers constraints that are included as O-nodes. It will not discover new type of constraints, only find the sound combinations of proposed ones.

The modeling procedure, however, allows extension by addition. For example, if one were to consider immediate precedence variables as well, that would introduce an additional I-node for an X variable that satisfies the required conditions, that are more strict than the ones required by general precedence models. Moreover, O-nodes would be added to produce and consume this I-node. Some models also employ an integer variable, that denotes the position of a task in the assigned units production sequence. This could be implemented by adding R-, I- and O-nodes similarly.

Thus, this is a model that can continuously grow, and feasible solution structures of a previous version would still remain feasible.

There are still options, that were not discussed here due to space limitations, and to the early stage of this research. For example, in an extended model, some I-nodes could require a mutually exclusive relation. This is a feature, that is not supported by the P-graph tools introduced here. P-graphs with material balances and an underlying MILP model can, however, easily model this.

Also, the presented model only allows redundancy among constraints, but not among variables. Simplest example to this would be, if two sets of C_i variables were introduced, and some would be used by one subset of O-nodes, and the other one by others. This feature, again, could be modeled by introducing material balances and quantities into the model.

6. CONCLUSIONS & FUTURE RESEARCH

In this paper, an approach is presented to develop a model, that can generate MILP models for a specific problem class. This modeling technique - based on P-graphs - is illustrated on the simple class of multipurpose batch process scheduling problems and with the scope on general precedence based MILP models by P-graphs. Following this technique results in a large PNS problem, where raw materials are variable declarations and operating units are linear constraints on them. An MILP model can easily be derived for the original illustrative problem class for every solution structure generated by SSG for this PNS problem. The model is backwards-compatible with addition, i.e., the introduction of new variables and constraints does not render previous solution structures (MILP formulations) infeasible (invalid).

This research is in an early stage. There are numerous additions and extensions of the proposed approach that could be considered for future research. After the inclusion of intermediate precedence variables, parts of time discretization models may be added, which may help uncover previously unknown hybrid models. Extensive performance testing of generated models, and observing the reduction between model variants by the preprocessor of various MILP solvers could be of interest.

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8. REFERENCES

[1] State-of-the-art review of optimization methods for short-term scheduling of batch processes. *Computers & Chemical Engineering*, 30:913–946, 2006.

[2] C. A. Floudas and X. Lin. Continuous-time versus discrete-time approaches for scheduling of chemical processes: a review. *Computers & Chemical Engineering*, 28:2109–2129, 2004.

[3] F. Friedler, K. Tarján, Y. W. Huang, L. T. Fan, K. Tarjan, Y. W. Huang, and L. T. Fan. Graph-theoretic approach to process synthesis: Axioms and theorems. *Chem. Engng Sci.*, 47:1973–1988, 1992.

[4] F. Friedler, B. J. Varga, E. Fehér, and L. T. Fan. *State of the Art in Global Optimization*, chapter Combinatorially Accelerated Branch-and-Bound Method for Solving the MIP Model of Process Network Synthesis, pages 609–626. Kluwer Academic Publishers, Dordrecht, 1996.

[5] F. Friedler, J. B. Varga, and L. T. Fan. Decision-mapping: A tool for consistent and complete decisions in process synthesis. *Chemical Engineering Science*, 50:1755–1768, 1995.

[6] F. Friedler, Ákos Orosz, and J. P. Losada. *P-graphs for Process Systems Engineering*. Springer, Cham, 1 edition, 2022.

[7] M. Hegyhati and F. Friedler. Overview of industrial batch process scheduling. *Chemical Engineering Transactions*, 21:895–900, 2010.

[8] J. Klemes and P. Varbanov. Spreading the message: P-graph enhancements: Implementations and applications. *Chemical Engineering Transactions*, 45:1333–1338, 10 2015.

[9] A. Éles, I. Heckl, and H. Cabezas. New general mixed-integer linear programming model for mobile workforce management. *Optimization and Engineering*, Feb. 2021. IF: 2.760.

On relations of Watson-Crick finite automata to other computational paradigms

[Extended Abstract]

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ABSTRACT

We study language classes that are accepted by some variants of Watson-Crick finite automata, i.e., with a 2-head model of finite automata working on Watson-Crick tape modeling DNA molecules. We show a relation between sticker systems and stateless traditional Watson-Crick automata where the two heads scan the input in the same direction. We also establish a new connection between external contextual grammars with choice to the sensing $5' \to 3'$ Watson-Crick automata, i.e., to the 2-head model of finite automata where the two heads starting from the two extremes of the input and they move in opposite direction till they meet.

Categories and Subject Descriptors

F.4.3 [**Formal Languages**]

General Terms

Theory, Automata, Languages, Computing paradigms

Keywords

Watson-Crick automata, sticker systems, formal languages, finite state machines, stateless automata, external contextual grammars, linear languages

1. INTRODUCTION

On the one hand, contextual grammars are one of the formal methods developed to generate languages [2, 9, 21] initiated by Solomon Marcus in the end of 1960s. The generation of the words, i.e., the derivation process is going by inserting or attaching two subwords at the same time to the actual word. The inserted/attached subwords are called context and the condition how the process is done, the "choice", is handled by selection languages. The main motivation comes from linguistics, as there are various non-context-free structures that occur in natural languages, in general. Contextual grammars give a somewhat orthogonal classes of languages to the Chomsky hierarchy. However, they are not independent of each other, as in the former model, the class of selection languages is frequently chosen as one of the classes of the Chomsky hierarchy. There are two main types of contextual grammars, the internal and the external types, in the former the words of a context are inserted inside the actual word, while in the latter the words of the context are attached to the two ends of the actual word. In this paper, we are interested mostly in the external contextual grammars, thus we will only recall those in Section 2. On the other hand, DNA computing belongs to new computing paradigms emerged in the end of the last century. Two of the 'traditional' models of DNA computing, the filtering and the sticker systems are in close relation to the ground breaking experiments of Adleman and Lipton solving (some instants) of the Hamiltonian path and SAT problems by coding graphs in sets of DNA molecules, filtering out and detecting the result [1, 8]. DNA computing and its models can also be used to generate/accept formal languages, and not only to solve some (combinatorially hard) problems. The sticker systems can also be used for language generation based on the sticking operation: DNA molecules having single stranded, so-called 'sticky' ends, can stick together to form a larger molecule. For a good analogy, one may think about how a (long) line can be built by dominos. (A more formal description is given in Section 2.)

Another early formal DNA computing model, named by the Nobel price winners Watson and Crick, who discovered the structure of the DNA molecules, is a generalisation of finite state automata working on two-stranded DNA molecules (also called Watson-Crick tape) instead of the traditional tape [3]. These models of computation, namely Watson-Crick automata, are entirely defined to describe some formal languages, in a similar manner as models of traditional automata theory do. Already it is mentioned in [20, 22] that Watson-Crick finite automata are developed as a kind of accepting counterpart of the language generating sticker systems.

In this paper, our aim is twofold, first we investigate a formal connection between some sticker systems and some variants of Watson-Crick finite automata, and then, we also concentrate on connections of reverse Watson-Crick automata and external contextual grammars. Some variants of the reverse Watson-Crick automata are also called $5' \to 3'$ Watson-

Crick automata as the heads of these automata are scanning the input DNA in opposite physical directions, i.e., both strands from their $5'$ to $3'$ direction. We note here that there is an expansive literature on the sensing $5' \to 3'$ Watson-Crick automata [10, 11, 12, 13, 14, 16, 17, 18, 19] in which the process on the input finishes when the heads meet if the automaton does not get stuck earlier. The structure of this paper is as follows. In the next section we recall some formal definitions from the literature mentioned earlier. In Section 3, the first part of the main results are presented, by establishing a connection between sticker systems and Watson-Crick automata. Then, in Section 4, we present connections between external contextual grammars and sensing $5' \to 3'$ Watson-Crick automata.

2. NOTATIONS AND DEFINITIONS

Here, we recall some important definitions and fix our notations. We assume that the reader already knows the basic concepts of finite automata, formal languages, generative grammars and computing. We denote the empty word by λ.

Let us start with external contextual grammars with choice (also called selection). Formally, an external contextual grammar EC is a triplet (V, A, P) where V is a finite alphabet, A is a finite set of words over V, the set of axioms and P is a finite set of pairs. The elements of P are of the form (C, S) where $C \subset V^* \times V^*$ contains the contexts and S is a language over V, the selection language for context C. The direct derivation relation is defined as follows: for any word $x \in V^*$, $x \Rightarrow uxv$ if there is a context $C = (u, v)$ such that $x \in S$, for a pair $(C, S) \in P$. As usual, the direct derivations (or also called derivation steps) can be extended to the derivation relation, denoted by $\Rightarrow^*$ by taking their reflexive and transitive closure. The generated language is then defined as

$$L(EC) = \{w \in V^* | \text{ there exists } x \in A \text{ such that } x \Rightarrow^* w\}.$$

We say that an external contextual grammar is without choice if $S = V^*$ for every element of P. If all choice languages are regular/linear etc., then we say that this is an external contextual grammar with regular/linear, etc. choice.

Now we describe some basic facts about DNA. DNA molecules are built up by 4 types of nucleotides which are usually abbreviated as A,C,G,T by their name. A DNA strand can be seen as a sequence of nucleotides. The sequence has two ends, one of them is denoted by $5'$ and the other by $3'$. These ends can easily be distinguished chemically. The nucleotides have a so-called Watson-Crick complementarity relation meaning that A and T are pairs of each other as well as C and G are pairs of each other. Two DNA strands could form a DNA molecule that is double stranded, if they are complement of each other as follows. At each position of a strand the nucleotide is the Watson-Crick pair of the nucleotide of the other strand at that position. Moreover, the direction of the two strands are opposite, i.e., the nucleotide of the $5'$ end of a strand is paired to the nucleotide of the $3'$ end of the other. A full double stranded DNA molecule is denoted by $\left[\begin{smallmatrix} u \\ v \end{smallmatrix}\right]$ with u on the upper and v on the lower strand. With the notation $\binom{u}{v}$ we may denote a DNA which has u on the upper and v on the lower strand, but it may not be a full double stranded molecule, e.g., their lengths may not be identical. When one of the strands has some extra nucleotides on one of the ends, than this is called a sticky end, as the molecule can be expanded by sticking there an appropriate other molecule...

Instead of the original nucleotides, in formal models we may use letters of any alphabet. Moreover, as [6] has proven, we may use the identity relation in the role of the complementarity relation without loss of generality, both at sticker systems and at traditional Watson-Crick automata. Thus, for simplicity, from now on we use always the identity relation.

Now, we are ready to see Watson-Crick automata (WK automata shortly). These automata work on (full double stranded) DNA molecules; they have two reading heads one for each of the two DNA strands. Formally, a Watson-Crick automaton is a 6-tuple $M = (V, \rho, Q, q_0, F, \delta)$, where V is the (input) alphabet, $\rho \subseteq V \times V$ denotes a complementarity relation, (in this paper, we use the identity), Q represents a finite set of states, $q_0 \in Q$ is the initial state, $F \subseteq Q$ is the set of final (accepting) states and δ is called transition mapping and it is of the form $\delta : Q \times \begin{pmatrix} V^* \\ V^* \end{pmatrix} \to 2^Q$, such that it is non empty only for finitely many triplets of q, u and v, i.e., $(q, \binom{u}{v})$, where $q \in Q, u, v \in V^*$. In case $Q = F = \{q_0\}$, we say that the automaton is stateless.

The description so far has not distinguished the traditional and the sensing $5' \to 3'$ models. Thus, the configuration and the computation steps, i.e., the transitions between configurations play crucial role to specify the type of the model. In a traditional WK automaton, both heads of the automaton starts from the same place, from one of the ends of the input DNA molecule, and both of them read the entire strand in an accepting computation. The input molecule is accepted, if the automaton could reach an accepting state when both strands are fully scanned. Formally, a configuration of a traditional WK automaton is a triplet $\left(\binom{u}{v}, q\right)$ in which $u, v \in V^*$ are the upper and lower strand parts of the input that have not processed yet, and $q \in Q$ is the actual state. The initial configuration is $\left(\binom{w}{w}, q_0\right)$ with the input word w in both strands, as at that stage of the computation the whole input DNA $\left[\begin{smallmatrix} w \\ w \end{smallmatrix}\right]$ is to be processed. From the configuration $\left(\binom{bu}{cv}, q\right)$ the configuration $\left(\binom{u}{v}, p\right)$ directly computed (or computed in one step), denoted by $\left(\binom{bu}{cv}, q\right) \Rightarrow \left(\binom{u}{v}, p\right)$), if $p \in \delta\left(q, \binom{b}{c}\right)$. The reflexive and transitive closure of $\Rightarrow$ is denoted by $\Rightarrow^*$ and called computation. A DNA molecule $\left[\begin{smallmatrix} w \\ w \end{smallmatrix}\right]$ or, let us say, the word w, is accepted if $\left(\binom{w}{w}, q_0\right) \Rightarrow^* \left(\binom{\lambda}{\lambda}, p\right)$ for some $p \in F$. The set of accepted words is the accepted language.

However, as we have already mentioned, the two strands of the DNA molecule have opposite $5' \to 3'$ orientations, thus it is worth to take into account such variants of Watson-Crick automata that parse the two strands of the Watson-Crick tape in opposite directions. These automata are also called reverse WK automata. Obviously, if each head starts to read its strand from its $5'$ end, as usually enzymes also do, then they start to scan the input DNA from physically different ends [7, 22]. On the other hand, as the two strands of a DNA molecule are determined by each other via the Watson-Crick complementarity relation, we may also think about the sensing $5' \to 3'$ WK automata, in which the two heads sense

if they arrived into the same position. Since, actually, by this point of the computation, exactly one of the letters of each position has been already read, this model finishes the work on the input at this point and decides on the acceptance. It is easy to see, that the complementarity relation can also be substituted by the identity in case of these automata without changing their computational power, (i.e., the class of languages that can be formed by the words on the upper strands of the accepted molecules).

Formally, a configuration of a sensing $5' \to 3'$ WK automaton is a pair (q, w) where q is the current state of the automaton and w is the (double stranded) part of the input word which has not been processed (read) yet by any of the heads. For $w', x, y \in V^*, q, q' \in Q$, we write a transition, a step of a computation, between two configurations as: $(q, xw'y) \Rightarrow (q', w')$ if and only if $q' \in \delta(q, \binom{x}{y})$. We denote the reflexive and transitive closure of the relation $\Rightarrow$ by $\Rightarrow^*$ also in this case. Therefore, for a given $w \in V^*$, an accepting computation is a sequence of transitions $(q_0, w) \Rightarrow^* (p, \lambda)$, starting from the initial state and ending in a final state $p \in F$. The language accepted by a sensing $5' \to 3'$ WK automaton M is:

$$L(M) = \{w \in V^* \mid (q_0, w) \Rightarrow^* (p, \lambda), p \in F\}.$$

Finally, let us recall the sticker systems. We note here that sticker systems, as computing model, can be used to provide efficient solutions to computationally hard, e.g., NP-complete problems (at least theoretically) [1, 4, 8, 15, 23]. However, in this paper we are concentrating in their language generating feature, thus we present them in the sequel from this point of view [5].

Single stranded DNA molecules of the form $\binom{u}{\lambda}$ are called upper dominos, while ones of the form $\binom{\lambda}{v}$ are called lower dominos. The set of double stranded DNA molecules with sticky end on the right side are denoted by $R(V)$: they are either of the form $\left[\begin{smallmatrix} w \\ w \end{smallmatrix}\right]\binom{u}{\lambda}$ or $\left[\begin{smallmatrix} w \\ w \end{smallmatrix}\right]\binom{\lambda}{v}$.

A simple regular sticker system is a pentuple $(V, \varrho, D_u, D_l, A)$, where
- V is an alphabet,
- ϱ is the complementarity relation (we use identity in this paper),
- D_u and D_l are sets of dominos that are associated to the upper and lower strand, respectively,
- $A \subset R(V)$ is a finite set of axioms.

The generation starts with an axiom and goes step by step. Depending on the position of the sticky end of the actual molecule, only dominos of the other strand may stick to it by filling that strand without gaps and maybe further expanding it. The generation has finished when a full double stranded DNA is produced. The generated language is defined consequently [5, 15].

Those special cases are called sticker systems without axioms, when $A = \left\{\binom{\lambda}{\lambda}\right\}$ to infer the fact that the molecules are built up only by dominos and the generation could start from any dominos in this case.

Let $(V, \varrho, D_u, D_l, A)$ be a simple regular sticker system. Let T be a finite alphabet and $u : D_u \to T$, $\ell : D_l \to T$ be two mappings to T. For a finished computation, let us assign the string $w_u \in T^*$, by using u, to the sequence of dominos used in the upper strand. Similarly, let us assign $w_l \in T^*$, by using ℓ, for the sequence of dominos used in the lower strand.

Further, a computation is coherent, if $w_u = w_l$. Based on that, the language generated by a simple regular sticker system R in coherent way is

$$\left\{w \mid \begin{bmatrix} w \\ w \end{bmatrix} \text{ can be generated in coherent way in } R\right\}.$$

3. STICKER SYSTEMS AND WATSON-CRICK AUTOMATA

In this section we present relations between two paradigms dealing with formal languages in DNA computing.

It is known that if a language L can be obtained by a simple regular sticker system in a coherent way, then there is a WK automaton that accepts L [22].

Now, we give a kind of extension of this result.

THEOREM 1. *If the language L can be obtained by a simple regular sticker system without axiom in a coherent way, then L is also accepted by a stateless WK automaton.*

PROOF. Let $(V, \varrho, D_u, D_l, A)$ be a simple regular sticker system that generates L in coherent way with the mappings $u : D_u \to T$ and $\ell : D_l \to T$ with some alphabet T. Let us construct a stateless WK automaton M that accepts L as follows. Let $M = (V, \varrho, \{q\}, q, \{q\}, \delta)$, where δ is defined in the following way: $q \in \delta\left(q, \binom{x}{y}\right)$, for all pairs $\binom{x}{\lambda} \in D_u$, $\binom{\lambda}{y} \in D_l$, if $u(x) = \ell(y)$.

By the construction, the application of the sticking operation in a coherent way is matched with the computing steps of M, and thus, exactly those molecules can be generated by the given sticker system as the ones accepted by M. □

4. $5' \to 3'$ WK AUTOMATA AND EXTERNAL CONTEXTUAL GRAMMARS

In this section we present two new links between Watson-Crick automata and external contextual grammars. On the first hand, sensing $5' \to 3'$ WK automata accept exactly the class of linear languages of the Chomsky hierarchy [10, 11, 13, 14, 17, 18]. It is also known (see, e.g., [2]) that external contextual grammars without choice generate exactly those languages which can be generated by linear grammar with exactly one nonterminal symbol. First, we complement these results as follows.

THEOREM 2. *If the language L is generated by external contextual grammars without choice such that the only axiom is the empty word λ, then L is accepted by a stateless sensing $5' \to 3'$ WK automaton.*

PROOF. We prove by construction. Let $EC = (V, \{\lambda\}, P)$ be an external contextual grammars without choice, where

P contains pairs (C_i, V^*) with $C_i = (u_i, v_i)$. Let $M = (V, \rho, \{q\}, q, \{q\}, \delta)$ be a stateless $5' \to 3'$ WK automaton with the identity relation on V as ρ and let δ be defined as follows based on P: $q \in \delta(q, \binom{u_i}{v_i})$ for each C_i. It is easy to see that derivations, i.e., generations of words in EC correspond step by step in an opposite order to accepting computations in M and vice versa. □

Further, we can establish the following new connection between these models.

THEOREM 3. *If the language L is accepted by sensing $5' \to 3'$ WK automaton, then it can be generated by external contextual grammars with linear choice languages.*

PROOF. Let $M = (V, \rho, Q, q_0, F, \delta)$ be a $5' \to 3'$ WK automaton that accepts L, where ρ is the identity relation on V. For each state $q \in Q$, let L_q denote the linear language that can be accepted from q, i.e., the language accepted by $M_q = (V, \rho, Q, q, F, \delta)$. Obviously, $L = L_{q_0}$. Now, we give an external contextual grammar EC with linear choice. Obviously the same alphabet V is used. Further, let the set of axioms be $A = \{\lambda\}$. Now, for each transition $p \in \delta(q, \binom{u}{v})$ of M (where $p, q \in Q, u, v \in V^*$), let the pair (C, S) $C = (u, v)$ and the choice L_p be in P. Thus, the system $EC = (V, A, P)$ is able to produce exactly L by a backward stepwise simulation of the accepting computations. □

5. CONCLUSIONS

Languages that can be obtained by a simple regular sticker system without axiom in a coherent way, are shown to be accepted by WK automaton with a sole state. On the other hand, languages generated by external contextual grammar without choice and with linear choice are related to languages of sensing $5' \to 3'$ WK automata.

6. REFERENCES

[1] L. M. Adleman. Molecular computation of solutions to combinatorial problems. *Science*, 226(5187):1021–1024, 1994.

[2] R. Ceterchi. Marcus contextual grammars. In *Formal languages and applications* (C. Martín-Vide, V. Mitrana and Gh. Păun, eds.), Springer, pp. 335–366, 2004.

[3] R. Freund, Gh. Păun, G. Rozenberg and A. Salomaa. Watson-Crick finite automata. In *3rd DIMACS Sympozium On DNA Based Computers, Philadelphia*, pp. 305–317, 1997.

[4] Z. Ignatova, I. Martínez-Pérez and K.-H. Zimmermann. *DNA computing models.* Springer, New York, 2008.

[5] L. Kari, Gh. Păun, G. Rozenberg, A. Salomaa and S. Yu. DNA computing, sticker systems, and universality. *Acta Informatica* 35: 401–420, 1998.

[6] D. Kuske and P. Weigel. The role of the complementarity relation in Watson-Crick automata and sticker systems. In *Developments in Language Theory, DLT 2004, LNCS* 3340, Springer, Berlin, Heidelberg, pp. 272—283, 2004.

[7] P. Leupold and B. Nagy. $5' \to 3'$ Watson-Crick automata with several runs. *Fundamenta Informaticae* 104, pp. 71-–91, 2010.

[8] R. J. Lipton. DNA solution of hard computational problems. *Science*, 268(5210), pp. 542–545, 1995.

[9] S. Marcus. Contextual grammars. *Revue Roum. Math. Pures Appl.*, 14, pp. 1525—1534, 1969.

[10] B. Nagy. On $5' \to 3'$ sensing Watson-Crick finite automata. In: *Preliminary proceedings of DNA13: The 13th International Meeting on DNA computing, Memphis, Tennessee, USA*, pp. 327–336, 2007.

[11] B. Nagy. On $5' \to 3'$ sensing Watson-Crick finite automata. In: *DNA Computing. DNA 2007: Selected revised papers, LNCS* 4848, Springer, Berlin, Heidelberg, pp. 256—262, 2008.

[12] B. Nagy. On a hierarchy of $5' \to 3'$ sensing WK finite automata languages. In: *Computaility in Europe, CiE 2009: Mathematical Theory and Computational Practice, Abstract Booklet*, Heidelberg, pp. 266—275, 2009.

[13] B. Nagy. $5' \to 3'$ Sensing Watson-Crick Finite Automata. In: G. Fung, ed.: *Sequence and Genome Analysis II - Methods and Applications*, iConcept Press, pp. 39—56, 2010.

[14] B. Nagy. On a hierarchy of $5' \to 3'$ sensing Watson-Crick finite automata languages. *Journal of Logic and Computation* 23(4), pp. 855—872, 2013.

[15] B. Nagy. *DNS számítógépek és formális modelljeik (in Hungarian).* Typotex, Budapest, Hungary, 2014.

[16] B. Nagy and S. Parchami. On deterministic sensing $5' \to 3'$ Watson–Crick finite automata: a full hierarchy in 2detLIN. *Acta Informatica* 58 pp. 153–175, 2021.

[17] B. Nagy and S. Parchami. $5' \to 3'$ Watson-Crick automata languages – without the sensing parameter. *Natural Computing*, online first, 2022. doi: 10.1007/s11047-021-09869-9

[18] B. Nagy, S. Parchami and H. M. M. Sadeghi. A new sensing $5' \to 3'$ Watson-Crick automata concept. In: *Proc. 15th Int. Conf. Automata and Formal Languages, AFL 2017, EPTCS* 252, pp. 195–204, 2017.

[19] S. Parchami and B. Nagy. Deterministic Sensing $5' \to 3'$ Watson-Crick Automata Without Sensing Parameter. In: *Unconventional Computation and Natural Computation, UCNC 2018, LNCS* 10867, Springer, pp. 173–187, 2018.

[20] Gh. Păun. DNA Computing by Matching: Sticker Systems and Watson-Crick Automata, In *Pattern Formation in Biology, Vision and Dynamics* (A. Carbone, M. Gromov, P. Prusinkiewicz, eds.), World Scientific, Singapore, pp. 336—362, 2000.

[21] Gh. Păun. Marcus Contextual Grammars. Kluwer Publ. House, Doordrecht, 1998.

[22] Gh. Păun, G. Rozenberg and A. Salomaa. *DNA Computing: New Computing Paradigms.* Springer-Verlag, Berlin, Heidelberg, 2002.

[23] S. Roweis, E. Winfree, R. Burgoyne, N. V. Chelyapov, M. F. Goodman, P. W. K. Rothemund, and L. M. Adleman. Sticker-based model for DNA computation. *Journal of Computational Biology* 5, pp. 615–629, 1998.

Surrogate Component Approach for a Synchronization Problem

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ABSTRACT

We deal here with electric vehicles, provided in energy by a local photovoltaic micro-plant, with limited storage and time-dependent production capacities. Our goal is to synchronize energy production and consumption. Because of the complexity of resulting bi-level model, we handle it by short-cutting the production level through surrogate estimators, whose values are computed with the help of flexible pricing and machine learning devices.

Keywords

Operational Research, Combinatorial Optimization, Machine Learning

1. INTRODUCTION

Multi-level decisional [1] models usually involve several players, tied together by some hierarchical or collaborative links. They aim at providing scenario which would be the best in case all the players accept a common rule (centralized paradigm), or at searching for a compromise (collaborative paradigm). Standard approaches involve decomposition schemes, hierarchical (Benders, Stackelberg,...) or transversal (Lagrangean). Main difficulties are related to the retrieval of information from the different levels in order to make them interact, and to the collaborative issue, which may impose the players to deal with incomplete information. A trend, boosted by the rise of machine learning technology [5], is to bypass some levels and replace them by surrogate constraints or estimators. We follow this trend here while dealing with the joint management of local photovoltaic energy [3] production and its consumption by a fleet of electric vehicles [2, 4]. This problem arose in the context of the activities of IMOBS3 (*Innovative Mobility*) Labex in Clermont-Ferrand, which conducts research on both autonomous electric vehicles and solar energy, and of the national PGMO program promoted by power company EDF.

So we consider here a fleet of K small identical electric vehicles, initially located at a depot $Depot = 0$, and required to perform VRP: *Vehicle Routing Problem* tours, that means to visit a set of stations $J = \{1, \ldots, M\}$ within a time horizon $[0, TMax]$. Moving from station j to station k requires $\Delta_{j,k}$ time units and an amount $E_{j,k}$ of energy. Recharge *transactions* take place at the depot. An *Elementary Trip* is any VRP sub-tour that a vehicle may perform without recharging at the depot. The fleet relies on a set B of identical batteries, with capacity C and charge speed C^S, initially located at *Depot*, and vehicles switch their battery every time they come back to *Depot*. This plug *out/in* operation is instantaneous and avoids that the vehicle waits for recharging. It comes that while the vehicles are running with *active* batteries, *idle* batteries are recharged at *Depot* before being used again by the vehicles. For any battery b in B, V_b denotes the energy load of b at time 0.

In order to implement a *self-consumption* policy, *Depot* is provided with a *PV-Plant*, that means a photovoltaic facility which assigns the batteries to the vehicles and produces energy that it distributes between the currently idle batteries or that it sells to the market. In case this energy is not enough, the *PV-Plant* can also buy energy to the market. The time space $[0, TMax]$ is divided into small periods $i = 1, ..., N$, all with same length p. We denote by C^R, the recharge per period capacity, that means the quantity $p \cdot C^S$ of energy which may be loaded into a battery during a period. We also denote by R_i the expected production of the *PV-Plant* at period i, by A_i the energy unit purchase price at period i, and by B_i the energy unit sale price. For technical reasons, a battery switch takes place only at the junction between 2 periods, that means at a time $t = p \cdot i, i = 0, \ldots, N$. So resulting *PV_Prod_VRP* decision problem, represented in the Figure 1, comes as follows:

PV_Prod_VRP: Simultaneously schedule the vehicles and the PV-Plant, in such a way that:

- Every station is visited at least once by the fleet;
- Every time a vehicle k comes back to *Depot*, it is assigned a battery charged in such a way that it will make possible its next elementary trip;
- The global energy load of the batteries does not to decrease between the beginning and the end of the process.
- Some global cost is minimized, which combines standard VRP cost with the PV-Plant cost of energy self-

consumption.

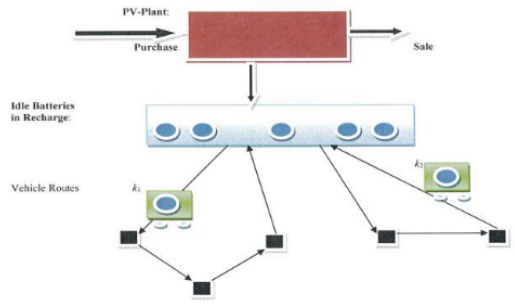

Figure 1: The *PV-Plant*, the batteries and the vehicle fleet.

In order to formalize, let us suppose that a collection Π_0 of *elementary trips* π has been computed and that every such a trip π has been scheduled inside a set of consecutive periods $I(\pi)$. We denote by $\Sigma_0 = \{(\pi, I(\pi)), \pi \in \Pi_0\}$ the resulting set of *scheduled trips* $\sigma = (\pi, I(\pi)$. For any trip π we denote by $E(\pi)$ the energy that its requires, by $T(\pi)$ its duration, and by $S(\pi)$ the set of stations that it visits. We extend those notations to scheduled trips σ and set $E^{Mean}(\sigma) = E(\sigma)/Card(I(\sigma))$. Then, *PV_Prod* resulting sub-problem is about the way the PV-Plant loads the batteries and assign them to *scheduled trips* σ.

PV_Prod(Σ_0) MILP (*Mixed Integer Linear Program*) *Model:*
Compute:

- $X^A = (X^A_i, i = 1, ..., N)$, $X^B = (X^B_i, i = 1, ..., N)$ and $X^D = (X^D_{b,i}, b \in B, i = 1, ..., N)$: respectively the energy amount bought on the market, sold to the market, and distributed to battery b by PV-Plant;
- $W = (W_{b,i}, b \in B, i = 0, ..., N)$: the amount of energy inside the battery b at the period i;
- $U = U_{\sigma,b}, \sigma \in \Sigma_0, b \in B : U_{\sigma,b} = 1$ if the battery b is assigned to the process σ;
- $\delta = \delta_{b,i}, b \in B, i = 1, ..., N : \delta_{b,i} = 1$ if the battery b is idle at period i.

Objective function: $\sum_i (A_i \cdot X^A_i - B_i \cdot X^B_i)$.
Constraints:

- For any $b, i : W_{b,i} \leq C$ and $X^D_{b,i} \leq C^R \cdot \delta_{b,i}$; (R1)
- For any $b : W_{b,0} = V_b$; (R2)
- $\sum_b W_{b,N} \geq \sum_b V_b$; (R3)
- For any $i : R_i + X^A_i = X^B_i + \sum_b X^D_{b,i}$; (R4)
- For any $b, i : (1 - \delta_{b,i}) = \sum_{\sigma \ s.t. \ i \in I(\sigma)} U_{\sigma,b} \leq 1$; (P1)
- For any $\sigma \in \Sigma_0 : \sum_b U_{\sigma,b} = 1$. (P2)
- For any $b, i : W_{b,i} = W_{b,i-1} + X^D_{b,i} - \sum_{\sigma \ s.t. \ i \in I(\sigma)} E^{mean}(\sigma) \cdot U_{\sigma,b}$; (P3)

Explanation: (R1): We charge a battery b only if it is idle. (R3): The batteries must be globally loaded with at least as much energy at the end of the whole process as at the beginning. (R4) tells the way energy is distributed between sale, purchase and battery loading. (P1): b is active at period i only if has been assigned to a unique *scheduled trip* σ active at period i. (P2): any *scheduled trip* σ is assigned a unique battery b. (P3) describes the evolution of a battery b from a period $i-1$ to next period i.

Any VRP decision means a collection Σ_0 of *scheduled trips* $\sigma = (\pi, I(\pi))$ such that:
- For any period i, $Card(\{\sigma \in \Sigma_0 \ s.t. \ i \in I(\sigma)\}) \leq K$; (S1)
- For any station j, $Card(\{\sigma \in \Sigma_0 \ s.t \ j \in S(\sigma)\}) \geq 1$; (S2)

If we consider as standard VRP cost of Σ_0 the global riding time $\sum_\sigma T(\sigma)$ *(Driver Cost)* then, a *time versus money* coefficient α being given, a bi-level setting of our *PV_Prod_VRP* problem comes as follows:

PV_Prod_VRP Problem: Compute a collection Σ_0 of *scheduled trips*, such that (S1, S2) hold and which minimizes the sum $\alpha \sum_\sigma T(\sigma) + Val_PV_Prod(\Sigma_0)$ where Val_PV_Prod is the optimal $PV_Prod(\Sigma_0)$ value.

2. HANDLING PV_PROD_VRP WITH SURROGATE COMPONENTS

MILP formulation of *PV_PROD_VRP* is hardly practicable and does not fit uncertain or collaborative contexts. So we try:

- First approach: It aims at benchmarking. We solve *PV_Prod_VRP* through the MILP model restricted to a set Σ_0 of *scheduled trips*, pre-computed through successive applications of a randomized simple greedy procedure.
- Second Approach: We short-cut the *PV_Prod* level through the introduction of surrogate constraints and estimators.

2.1 Solving the PV_Prod_VRP bi-level model, while partially short-cutting the slave PV_Prod level.

Our purpose here is to compute the scheduled trip set Σ_0 without involving the PV-Plant. But, while the schedule $\sigma \rightarrow I(\sigma)$ must take into account prices A_i, B_i and production rates R_i, we can only say that a well-fitted collection Σ_0 requires small amounts of both time and energy. This suggests that we should distinguish between the design of the trip collection Π_0 and the way we turn it into a collection Σ_0 of *scheduled trips*. This leads us to the following parametric *VRP_Surrogate* process:

***VRP_Surrogate* Parametric Algorithm:**
Initialize flexible scaling parameter γ; Not Stop; current best solution *Best_Sol* is undefined;
While Not *Stop* do
1st step: Compute an *ad hoc* elementary trip collection Π_0 which minimizes $\alpha \cdot \sum_{\pi \in \Pi_0} T(\pi) + \gamma \cdot \sum_{\pi \in \Pi_0} E(\pi)$;
2nd step: Turn Π_0 into a *scheduled trip* collection Σ_0, that means compute the period sets $I(\pi), \pi \in \Pi_0$ in such a way that some surrogate constraints (SURR1) be satisfied and that some surrogate cost $\Phi(\pi \rightarrow I(\pi)$ be minimized;
3rd step: Update γ and *Stop*; Solve $PV_Prod(\Sigma_0)$ and update *Best_Sol*.

2.2 Dealing with Step 1: A Branch and Cut Algorithm based upon Strong No Subtour constraints

For any subset A of the station set $J = \{1, \ldots, M\}$, we set: $\delta^+(A) = \{$arcs (j, k) such that $j \notin A$ and $k \in A\}$ and

$Cl(A) = \{$ arcs $e = (j,k)$ s. t. at least j or k is in $A\}$. Then the auxiliary *Elementary_Trip* ILP model comes as follows:

Elementary_Trip ILP model:
Compute a (0, 1)-valued vector $Z = (Z_{j,k}, j, k = 0, ..., M)$ in such a way that :

- For any j in $\{1, ...M\} : \sum_k Z_{j,k} = \sum_j Z_{j,k} = 1$; (S2)
- For any subset A of $\{1, ...M\}$: $C \cdot \sum_{(j,k)\in\delta^+(A)} Z_{j,k} \geq \sum_{(j,k)\in Cl(A)} E_{j,k} \cdot Z_{j,k}$; (SNS)
- Minimize $\alpha \cdot (\sum_{j,k} Z_{j,k} \cdot T_{j,k}) + \gamma \cdot (\sum_{j,k} Z_{j,k} \cdot E_{j,k})$.

Explanation: Above SNS: *Strong No Sub-Tour* constraints not only forbid sub-tours in the usual sense, but also ensure us that vector Z represents a collection of *elementary trips*, that means of routes π from *Depot* to *Depot* such that $E(\pi) \leq C$.

Theorem 1: *$\{0, 1\}$ vector Z satisfies (S2, SNS) if and only if arcs (j, k) such that $Z_{j,k} = 1$ define a collection Π_0 of sub-tours $\pi_1, ..., \pi_S$ with $S = \sum_k Z_{0,k}$ such that:*

- *For every $s = 1, ..., S, \pi_s$ starts from Depot = 0 and ends into Depot, and spends less than C energy;*
- *Every station is visited exactly once by collection Π_0.*

Constraints SNS may be separated in polynomial time through application of a max flow (min cut) procedure.

Sketch of the Proof: (S2, SNS) imply that Z gives rise to a collection τ of sub-tours $\tau_0, ..., \tau_S$, and that if some tour τ_S spends more energy than capacity C, then a subset A of $\{0, \ldots, M+1\}$ exists which makes Z violate (SNS). We get our first statement. As for the second, we see that, Z (integral or rational) being given, separating (SNS) means searching for $A \subseteq \{1, ..., M\}$ and $B = \{1, ..., M\} - A$, such that (*):
$\sum_{j,k\in B} Z_{j.k} \cdot E_{j,k} + C \cdot \sum_{(j,k)\in\delta^+(B)} Z_{j,k} < \Delta = \sum_{j,k} \cdot E_{j,k}$
So we construct a network G^{Aux}, whose node set is $\{0, 1, ..., M+1\}$ and whose arc set may be written as $U^{Aux} = U \cup Copy(U)$ with:

- $U = \{$all pairs $(j,k), j, k = 0, ..., M\}$ s.t $Z_{j,k} \neq 0$: such an arc $u = (j,k)$ is provided with a capacity $w_u = Z_{j,k} \cdot (C - E_{j,k})$;
- With any arc $e = (j,k)$ in U, we associate an arc $u = Copy(e) = (j, M+1)$: such an arc $u = Copy(e) = (j, M+1)$ is provided with a capacity $w_u = Z_{j,k} \cdot E_{j,k}$. Then arc set *Copy(U)* is the set of all arcs *Copy(e)*, $e \in U$.

We conclude, by checking that searching for B such that (*) holds is equivalent to solving a Max Flow problem in G^{Aux}. □

Theorem 1 and related proof provide us with an efficient *separation* procedure which opens the way to the implementation of a *Branch and Cut* process. Still, because such a *Branch and Cut* approach remains difficult to use in case of large size instances and in case of uncertainty, we also implement a heuristic *Insertion/Removal (Build/Destroy)* algorithm.

2.3 Dealing with Step 2: Surrogate Components

In order to enhance $PV_Prod(\Sigma_0)$ feasibility, we impose the following surrogate necessary (but not sufficient) constraints:

- For any period i: $Card(\{\sigma \in \Sigma_0$ such that $i \in I(\sigma)\}) \leq K$; (S1)
- For any subset $i_0 = 1, ..., N : C^R \cdot \sum_{i\leq i_0-1} n(\Sigma_0, i) + \Sigma_b V_b \geq \sum_{\sigma \ s.t.\ Start(\sigma)\leq i_0} E(\sigma)$, where $n(\Sigma_0, i)$ is the number of *scheduled trips* σ idle at period i, and $Start(\sigma)$ is the starting period of σ. (SURR1)

The constraint (SURR1) means that we must be able to feed the batteries in such a way that trips becomes possible. Then, in order to make possible the use of any surrogate estimator $\Phi(\pi \rightarrow I(\pi))$, we implement Step 2 while relying on a non deterministic local search heuristic $Scheduled_Trip(\Pi_0, \Phi)$. So, what remains to be done is to discuss estimator Φ.

Defining $\Phi(\Sigma_0)$ according to a Pricing Mechanism. The idea here is that the cost of a schedule $(\pi \rightarrow I(\pi))$ is determined by the distribution of above defined values $n(\Sigma_0, i)$. Let $E = \sum_{\pi\in\Pi_0} E(\pi)$ be the global charge loaded into the batteries and $I = \sum_{\pi\in\Pi_0} \lceil T(\pi)/p \rceil$ be the number of periods required by the trips of Σ_0. If all batteries receive a same charge $E^{Mean} = E/I$ at every period when they are idle, then the cost of the production process is $I \cdot Q^{Stand}_{i,n(\Sigma_0,i)}$, where $Q^{Stand}_{i,n} = A_i \cdot (n \cdot E^{Mean} - R_i)$ if $n \cdot E^{Mean} \geq R_i$ and $Q^{Stand}_{i,n} = B_i \cdot (n \cdot E^{Mean} - R_i)$ else. This suggests us to express the surrogate cost $\Phi(\pi \rightarrow I(\pi))$ involved into the *VRP_Surrogate* algorithm as a sum $\sum_i Q_{i,n(\Sigma_0,i)}$, where $Q_{i,n}$ is the estimation of the cost induced by n batteries in recharge (idle) at period i. We notice that if $n(\Sigma_0, i) \cdot E^{Mean} \geq R_i$, then $Q_{i,n}$ should increase with A_i and that if $n(\Sigma_0, i) \cdot E^{Mean} < R_i$, then $Q_{i,n}$ should decrease as B_i increases. This suggests to set:

- A^{Mean} = mean value $A_i, i = 1, ..., N$; B^{Mean} = mean value $B_i, i = 1, ..., N$;
- $Q_{i,n} = Q^{Stand}_{i,n} \cdot (1 + \rho_1(A_i - A^{Mean}))$ if $n(\Sigma_0, i) \cdot E^{Mean} \geq R_i$, and $Q_{i,n} = Q^{Stand}_{i,n} \cdot (1 + \rho_2(B_i - B^{Mean}))$ else, where ρ_1 and ρ_2 are 2 non negative flexible parameters.

Computing $\Phi(\Sigma_0)$ through a Neural Network *N_Energy*. Instead of relying on energy price coefficients $Q_{i,n}$, we use a neural network *N_Energy* in order to provide us with the quality of a *scheduled trip* collection Σ_0. *N_Energy* is implemented with the help of the TensorFlow open software and trained with a large number (4000) of $PV_Prod(\Sigma_0)$ instances. It is designed as a *convolutional* neural network. Such a network, whose main purpose is to be adaptable to inputs with flexible sizes, usually works in 2 (or more) steps: In the first step, a same standard perceptron called *convolutional mask* is applied to fixed size neighbours of the components of the input vector $IN = (IN_m, m \in M)$, and yields an output vector $OUT = (OUT_m, m \in M)$. In the next step, a pooling mechanism is applied to OUT, in order to compact it into the fixed size input of another perceptron which computes the final output. In the present case this final output is a number Θ between 0 and 1, such that the optimal value $VAL_PV_Prod(\Sigma_0)$ of $PV_Prod(\Sigma_0)$ may be written $VAL_PV_Prod(\Sigma_0) = Val_Min + \Theta \cdot (Val_Max - Val_Min)$, where *Val_Max* and *Val_Min* are respectively

lower and upper easy to compute bounds of $VAL_PV_Prod(\Sigma_0)$. More precisely we homogenize any input Σ_0, A, B, R, V of *PV_Prod* as a vector *IN*, with $IN[i] = (A_i^*, B_i^*, R_i^*, \mu_i^*, Q_i, C^*, C^{R*})$ as follows:

- $A_i^* = A_i/A^{Mean}$; $B_i^* = B_i/A^{mean}$;
- R^{Mean} = Mean values of coefficients R_i;
- $\mu_i = \sum_{\sigma \ s.t. \ i \in I(\sigma)} E^{Mean}(\sigma)$; $\mu_i^* = \mu_i/R^{Mean}$;
- $R_I^* = R_i/R^{Mean}$; $Q_i = n(\Sigma_0, i)/Card(B)$;
- $C^* = C/R^{Mean}$; $C^{R*} = C^R/R^{Mean}$.

The *convolutional mask CM* works on any sub-vector $IN_i^* = (IN[i], \ldots, IN[i+4])$, which means an input with 35 input arcs. It contains 3 inner layers, respectively with sizes 8, 4 and 2, and ends into an output layer, with 1 input value OUT_i. This network is complete in the sense that all 322 synaptic arcs are allowed, together with standard biased sigmoid activation functions whose derivative value in 0 is equal to 1/2. The *pooling* mechanism works by merging consecutive values OUT_i into a single value, in such a way it yields an intermediate vector *AUX*, with 13 entries, all with values between 0 and 1, which we handle with a perceptron *N_Pool*, with intermediate layers with size 6 and 3, and a final layer with size 1. At the very end, we must learn 421 synaptic coefficients.

3. NUMERICAL EXPERIMENTS

Technical Context: We use libraries CPLEX12 (for ILP models) and TensorFlow/Keras (for Machine Learning).

Instances: The main characteristics of an instance are: N = Number of periods, M = Number of stations, S = Expected number of *elementary trips* involved into a VRP solution, Q = number of macro-periods, which are associated with general trends in the production rate and in the market prices, L = expected length of an *elementary trip*, μ = *Battery Stress* coefficient, β = *Recharge Stress* coefficient, H = *Production Stress* coefficient and α = *time versus money* coefficient. *Stress* is related to the difficulty that one may have in computing the solution of the instance, in such a way that decreasing the *Stress* parameters increases the difficulty. The Table 1 shows the characteristics of the instances used during the experimentation.

Table 1: Characteristics of the instances

Instance	N	M	S	Q	L	μ	β	H	α
1	40	50	20	4	5	2	1.5	1	1.2
2	40	75	25	5	5	1.5	2	1.5	0.8
3	40	100	32	4	3	2.5	1.5	0.8	1.2
4	60	150	42	3	8	3	3	0.5	1.5
5	60	200	55	5	10	2	1.5	0.75	1.2

Outputs: For every instance, we apply the *VRP_Surrogate* resolution scheme while relying on both the pricing mechanism and the machine learning mechanism, performing the first *VRP_Surrogate* step through the *Insertion / Removal* algorithm. We denote by *W_Price* the value obtained with the pricing device and we denote by *W_ML* the value obtained while involving Machine Learning. *UB_G* denote an upper bound obtained through the first approach described in Section 2. The Table 2 shows these results. When the size of the instances increases, it tends to outperform the results produced by the global MILP model. Notice that the cost value of *PV_Prod_VRP* may be negative, due to the fact that the cost may become a profit. Also, we try the *Branch and Cut* algorithm and the *Insertion / Removal* heuristic algorithm of Section 2.2 on the *Elementary_Trip* model, and retrieve in less that 1 CPU h:

Table 2: Behavior of the Price and Machine Learning based *VRP_Surrogate* Algorithms

Inst.	UB_G	W_ML	W_Price
1	-235.91	-193.38	-116.28
2	-1311.60	-835.27	-1165.42
3	248.43	409.91	631.02
4	1760.33	1861.24	2138.38
5	3742.12	1602.39	1900.69

- The lower and upper bounds *LB_BC* and *UB_BC* computed by the algorithm;
- The value *Relax* induced by the relaxation of the integrality constraint;
- The number *CUT* of *SNS* cuts generated during the Branch and Cut process;
- The value *W_Heur* computed by the heuristic algorithm.
- Related CPU time *Time* of the heuristic algorithm. The *Branch and Cut* algorithm was executed during 1 hour.

Related results are contained into the Table 3.

Table 3: Behavior of the *Branch and Cut* Algorithm

Inst.	LB_BC	UB_BC	Relax	CUT	W_Heur	Time
1	366.258	424.268	362.979	2917	428.08	1.19
2	362.481	470.942	359.901	904	470.50	5.41
3	421.34	528.725	420.884	712	534.73	10.38
4	1514.61	1809.3	1514.6	583	1776.16	28.30
5	2425.26	3372.26	2425.26	367	3025.93	41.79

Comments: Taken as a whole, solving *PV_Prod_VRP* while relying on surrogate component happens to be rather efficient. We also see that, even with *Strong No Sub-Tour* constraints, the *Elementary_Trip* model is difficult for large instances. The heuristic algorithm allows us to get close upper bounds to the *Branch and Cut* in reasonable time.

4. REFERENCES

[1] S. Dempe, V. Kalashnikov, Pérez-Valdés, and N. Kalashnykova. Bilevel Programming Problems Theory. *Springer*, 2015.

[2] T. Erdelić and T. Carić. A survey on the electric vehicle routing problem: variants and solution approaches. *Journal of Advanced Transportation*, 2019, 2019.

[3] S. Irani and K. R. Pruhs. Algorithmic problems in power management. *ACM Sigact News*, 36(2):63–76, 2005.

[4] G. Macrina, L. D. P. Pugliese, and F. Guerriero. The green-vehicle routing problem: a survey. In *Modeling and Optimization in Green Logistics*, pages 1–26. Springer, 2020.

[5] J. Wojtusiak, T. Warden, and O. Herzog. Machine learning in agent-based stochastic simulation: Inferential theory and evaluation in transportation logistics. *Computers & Mathematics with Applications*, 64(12):3658–3665, 2012.

Local reflection symmetry detection in Earth observation data

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ABSTRACT

We propose a new algorithm which detects patterns with reflection symmetry in Earth observation data. It must consider approximate symmetries, as the acquisition of input datasets is not able to provide exact pairs of symmetric elements. Therefore, we look for symmetries between voxels, not between the input points. Furthermore, the nature of such data implies that the symmetric patterns in the top view are the most interesting and, thus, it suffices to detect symmetries with vertical symmetry planes. The symmetry detection may thus be split into horizontal voxel slices and the results with the same symmetry plane are then merged. At the end, the resulting symmetries are ranked with respect to the number of voxels involved. Early results obtained for some voxelisations of two LiDAR datasets of different sizes are promising both in terms of the detection speed and quality of solutions.

Categories and Subject Descriptors

I.3.5 [**Computing Methodologies**]: Computer Graphics—*Computational Geometry and Object Modeling*

General Terms

Algorithms, Performance, Theory

Keywords

Approximate symmetry, voxelization, line segment, merging

1. INTRODUCTION

An object is symmetric if there is a transformation (such as translation, scaling, rotation, reflection, etc.) that maps it onto itself [6]. The symmetry perception has been studied and demonstrated in humans, but also in birds, dolphins, apes and even honey bees [3]. It is assumed that symmetry perception has become an integral part of the individual's perceptual organization process during the evolution of visual systems where individual regularities have been selected on the basis of their relevance [9]. This explains why symmetry has always inspired people in different fields, including arts, architecture, biology, medicine, mathematics, and various engineering disciplines [1]. However, in contrast to natural, almost self-evident symmetry perception processes in living beings, computer-aided symmetry detection is anything but simple [1]. Machine learning approaches are increasingly popular as everywhere else [8], but they rely heavily on training datasets, which are usually incomplete. Traditional constructive approaches for individual types of symmetries, particularly the reflection and rotational one, still prevail. Symmetry can be global when it concerns the whole object, or local when only parts of the scene are incorporated. A local symmetry containing a single connected component is called partial symmetry. Furthermore, symmetry can be perfect (strong) or approximate (weak) [5]. Approaches of Žalik et al. [1] and Hruda et al. [4] are representatives of global reflection symmetry detection algorithms. Local (partial) symmetry is sometimes handled by decomposing the scene into individual parts and then detecting global symmetry separately on each of them [7]. Cailliere et al. [2] presented a true local reflection symmetry detection operating on triangular meshes. In 2006 already, Mitra et al. [5] presented a powerful general algorithm that detects different types of global and local symmetry.

In this paper, a new algorithm is presented, predominantly designed to detect local reflection symmetries in Earth observation (EO) data. Section 2 illustrates the overall idea of the proposed approach, while section 3 experimentally confirms its usability. Section 4 briefly summarizes the presented work and discusses future research challenges.

2. METHODOLOGY

The presented algorithm is predominantly designed to detect local reflection symmetries in EO and complementary geographic information systems (GIS) data. Current implementation reads LiDAR (light detection and ranging) point clouds stored in LAS files only, but these data are immediately voxelized and, thus, 3D or 2D raster grids may also be considered valid inputs. The algorithm is fully scalable, as the resolution of the voxelisation can vary from a few centimetres or even lower up to tens or hundreds of metres, depending on the data acquisition technology and the intended use. Furthermore, grayscale and colour raster im-

```
Algorithm: Local Reflection Symmetry Detection.
  Voxelization.
  For each horizontal slice of the voxel grid
    Identify LSs through interesting voxels.
    Cluster the LSs with respect to their lengths.
    For each cluster of LSs
      Establish basic symmetries among pairs of LSs.
Merge symmetries from different clusters and slices.
Postprocessing.
End.
```

Figure 1: Concept of the new algorithm.

ages may be processed if colours are interpreted as altitudes. Whether these input datasets are 2D or 3D, they are mostly acquired downwards from satellites, airplanes, drones, etc. This means that much more data are collected from the visible top surfaces than from the side and bottom surfaces. Furthermore, width and length of a considered geographic area are usually much greater than the range of altitudes, i.e. bigger geographic areas are relatively flat. All these findings have the following implications on symmetry detection:

- Due to sampling, points of an „original“ part and mirrored part rarely match exactly.
- Due to higher density of acquired data on visible top sides, it is more likely to detect symmetric parts there.
- Due to „flatness“ of acquired areas, it is more likely to explore symmetries from above than from side.

For these reasons, the algorithm is designed to detect locally symmetric patterns with approximate (and not the ideal) reflection symmetries with regard to vertical symmetry planes only. The latter implies that it is sufficient to detect symmetries in horizontal slices and then combine them on the basis of the common detected symmetry planes. This constraint crucially contributes to the affordable time complexity of the algorithm in the EO data domain, although the majority of the algorithm's steps can be easily generalized when we can afford a slower execution.

Bottom-up approach is another crucial feature of the proposed algorithm. The idea is to find basic symmetries first and then construct larger ones by merging. In the context of the reflection symmetry, the basic symmetry is the symmetry of two geometric primitives, while the construction means merging the symmetric pairs which share the same symmetry plane. Primitives may be points (voxels), line segments, or more complex structures, and our choice are line segments. Core idea is that each line segment which appears in some symmetry should have a symmetric pair (copy) or more of them with the same length somewhere (in the slice).

A rough outline of the algorithm is presented in Figure 1, and a more detailed explanation of the individual steps is given in the subsections that follow.

2.1 Voxelization

A user enters the total number of voxels, and the program computes subdivisions in each coordinate direction, where the ratios between the three sides of the bounding box are tried to be kept and, furthermore, the number of voxels in each coordinate direction must be above some user-defined threshold. Consequently, the actual number of voxels may be significantly lower than the value entered by the user.

The material voxels are then identified in the grid. Each material voxel contains at least one point from the input point cloud. Theoretically, the symmetries should be identified among these voxels, but this would result in numerous trivial solutions (e.g. “infinitely” many symmetries could be found on a flat surface), so we further reduce the set of candidates for the symmetry detection by extracting the so-called interesting voxels.

A voxel is considered interesting for further processing if its surroundings is not flat. We therefore test each material voxel against the patterns of 26 adjacent voxels and filter out the interesting ones which are not in the middle of a vertical, horizontal or diagonally slanted local surface. Such interesting voxels represent the input for the next step.

2.2 Clustering

Our algorithm is designed to determine the basic symmetries between pairs of LSs. Such a pair may be symmetric only if both LSs have the same length. Furthermore, only the LSs which mainly pass through the interesting voxels are considered in this step. It is worthless to compare two LSs of the same length where one lies on the objects' surfaces and the other penetrates the air. The default threshold for amount of material voxels in a regular LS is set to 80. Therefore, the “regular” LSs are extracted in this step and arranged into clusters due to their lengths.

2.3 Basic Symmetry Detection

As this step runs separately for each horizontal voxel slice, it appears quite straightforward. However, the distance between two voxels differs from the distance between two points inside these voxels, and the angle between two LSs defined by four points differs from the angle between two LSs defined by the centres of four voxels. Some user defined tolerances must be considered in this step. Smaller voxels decrease relevance of these tolerances, but they significantly increase the time complexity. Note that this is computationally most demanding task with the theoretical time complexity $O(n^4)$, where n is the number of voxels. The previous steps of extracting interesting voxels and grouping them into clusters not only prevent the calculation of trivial (meaningless) symmetries, but above all reduce the number of pairs of LSs that need to be compared here.

2.4 Merging

The previous step determines all symmetry planes between pairs of “regular” LSs. Next, we join all pairs that share a common plane of symmetry. This step simultaneously considers both the clusters in a single slice and the results in different slices, as seen in the concept from Fig. 1.

2.5 Postprocessing

After determining all symmetry planes and arranging all interesting voxels into individual symmetries, the method concludes its work by coupling the rest of the material (non-

Table 1: Results for two voxelizations of the Maribor Cathedral and two of the Slomšek Square

Measure	Cathedral	Cathedral	Square	Square
Points	11779	11779	35985	35985
Input voxels	500	1500	1000	2000
Voxels	384	1089	960	1680
Material	78	193	64	428
Interesting	37	64	129	132
Symmetries	45	152	1490	2340
Time [s]	0.38	1.86	48.73	55.93

interesting) voxels with respect to each symmetry plane. Furthermore, input points within the voxels participating in an individual symmetry may be checked, whether they have a mirrored sibling close enough on the other side of the symmetry plane. The same effect can be reached by increasing the number of voxels, which requires less effort for implementation but importantly slows down the performance. The classification of points on the two sides of the symmetry plane is based on a simple vector product test.

3. RESULTS

Two point clouds read from LiDAR LAS files were used to demonstrate the performance of the algorithm. The first one represents Slomšek Square with the Cathedral of Saint John the Baptist to the east, the Rectorate of the University of Maribor to the west, the Slovene National Theatre to the north, and the building of the main Maribor Post office to the south. The second file contains the Cathedral extracted from the first one. Experiments were carried out on a PC computer with Intel Core i7-5820K and 32GB DDR4 RAM. The algorithm was programmed in C++ in QtCreator 7.0.1. Two different voxelizations of the Maribor Cathedral and two voxelizations of the Slomšek Square point cloud were used in the measurements.

Fig. 2 shows the results for the strongest symmetry detected on the Maribor Cathedral point cloud, voxelized with 384 voxels (the input was set to 500). Red and blue points are those inside the detected symmetric pairs of voxels on both side of the symmetry plane (in black), while gray points are in material voxels not participating in this strongest symmetry. Fig. 3 shows only the points in the bottommost horizontal slice of voxels. By merging this slice and other 7 slices above it, the results from Fig. 2b are obtained. In another voxelization with 1089 voxels (the input se to 1500), the symmetry from Fig. 4 was detected as the strongest. Nearly the same symmetry was at the sixth place (out of 45) in the previous voxelization, while the strongest symmetry from Fig. 2 and Fig. 3 is the 11th strongest (out of 152) in this different voxelization. In the top part of Table 1, a process of decreasing the number of entities from the LiDAR points to interesting voxels is demonstrated. Instead of 11779 points, only 37 or 64 interesting voxels were used in the basic symmetry detection step in both voxelizations of the Cathedral.

Fig. 5 shows two different local reflection symmetries detected in the point cloud representing the Slomšek Square in Maribor. The first one (Fig. 5a) is the strongest one obtained from the voxelization with 960 voxels (the input set

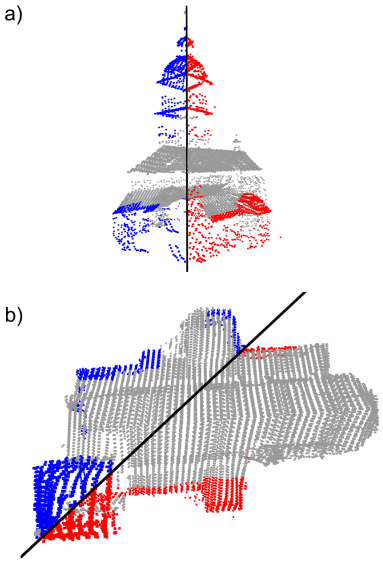

Figure 2: The Maribor Cathedral – the strongest symmetry in the 384 voxels grid: a) side view, b) top view.

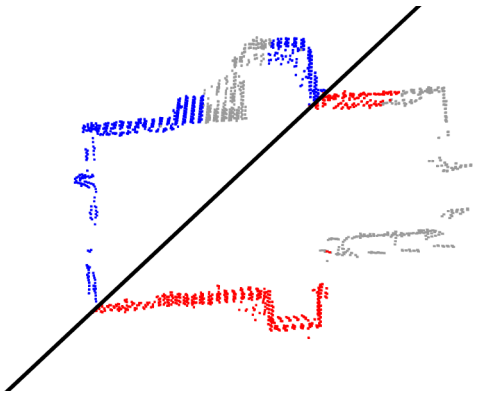

Figure 3: The Maribor Cathedral – the bottommost slice of 8 in the strongest symmetry in the grid of 384 voxels.

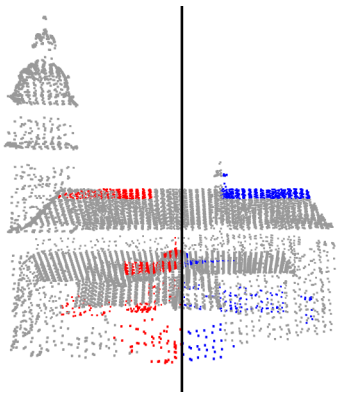

Figure 4: The Maribor Cathedral – the side view in the strongest symmetry in the grid of 1089 voxels.

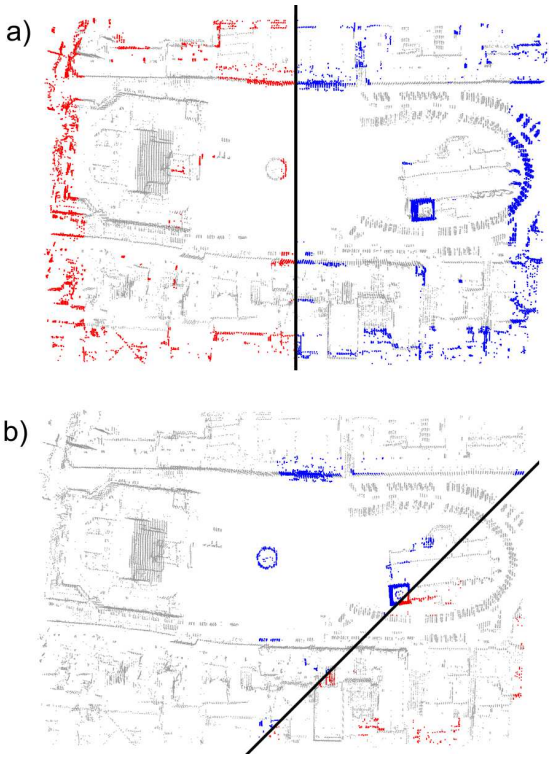

Figure 5: Slomšek Square in Maribor: a) the strongest symmetry out of 1490 in the grid of 960 voxels and b) the 68th strongest symmetry out of 2340 in the grid of 1680 voxels.

to 1000), and the bottom one (Fig. 5b) was obtained from the voxelization with 1680 voxels (the input set to 2000). Relatively low number of red in blue points indicates that this symmetry (Fig. 5b) is not among the strongest – it is indeed at the 68th place out 2340. Note that this example was not chosen at random. Namely, the symmetry plane here coincides with that of the Cathedral in Fig. 2.

In each voxelization, the algorithm detects as many symmetries as possible. They are ranked with respect to the number of voxels in a symmetry. Table 2 shows indicators of the three strongest and the weakest symmetries for the Cathedral with 384 voxels and Slomšek Square with 1680 voxels. The former is described wit 11,779 LiDAR points and with 78 material voxels, while the latter has 35,985 points and 428 material voxels.

We have also carried out experiments with bigger point clouds. Of course, the execution time and the quality of detected symmetries depend on voxelization. For an urban area about 20 times the size of Slomšek Square, described by half a million points and voxelised with 5000 voxels, the algorithm took just over 1 hour.

4. CONCLUSIONS

In this paper, we introduce a new algorithm for local reflection symmetry detection. It was predominantly designed for EO data processing, where it typically suffices to detect symmetries with vertical symmetry planes. The algorithm

Table 2: Number of points and voxels in individual symmetries and the proportion of the latter (%) among the material voxels

	The Cathedral			Slomšek Square		
	Points	Voxels	%	Points	Voxels	%
Best	2493	26	33.33	7489	133	31.07
2nd	2129	18	23.08	5715	116	27.10
3rd	779	10	12.82	7428	106	24.77
Last	174	4	5.13	131	4	0.93

first voxelizes the point cloud, extracts the so-called interesting voxels, and then finds basic symmetries between pairs of line segments of the same length, separately in each horizontal voxel slice. Basic symmetries sharing the symmetry plane are then merged into larger ones. The first results are promising, but there is a plenty of work left in order to ultimately affirm the method. The code and particularly some data structures must be optimized for faster performance. Individual voxel slices could be easily processed in parallel. Besides this, the inputs and the results must be filtered to eliminate connected parts with the number of voxels below some threshold. Finally, the algorithm must be evaluated in comparison to state-of-the-art methods.

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] B. Žalik, D. Strnad, S. Kohek, I. Kolingerová, A. Nerat, N. Lukač, and D. Podgorelec. A hierarchical universal algorithm for geometric objects's reflection symmetry detection. *Symmetry*, 14(5), 2022.

[2] D. Cailliere, F. Denis, D. Pele, and A. Baskurt. 3d mirror symmetry detection using hough transform. In *2008 15th IEEE International Conference on Image Processing*, pages 1772–1775. IEEE, 2008.

[3] M. Giurfa, B. Eichmann, and R. Menzel. Symmetry perception in an insect. *Nature*, 382(6590):458–461, 1996.

[4] L. Hruda, I. Kolingerová, and L. Váša. Robust, fast and flexible symmetry plane detection based on differentiable symmetry measure. *The Visual Computer*, 38(2):555–571, 2022.

[5] N. J. Mitra, L. J. Guibas, and M. Pauly. Partial and approximate symmetry detection for 3d geometry. *ACM Transactions on Graphics (TOG)*, 25(3):560–568, 2006.

[6] M. Petitjean. A definition of symmetry. *Symmetry: Culture and Science*, 18(2-3):99–119, 2007.

[7] I. Sipiran, R. Gregor, and T. Schreck. Approximate symmetry detection in partial 3d meshes. In *Computer Graphics Forum*, volume 33, pages 131–140. Wiley Online Library, 2014.

[8] S. Tsogkas and I. Kokkinos. Learning-based symmetry detection in natural images. In *European Conference on Computer Vision*, pages 41–54. Springer, 2012.

[9] C. W. Tyler. Human symmetry perception. *Human symmetry perception and its computational analysis*, pages 3–22, 1996.

Approximate Keys and Functional Dependencies in Incomplete Databases With Limited Domains–Algorithmic Perspective

[Extended Abstract]

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ABSTRACT

A possible world of an incomplete database table is obtained by imputing values from the attributes (infinite) domain to the place of `NULL` s. A table satisfies a possible key or possible functional dependency constraint if there exists a possible world of the table that satisfies the given key or functional dependency constraint. A certain key or functional dependency is satisfied by a table if all of its possible worlds satisfy the constraint. Recently, an intermediate concept was introduced. A strongly possible key or functional dependency is satisfied by a table if there exists a strongly possible world that satisfies the key or functional dependency. A strongly possible world is obtained by imputing values from the active domain of the attributes, that is from the values appearing in the table. In the present paper, we study approximation measures of strongly possible keys and FDs. Measure g_3 is the ratio of the minimum number of tuples to be removed in order that the remaining table satisfies the constraint. We introduce a new measure g_5, the ratio of the minimum number of tuples to be added to the table so the result satisfies the constraint. g_5 is meaningful because the addition of tuples may extend the active domains. We prove that if g_5 can be defined for a table and a constraint, then the g_3 value is always an upper bound of the g_5 value. However, the two measures are independent of each other in the sense that for any rational number $0 \leq \frac{p}{q} < 1$ there are tables of an arbitrarily large number of rows and a constant number of columns that satisfy $g_3 - g_5 = \frac{p}{q}$. A possible world is obtained usually by adding many new values not occurring in the table before. The measure g_5 measures the smallest possible distortion of the active domains. We study complexity of determining these approximate measures.

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Categories and Subject Descriptors

H.2 [**Database Management**]: Miscellaneous; F.2 [**Analysis of Algorithms and Problem Complexity**]: Miscellaneous

General Terms

Theory

Keywords

Strongly possible functional dependencies, Strongly possible keys, incomplete databases, approximate functional dependencies, approximate keys.

1. INTRODUCTION

The information in many industrial and research databases may usually be incomplete due to many reasons. For example, databases related to instrument maintenance, medical applications, and surveys [8]. This makes it necessary to handle the cases when some information missing from a database and are required by the user. Imputation (filling in) is one of the common ways to handle the missing values [13].

In the present paper the classical relational model is considered that is the underlying concept of practical SQL database systems. The database is considered as a table, where rows (tuples) represent individual records, while columns correspond to properties or attributes. Important properties of these tables are the integrity constraints they (must) satisfy. In particular, keys and functional dependencies are the most common ones of those. An attribute set is a key if it determines all other attribute values in individual records, while functional dependency $X \to Y$ means that the values in attributes of X determine the values in attributes of Y.

A new approach for imputing values in place of the missing information was introduced in [3], to achieve complete data tables, using only information already contained in the SQL table attributes (which are called the active domain of an attribute). Any total table obtained in this way is called a *strongly possible world*. We use only the data shown on the table to replace the missing information because in many cases there is no proper reason to consider any other attribute values than the ones that already exist in the table. Using this concept, new key and functional dependency constraints called strongly possible keys (spKeys) and strongly possible functional dependencies (spFDs) were defined in [5, 4] that are satisfied after replacing any missing value (`NULL`) with a value that is already shown in the corresponding attribute. In Section 2, we provide the formal definitions of spKeys and spFDs.

The present paper continues the work started in [5], where an approximation notion was introduced to calculate how close any given set of attributes can be considered as a key. A classical measure is the ration of tuples needed to be removed. Tuple removal may be necessary because the active domains do not contain enough values to be able to replace the `NULL` values so that the tuples are pairwise distinct on a candidate key set of attributes K. In the present paper, we introduce approximation measures of spKeys and spFDs by adding tuples. Adding a tuple with new unique values will add more values to the attributes' active domains, thus some unsatisfied constraints may get satisfied. Adding tuples is only meaningful for strongly possible worlds. Earlier concept of possible worlds when any value of the attribute domain could be added is not appropriate, as adding tuples does not change the range of values usable for imputation. However, for strongly possible constraints the minimum ratio of tuples added to satisfy the constraint shows a smallest possible extension such that the constraint holds.

We denote by g_3 the minimum ratio of necessary tuple deletions and g_5 is the minimum ratio of necessary tuple additions. These two measures were shown to be basically independent of each other in [1]. In the present paper we review these results then turn our attention to interesting algorithmic and complexity problems involving the two approximation measures. The structure of the paper is as follows. Section 2 contains the necessary definitions, Section 3 discusses some related work. Section 4 reviews the definitions and main theorems about approximation measures. Subsection 4.2 contains the new results about complexity questions. Finally, Section5 includes some summary and concluding remarks.

2. DEFINITIONS

Let $R = \{A_1, A_2, \dots A_n\}$ be a relation schema. The set of all the possible values for each attribute $A_i \in R$ is called the domain of A_i and denoted as $D_i = dom(A_i)$ for $i = 1,2,\dots n$. Then, for $X \subseteq R$, then $D_X = \prod_{\forall A_i \in K} D_i$.

An instance $T = (t_1,t_2,\dots t_s)$ over R is a list of tuples such that each tuple is a function $t : R \to \bigcup_{A_i \in R} dom(A_i)$ and $t[A_i] \in dom(A_i)$ for all A_i in R. By taking a list of tuples we use the *bag semantics* that allows several occurrences of the same tuple. Usage of the bag semantics is justified by that SQL allows multiple occurrences of tuples. Of course, the order of the tuples in an instance is irrelevant, so mathematically speaking we consider a *multiset of tuples* as an instance. For a tuple $t_r \in T$ and $X \subset R$, let $t_r[X]$ be the restriction of t_r to X.

It is assumed that $\perp$ is an element of each attribute's domain that denotes missing information. t_r is called V-total for a set V of attributes if $\forall A \in V$, $t_r[A] \neq \perp$. Also, t_r is a total tuple if it is R-total. t_1 and t_2 are *weakly similar* on $X \subseteq R$ denoted as $t_1[X] \sim_w t_2[X]$ defined by Köhler et.al. [12] if

$$\forall A \in X \quad (t_1[A] = t_2[A] \text{ or } t_1[A] = \perp \text{ or } t_2[A] = \perp).$$

Furthermore, t_1 and t_2 are *strongly similar* on $X \subseteq R$ denoted by $t_1[X] \sim_s t_2[X]$ if

$$\forall A \in X \quad (t_1[A] = t_2[A] \neq \perp).$$

For the sake of convenience we write $t_1 \sim_w t_2$ if t_1 and t_2 are weakly similar on R and use the same convenience for strong similarity. Let $T = (t_1, t_2, \dots t_s)$ be a table instance over R. Then, $T' = (t'_1, t'_2, \dots t'_s)$ is a *possible world* of T, if $t_i \sim_w t'_i$ for all $i = 1, 2, \dots s$ and T' is completely `NULL` -free. That is, we replace the occurrences of $\perp$ with a value from the domain D_i different from $\perp$ for all tuples and all attributes. A active domain of an attribute is the set of all the distinct values shown under the attribute except the `NULL`. Note that this was called the *visible domain* of the attribute in papers [3, 4, 5, 2].

Definition 1. The *active domain* of an attribute A_i (VD_i^T) is the set of all distinct values except $\perp$ that are already used by tuples in T:

$$VD_i^T = \{t[A_i] : t \in T\} \setminus \{\perp\} \text{ for } A_i \in R.$$

To simplify notation, we omit the upper index T if it is clear from the context what instance is considered.

While a possible world is obtained by using the domain values instead of the occurrence of `NULL`, a strongly possible world is obtained by using the active domain values.

Definition 2. A possible world T' of T is called a *strongly possible world (spWorld)* if $t'[A_i] \in VD_i^T$ for all $t' \in T'$ and $A_i \in R$.

The concept of *strongly possible world* was introduced in [3]. A strongly possible worlds allow us to define *strongly possible keys (spKeys)* and *strongly possible functional dependencies (spFDs)*.

Definition 3. A strongly possible functional dependency, in notation $X \to_{sp} Y$, holds in table T over schema R if there exists a strongly possible world T' of T such that $T' \models X \to Y$. That is, for any $t'_1, t'_2 \in T'$ $t'_1[X] = t'_2[X]$ implies

$t'_1[Y] = t'_2[Y]$. The set of attributes X is a strongly possible key, if there exists a strongly possible world T' of T such that X is a key in T', in notation $sp\langle X\rangle$. That is, for any $t'_1, t'_2 \in T'$ $t'_1[X] = t'_2[X]$ implies $t'_1 = t'_2$.

If $T = \{t_1, t_2, \ldots, t_p\}$ and $T' = \{t'_1, t'_2, \ldots, t'_p\}$ is an spWorld of it with $t_i \sim_w t'_i$, then t'_i is called an *sp-extension* or in short an *extension* of t_i. Let $X \subseteq R$ be a set of attributes and let $t_i \sim_w t'_i$ such that for each $A \in R$: $t'_i[A] \in VD(A)$, then $t'_i[X]$ is an *strongly possible extension of* t_i *on* X *(sp-extension)*

3. RELATED WORK

Giannella et al. [9] measure the approximate degree of functional dependencies. They developed the IFD approximation measure and compared it with the other two measures: g_3 (minimum number of tuples need to be removed so that the dependency holds) and τ (the probability of a correct guess of an FD satisfaction) introduced in [11] and [10] respectively. They developed analytical bounds on the measure differences and compared these measures analysis on five datasets. The authors show that when measures are meant to define the knowledge degree of X determines Y (prediction or classification), then IFD and τ measures are more appropriate than g_3. On the other hand, when measures are meant to define the number of "violating" tuples in an FD, then, g_3 measure is more appropriate than IFD and τ. This paper extends the earlier work of [5] that utilized the g_3 measure for spKeys by calculating the minimum number of tuples to be removed from a table so that an spKey holds if it is not. The same paper proposed the g_4 measure that is derived from g_3 by emphasizing the effect of each connected component in the table's corresponding bipartite graph (where vertices of the first class of the graph represent the table's tuples and the second class represent all the possible combinations of the attributes' active domains). In this paper, we propose a new measure g_5 to approximate FDs by adding new tuples with unique values rather than deleting tuples as in g_3. In [14], Jef Wijsen summarizes and discusses some theoretical developments and concepts in Consistent query answering CQA (when a user queries a database that is inconsistent with respect to a set of constraints). Database repairing was modeled by an acyclic binary relation $\leq_{db}$ on the set of consistent database instances, where $r_1 \leq_{db} r_2$ means that r_1 is at least as close to db as r_2. One possible distance is the number of tuples to be added and/or removed. In addition to that, Bertossi studied the main concepts of database repairs and CQA in [6], and emphasis on tracing back the origin, motivation, and early developments. J. Biskup and L. Wiese present and analyze an algorithm called preCQE that is able to correctly compute a solution instance, for a given original database instance, that obeys the formal properties of inference-proofness and distortion minimality of a set of appropriately formed constraints in [7].

4. APPROXIMATION OF STRONGLY POSSIBLE INTEGRITY CONSTRAINTS

For examples of the following definitions see [1].

Definition 4. Attribute set K is an approximate strongly possible key of ratio a in table T, in notation $asp_a^- \langle K\rangle$, if there exists a subset S of the tuples T such that $T \setminus S$ satisfies $sp\langle K\rangle$, and $|S|/|T| \leq a$. The minimum a such that $asp_a^- \langle K\rangle$ holds is denoted by $g_3(K)$.

The g_3 approximation measure for spKeys was introduced in [5]. In this section, we introduce a new approximation measure for spKeys.

Definition 5. Attribute set K is an add-approximate strongly possible key of ratio b in table T, in notation $asp_b^+ \langle K\rangle$, if there exists a set of tuples S such that the table TS satisfies $sp\langle K\rangle$, and $|S|/|T| \leq b$. The minimum b such that $asp_b^+ \langle K\rangle$ holds is denoted by $g_5(K)$.

Definition 6. For the attribute sets X and Y, $\sigma : X \rightarrow_{sp} Y$ is a remove-approximate strongly possible functional dependency of ratio a in a table T, in notation $T \models\approx_a^- X \rightarrow_{sp} Y$, if there exists a set of tuples S such that the table $T \setminus S \models X \rightarrow_{sp} Y$, and $|S|/|T| \leq a$. Then, $g_3(\sigma)$ is the smallest a such that $T \models\approx_a^- \sigma$ holds.

Definition 7. For the attribute sets X and Y, $\sigma : X \rightarrow_{sp} Y$ is an add-approximate strongly possible functional dependency of ratio b in a table T, in notation $T \models\approx_b^+ X \rightarrow_{sp} Y$, if there exists a set of tuples S such that the table $T \cup S \models X \rightarrow_{sp} Y$, and $|S|/|T| \leq b$. Then, $g_5(\sigma)$ is the smallest b such that $T \models\approx_b^+ \sigma$ holds.

4.1 Relation between g_3 and g_5 measures

The following Proposition is used to prove Proposition 2.

PROPOSITION 1. *[1] Let T be an instance over schema R and let $K \subseteq R$. If the K-total part of the table T satisfies the key $sp\langle K\rangle$, then there exists a minimum set of tuples U to be removed that are all non-K-total so that $T \setminus U$ satisfies $sp\langle K\rangle$.*

PROPOSITION 2. *[1] For any $K \subseteq R$ with $|K| \geq 2$, we have $g_3(K) \geq g_5(K)$.*

Apart form the previous inequality, the two measures are totally independent for spKeys.

THEOREM 1. *[1] Let $0 \leq \frac{p}{q} < 1$ be a rational number. Then there exist tables over schema $\{A_1, A_2\}$ with arbitrarily large number of rows, such that $g_3(\{A_1, A_2\}) - g_5(\{A_1, A_2\}) = \frac{p}{q}$.*

Unfortunately, the analogue of Proposition 1 is not true for spFDs, so the proof of the following theorem is quiet involved.

THEOREM 2. *[1] Let T be a table over schema R, $\sigma : X \rightarrow_{sp} Y$ for some $X, Y \subseteq R$. Then $g_3(\sigma) \geq g_5(\sigma)$.*

Theorem 3 is proven by a construction [1] similar to the proof of Theorem 1.

THEOREM 3. *[1] For any rational number* $0 \leq \frac{p}{q} < 1$ *there exists tables with an arbitrarily large number of rows and bounded number of columns that satisfy* $g_3(\sigma) - g_5(\sigma) = \frac{p}{q}$ *for* $\sigma\colon X \to_{sp} Y$.

4.2 Complexity problems

Definition 8. The *SPKey problem* is the following.
Input Table T over schema R and $K \subseteq R$.
Question Is it true that $T \models sp\langle K\rangle$?
The *SPKeySystem problem* is the following.
Input Table T over schema R and $\mathcal{K} \subseteq 2^R$.
Question Is it true that $T \models sp\langle\mathcal{K}\rangle$?
The *SPFD problem* is the following.
Input Table T over schema R and $X, Y \subseteq R$.
Question Is it true that $T \models X \to_{sp} Y$?

The following was shown in [4].

THEOREM 4. *SPKey∈P, SPkeySystem and SPFD are NP-complete*

However, the approximation measures raise new, interesting algorithmic questions.

Definition 9. The *SpKey-g3* problem is the following.
Input Table T over schema R, $K \subseteq R$ and $0 \leq q < 1$.
Question Is it true that $g_3(K) \leq q$ in table T?
The *SpKey-g5* problem is the following.
Input Table T over schema R, $K \subseteq R$ and $0 \leq q < 1$.
Question Is it true that $g_5(K) \leq q$ in table T?

THEOREM 5. *Both, SpKey-g3 and SpKey-g5 are in P.*

PROOF. *SpKey-g3:* Let bipartite graph $G = (T, T^\star; E)$ be defined as in [4]. $T^\star$ is the set of sp-extensions of tuples in T on K, $\{t, t^\star\} \in E \iff t^\star$ is an extension of t. Then $T \setminus X \models sp\langle K\rangle$ iff there exists a matching covering $T \setminus X$ in G. Thus, X is a minimum set of tuples to be removed iff $|T \setminus X| = \nu(G)$, the matching number of G. This gives us $g_3(K) = \frac{|T| - \nu(G)}{|T|}$, so determination of $g_3(K)$ is equivalent with finding $\nu(G)$. The only problem is that $|T^\star|$ is usually of exponential size. In order to avoid exponential sized bipartite graph we only generate as many extensions as needed.For the sake of simplicity assume that $K = \{A_1, A_2, \ldots, A_b\}$. Let $T = \{t_1, t_2 \ldots t_m\}$ and $\ell(t_i) = |\{t^\star \in VD_1 \times VD_2 \times \ldots \times VD_b\colon t^\star \sim_w t_i[K]\}|$. Note that $\ell(t_i) = \prod_{j\colon t_i[A_j]=\perp} |VD_j|$, hence these values can be calculated by scanning T once and using appropriate search tree data structures to hold values of visible domains of each attribute. Sort tuples of T in non-decreasing $\ell(t_i)$ order, i.e. assume that $\ell(t_1) \leq \ell(t_2) \leq \ldots \leq \ell(t_p)$. Let $j = \max\{i\colon \ell(t_i) < i\}$ and $T_j = \{t_1, t_2, \ldots t_j\}$, furthermore $T_j^\star = \{t^\star : \exists t \in T_j : t^\star \sim_w t[K]\} \subseteq VD_1 \times VD_2 \times \ldots \times VD_b$. Note that $|T_j^\star| \leq \frac{1}{2}j(j-1)$. If $\forall i = 1, 2, \ldots, m\colon \ell(t_i) \geq i$, then define $j = 0$ and $T_j^\star = \emptyset$. Let $G^\star = (T_j, T_j^\star; E^\star)$ be the induced subgraph of G. Clearly $\nu(G) \leq \nu(G^\star) + |T \setminus T_j|$. On the other hand, a matching of G of size $\nu(G^\star) + |T \setminus T_j|$ can be created by extending a maximum matching of $G^\star$ greedily to the vertices (tuples) in $T \setminus T_j$.

SpKey-g5: To check whether $g_5(K) \leq q$ it is enough to add $\lfloor q|T|\rfloor$ pairwise distinct tuples with pairwise distinct new values and then check the satisfaction of $sp\langle K\rangle$ in polynomial time in the extended table. □

Example. Let $R = \{A_1, A_2, A_3\}$, $K_1 = \{A_1, A_2\}, K_2 = \{A_2, A_3\}$.

$$T = \begin{array}{c|ccc} & A_1 & A_2 & A_3 \\ \hline t_1 & 1 & \perp & 1 \\ t_2 & 1 & 2 & 2 \\ t_3 & 2 & 1 & 1 \\ t_4 & 2 & 1 & 1 \end{array}$$

$T \setminus \{t_4\} \models sp\langle K_1\rangle$ and $T \setminus \{t_4\} \models sp\langle K_2\rangle$, but the spWorlds are different. In particular, this implies that for $\mathcal{K}$ we have $g_3(\mathcal{K}) > \max\{g_3(K)\colon K \in \mathcal{K}\}$ On the other hand, trivially $g_3(\mathcal{K}) \geq \max\{g_3(K)\colon K \in \mathcal{K}\}$ holds. This motivates the following theorem.

THEOREM 6. *Let Table T over schema R and $\mathcal{K} \subseteq 2^R$. The problem* Max-g3 *defined as*
Is $g_3(\mathcal{K}) = \max\{g_3(K)\colon K \in \mathcal{K}\}$?
is NP-complete.

PROOF. The problem is in NP, a witness consists of a set of tuples U to be removed, an index $j\colon \frac{|U|}{|T|} = g_3(K_j)$, also an spWorld T' of $T \setminus U$ such that each K_i is a key in T'. Verifying the witness can be done in three steps.

1. $g_3(K_j) \not\leq \frac{|U|-1}{|T|}$ is checked in polynomial time using Theorem 5.
2. For all $i \neq j$ check that $g_3(K_i) \leq \frac{|U|}{|T|}$ using again Theorem 5.
3. Using standard database algorithms check that $\forall i\colon K_i$ is a key in T'.

On the other hand, the SPKeySystem problem can be Karp-reduced to the present question as follows. First check for each $K_i \in \mathcal{K}$ separately whether $sp\langle K_i\rangle$ holds, this can be done in polynomial time. If $\forall i\colon T \models sp\langle K_i\rangle$ then give $\mathcal{K}$ and T as input for Max-g3. It will answer Yes iff $T \models sp\langle\mathcal{K}\rangle$. However, if $\exists i\colon T \not\models sp\langle K_i\rangle$, then give the example above as input for Max-g3. Clearly both problems have No answer. □

5. CONCLUSIONS

In the present paper we treat approximation measures of keys and functional dependencies in SQL database tables with null values. The strongly possible world semantics is used, that is only values from the active domains of attributes are allowed to be imputed in place of the null values. This semantics avoids unnecessary distortions of domains, since the active domain of an attribute is the set of values

that actually occur in the table. A classical approximation measure of an integrity constraint is that what percentage of the tuples must be deleted in order to that the remaining table satisfies the constraint. This is usually denoted by g_3. The strongly possible world semantics allows to introduce a new approximation measure, namely by adding new tuples the active domains can be extended and so the integrity constraints may be made valid in that way, as well. The minimum set of tuples to be added is a minimum extension of the current strongly possible world(s) to one, which satisfies the given constraint. The percentage of the necessary new tuples is denoted by g_5. It was shown earlier that for keys and functional dependencies $g_3 \geq g_5$, but otherwise they are independent. The approximation measures give rise to new algorithmic problems and complexity questions. The new results of the present note are about the complexity to determine $g_3(K)$ and $g_5(K)$ for a key constraint K. Also a natural decision problem about system of keys is investigated and it is shown to be NP-complete.

6. REFERENCES

[1] M. Al-Atar and A. Sali. Approximate keys and functional dependencies in incomplete databases with limited domains. In *Foundations of Information and Knowledge Systems 12th International Symposium, FoIKS 2022 Helsinki, Finland, June 20–23, 2022 Proceedings*, volume 13388 of *LNCS*, pages 147–167. Springer Nature Switzerland AG, 2022.

[2] M. Al-Atar and A. Sali. Strongly possible functional dependencies for sql. *Acta Cybernetica*, 2022.

[3] M. Alattar and A. Sali. Keys in relational databases with nulls and bounded domains. In *European Conference on Advances in Databases and Information Systems*, pages 33–50. Springer, 2019.

[4] M. Alattar and A. Sali. Functional dependencies in incomplete databases with limited domains. In *International Symposium on Foundations of Information and Knowledge Systems*, pages 1–21. Springer, 2020.

[5] M. Alattar and A. Sali. Strongly possible keys for sql. *Journal on Data Semantics*, 9(2):85–99, 2020.

[6] L. Bertossi. Database repairs and consistent query answering: Origins and further developments. In *Proceedings of the 38th ACM SIGMOD-SIGACT-SIGAI Symposium on Principles of Database Systems*, pages 48–58, 2019.

[7] J. Biskup and L. Wiese. A sound and complete model-generation procedure for consistent and confidentiality-preserving databases. *Theoretical Computer Science*, 412(31):4044–4072, 2011.

[8] A. Farhangfar, L. A. Kurgan, and W. Pedrycz. A novel framework for imputation of missing values in databases. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, 37(5):692–709, 2007.

[9] C. Giannella and E. Robertson. On approximation measures for functional dependencies. *Information Systems*, 29(6):483–507, 2004.

[10] L. A. Goodman and W. H. Kruskal. Measures of association for cross classifications. *Measures of association for cross classifications*, pages 2–34, 1979.

[11] J. Kivinen and H. Mannila. Approximate inference of functional dependencies from relations. *Theoretical Computer Science*, 149(1):129–149, 1995.

[12] H. Köhler, U. Leck, S. Link, and X. Zhou. Possible and certain keys for sql. *The VLDB Journal*, 25(4):571–596, 2016.

[13] W. Lipski Jr. On databases with incomplete information. *Journal of the ACM (JACM)*, 28(1):41–70, 1981.

[14] J. Wijsen. Foundations of query answering on inconsistent databases. *ACM SIGMOD Record*, 48(3):6–16, 2019.

Building energy demand regression

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ABSTRACT

In the paper the applicability of regression models for building heating energy estimation is examined. During the experiment, regression models were created to estimate annual heating energy demand of generic family houses. Non-linearity of regression models was enhanced by creating non-linearly correlated new input variables. Then performance of generated models was measured and compared. As a result, multilayer dense neural net model with original input parameters was proposed. Its performance was almost equal to linear regression with extended input variables, but its structural and functional flexibility makes the neural network applicable in wider range of tasks.

Keywords

Heating energy, Regression, Neural network, Regression tree

INTRODUCTION

Heating energy demand determination by simulation for a family house by a special energetic simulation software requires time consuming setup and calculation per each building configuration. For energy optimization, a lot of simulations must be done, therefore speeding up the process would be very helpful.

Investigated simulations apply the same, generic engineering setup, since finding optimal building configurations and construction parameters are in the focus of the experiment series. Therefore, thermal insulation is, but artificial heating type and organization is not taken into consideration. Based on priorities specified by architect experts, from the collection of optimization aims, annual heating energy demand minimization comes first.

Complex and computation-intensive simulations could be replaced by multivariate linear regression. First test resulted bad regression accuracy, because as expected, the estimated energy demand function is not linear. But when increasing non-linearity of the model by enhance it with max. 3rd power of multiplicative combination of input variables, the accuracy of multivariate linear regression model grew above 0.95 of R^2 points, which is high enough to be accepted by architect experts.

But increasing the number of input variables in a non-linear extent, makes the model much more complex meanwhile the new input features are not interpretable by experts.

The proposed dense neutral network-based regression model is generated in 346 seconds. The created model calculates 3500 (train) estimations in 0.12 second and 1500 (test) estimations in 0.05 seconds. Its performance in accuracy, 0.96 R^2 is also acceptable by architect experts. The model operates on the initial input variables, no need for non-linearity addition by increasing number and complexity of input. Required non-linear features were extracted by the network in the training process. Besides, its structural flexibility opens possibilities of extended applications.

ENERGY REGRESSION

The main aim of regression models is to approximate unknow or known but complex correlation of descriptor and response variables. Such procedures are applied in all fields of science; thus, their application is not new in architectural energetics.

Peña-Guzmán and Rey [1] applied several types of linear regression models to estimate future development of residential electric power consumption with higher than 0.93 R^2 accuracy.

Mehedintu et al. [2] also used R^2 score for efficiency measurement of polynomial and auto regression methods. They applied these regression methods estimate the rate of total energy consumption and its part from renewable sources with higher than 0.91 score.

Mohammed et al. [3] estimated energy demand of school facilities. For the creation of linear regression model, 350 samples were used for training and 35 for testing. The accuracy of generated model was higher than 90%.

REGRESSION MODELS

Descriptive data
Building configurations can be used as input variables only if an appropriate representation is found for the blueprints. To help creation of this representation, the building is created from equal size boxes joined on sides conforming predefined architectural rules.
Figure 1. shows a valid building configuration.

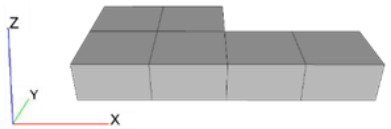

Figure 1: Building configuration example

Multivariate regression models cannot handle close relation of input variables (like coordinate triplets) therefore instead of using 3D coordinates of building components, count of details with special properties (convex edges and vertices, side walls, floors, roofs, etc.) were used as independent input variables.

Regression is a widely used statistical method [4], in which the aim is to model the relation between the descriptors and the dependent variable.

Linear regression
Linear regression [5] is a special case of generic regression, in which dependent variable is generated as linear combination of descriptor variables, as first-order Taylor series. For parameter determination in model generation, most commonly the least squares method is used.
Heating energy demand of family houses is a non-linear function. Definition of linear regression method enables dependency between its input variables, therefore multiplicative combination of inputs can be added to increase input complexity. Difficulty of this is the determination of maximum power of these combinations. As stated in the results, application of maximum 3rd power provides more than 0.95 of R^2 score.

Decision tree
Regression trees are special decision trees [6] for regression tasks. A decision tree is generated by a recursive binary partitioning process, which results internal nodes of the tree as decision nodes. These contain a test of the value of a specific input variable. The terminal nodes are the predicted output variable values.
Keys of regression tree generation are first the selection of the input variable for the decision – what to test. Next the selection of the separator value to test for. The idea behind the selection is the minimalization of variance of subspaces resulted by the split of decision.

For measuring the variances, the following methods are used:

- Mean Absolute Error based on L1 distance
- Mean Squared Error based on L2 distance
- Poisson method

Finally for the terminal nodes the predicted response value must be selected. This is done by averaging the group of samples covered by the terminal node.

Benefits of regression trees:

- greedy algorithm
- results good approximation
- short execution time – low resource needs
- well understandable decisions

Drawbacks of regression trees:

- not robust – sensitive to training data changes
- creation of optimal tree is NP-complete
- high chance for overfitting

Dense neural net

Neural net regression model [7] is inspired by nerve system and based on universal approximation theorem.

In terms of its structure, consists of independent analogue processing units which are organized into connected layers. The first layer of the network is called input, the last is the output, and layer between them (if any) is called hidden layer. Figure 2. shows the schematic model of a network with one hidden layer and l, m, n processors in input, hidden and output layers.

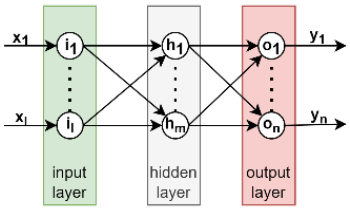

Figure 2: Neural net with 3 layers

Processors of consecutive layers are fully connected, but there are no connections between processors of same or non-consecutive layers.
The individual elements first calculate weighted sum of their inputs, then generate their output using an activation function. For providing the non-linearity and to support the learning procedure, special activations could be chosen.

MODEL GENERATION

For the model generation, 5010 samples were created by IDA ICE energy demand simulation software. Through simulations, architect experts designed 167 configuration of valid family houses of the same size. Then had to equip those with architectural (wall window ratio and orientation) and engineering (thermal insulation, heating system) components Then using weather data from local statistics of many years annual energy demand simulation must be done. Simulation outputs are generated by summarization of daily demands.
Using 70% of these samples (3507) 5 different type of models were created:

- linear regression
- decision tree with L1 metric
- decision tree with L2 metric
- decision tree with Poisson metric
- dense neural net with 1 hidden layer

3 versions were generated from all 5 model types, using different inputs:

- default inputs
- inputs extended with max. 2nd power of multiplicative combination
- inputs extended with max. 3rd power of multiplicative combination

That result 15 different model classes. To get rid of performance differences caused by randomization, 25 instances were generated from all 15 model classes. All 375 model instances were evaluated, then individual evaluations were averaged on classes.

MODEL EVALUATION

For better evaluation of model instance performances, a calculation of a single value is required for all instances. This single value must represent the approximation errors of each individual tests. R^2 metric is widely used in statistics and regression analyses was applied. As stated in equation 1, it conforms aforementioned requirement to represent individual approximation errors.

$$R^2 = 1 - \frac{\sum(y - \tilde{y})^2}{\sum(y - \bar{y})^2} \qquad \textbf{Equation 1}$$

where y is the value to approximate, $\bar{y}$ is its average and $\tilde{y}$ is the approximation.

In addition to R^2 score absolute and relative

(relative to the value to approximate) error average and their standard deviation also were measured.

RESULTS

After analysing averages and accuracy metrics of data groups, it can be stated that linear regression with 3rd and 2nd power of input variables and dense neural network with 1st (default) input had almost same performance, around 0.96 R^2 score. Score of all other model classes were below 0.75, therefore they were rejected.
Averages of absolute errors of estimations for all models are negligible compared to the annual demands, but only for the previously selected 3 model classes did the standard deviance of estimation error stayed below 500kWh/year.

CONCLUSION

As a final conclusion, it is stated that linear regression with higher power of input and dense neural net with default input perform the same.
But for model selection, structural flexibility is also taken into consideration. And linear regression model cannot be enhanced in the future. In the other hand, neural network structure can be extended or with more processors of the same type or different type of processor layers (convolutional, recurrent).
Therefore, the proposed model is the dense neural network with 1 hidden layer.

REFERENCES

[1] Peña-Guzmán C., Rey J. Forecasting residential electric power consumption for Bogotá Colombia using regression models, Energy Reports, (2020) vol. 6 sup. 1., pp. 561-566

[2] Mehedintu, A., Sterpu, M., Soava, G Estimation and Forecasts for the Share of Renewable Energy Consumption in Final Energy Consumption by 2020 in the European Union. Sustainability 2018, 10(5), 1515

[3] Mohammed, A., Alshibani, A., Alshamrani, O., Hassanain, M., A regression-based model for estimating the energy consumption of school facilities in Saudi Arabia. Energy & Buildings. 2021 vol. 237, 110809

[4] Sarstedt, M., Mooi, E. Regression Analysis. A Concise Guide to Market Research. pp 193-233. Springer Texts in Business and Economics 2014 ISBN: 978-3-642-53964-0

[5] Heiberger R., M., Holland B. Linear Regression by Least Squares in book Statistical Analysis and Data Display 2015 pp. 235-262, Springer

[6] Loh, W.Y. Classification and regression trees 2011. Wiley interdisciplinary reviews: Data Mining and KnowledgeDiscovery, 1(1), 14-23.

[7] Malte, J. Artificial neural network regression models: Predicting GDP growth. 2018. HWWI Research Paper, No. 185, Hamburgisches WeltWirtschaftsInstitut (HWWI), Hamburg

Clique relaxations of zero-one linear programs

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ABSTRACT

In an earlier work a so-called conflict graph was associated to a given zero-one linear program basically to accumulate information to construct cuts to speed up the solution of the program. Later it was noticed that the conflict graph can be used in fixing values of variables and fathoming partial solutions in enumerative type solvers. In this paper we will show that the conflict graph helps in dividing dividing a zero-one linear program into independent smaller instances and so it opens a way for a parallel solution. Further the conflict graph suggests certain possibilities for preprocessing and simplifying the given zero-one linear program.

Keywords

discrete optimization, clique, independent set, weighted clique, zero-one program, parallel computing, preprocessing

1. INTRODUCTION

Given a zero-one linear program P. We assume that objective function of P is to be maximized, that is, we are dealing with a maximization problem. A zero-one variable sometimes called a binary or Boolean variable. The fact that a zero-one variables takes on the value zero sometimes expressed saying that variable is on level zero. Similarly, we can say that the variable is on level one.

Following [1] using the linear program P we construct a so-called conflict graph H and we assign this graph H to the program P. Here is the construction of H. Let $x_1, \ldots, x_n$ be the variables of the given zero-one linear program P and let $y_1 = 1 - x_1, \ldots, y_n = 1 - x_n$. Finally, for the sake of a uniform notation let

$$u_1 = x_1, \ldots, u_n = x_n, u_{n+1} = y_1, \ldots, u_{2n} = y_n.$$

The nodes of the conflict graph H are the variables

$$u_1, \ldots, u_n, u_{n+1}, \ldots, u_{2n}.$$

The nodes u_i, u_j, $1 \leq i < j \leq 2n$ are connected by an edge in H if the inequality $u_i + u_j \leq 1$ holds.

We distinguish two types of conflict graphs such as totally computed conflict graphs and partially computed conflict graphs. In other words a partially computed conflict graph can be viewed as a relaxed version of the totally computed conflict graph. Typically one works with partially computed conflict graphs. The reason of this is the following. Deciding whether the pair $\{u_i, u_j\}$ is an edge of the conflict graph H amounts to deciding the linear program P has a feasible solution with the extra constraints $u_i = u_j = 1$.

If the zero-one linear program P with the extra constraints $u_i = u_j = 1$ does not have any feasible solution then, the unordered pair $\{u_i, u_j\}$ is an edge of the conflict graph H. Carrying out these computations for each $1 \leq i < j \leq 2n$ can be computationally prohibitive. So one accepts this limitation and introduces edges into H whose existence can be verified easily. In this way we end up with a partially constructed conflict graph.

In [1] a number of properties of the conflict graph were established and were used to construct cuts. The next three of the above results were used to aid an enumerative solutions in [9].

LEMMA 1. *(Extension rule) If $\{x_i, u_j\}$ and $\{y_i, u_k\}$ are edges of H, then $\{u_j, u_k\}$ is an edge of H.*

LEMMA 2. *(Fixing rule) If $\{u_i, u_i\}$ is an edge (loop) of H, then $u_i = 0$ must hold.*

LEMMA 3. *(Fathoming rule) A partial solution in which x_i is fixed on level 0 and y_i is fixed on level 0 cannot be a feasible solution.*

We apply the extension rule repeatedly as long as the extension rule is applicable. This leads to the so-called closure of the conflict graph. If we are lucky we may fix the value of some variable in the linear program or we may fathom a partial solution.

The set of neighbors of a node v of the graph G consists of all the nodes of G that are adjacent to v. The set of neighbors of v is denoted by $N(v)$. In practice we apply the extension rule to the nodes x_i and y_i for each i, $1 \leq i \leq n$. Namely, the edges $\{x, y\}$, $x \in [N(x_i) \setminus \{y_i\}]$, $y \in [N(y_i) \setminus \{x_i\}]$ are added to the conflict graph. Of course some of these edges

Table 1: The adjacency matrix of a conflict graph.

		x	x	x	x	x	y	y	y	y	y
		1	2	3	4	5	1	2	3	4	5
x	1		•	•	•		•				•
x	2	•						•			
x	3	•							•		
x	4	•								•	
x	5										•
y	1	•						•	•		
y	2		•				•				
y	3			•			•				
y	4				•						
y	5	•				•					

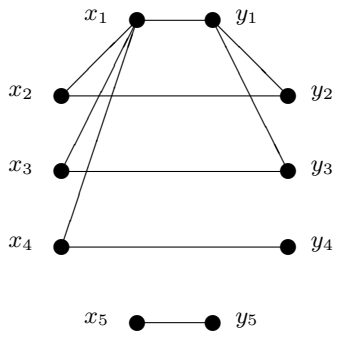

Figure 1: A graphical representation of the conflict graph

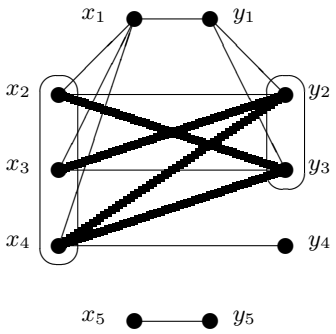

Figure 2: Extending the conflict graph. The newly added edges are bold.

may already be an edge of the conflict graph in which case we do not add any new edge to the conflict graph. Note that $y_i \in N(x_i)$, $x_i \in N(y_i)$ and so if $|N(x_i)| = 1$ or $|N(y_i)| = 1$, then we do not add any new edge to the conflict graph. If $[N(x_i) \setminus \{y_i\}] \cap [N(y_i) \setminus \{x_i\}] \neq \emptyset$, then there are variables whose values can be fixed. Namely, the variables appearing in the intersection can be fixed.

To see why let us assume that u_j is an element of the intersection. In this situation by the extension rule the unordered pairs $\{x_i, u_j\}$ and $\{y_i, u_j\}$ are edges of the conflict graph. Again, by the fixing rule $\{u_j, u_j\}$ is an edge of the conflict graph.

As an illustration we included a small example. In Table 1 the reader can see the adjacency matrix of a conflict graph. Figure 1 depicts a possible geometric representation of this conflict graph. Figure 2 shows the new edges we get applying the extension rule.

Of course the computations are happening on the adjacency matrices. During a computations only Tables 1 and 2 appear.

Table 2: The adjacency matrix of the extended conflict graph. The new edges are indicated by "○" signs.

		x	x	x	x	x	y	y	y	y	y
		1	2	3	4	5	1	2	3	4	5
x	1		•	•	•		•				•
x	2	•						•	○		
x	3	•						○	•		
x	4	•						○	○	•	
x	5										•
y	1	•						•	•		
y	2		•	○	○		•				
y	3		○	•	○		•				
y	4				•						
y	5	•				•					

2. THE WEIGHTED AGREEMENT GRAPH

In this section we define a new agreement graph G. This G can be used to preprocessing or precondition the original linear program and to divide it into smaller independent instances.

Let G be the complement of the subgraph of H induced by the set of nodes $\{x_1, \ldots, x_n\}$. To the node x_i of G we assign the coefficient of x_i in the objective function as a weight.

A subset C of the vertices $\{x_1, \ldots, x_n\}$ of the weighted agreement graph G is called a clique if each two distinct vertices in C are adjacent in G. The sum of the weights assigned to the elements of C is called the weight of the clique. The vector $[\alpha_1, \ldots, \alpha_n]$ is referred to as the characteristic vector of the set C if $\alpha_i = 1$ whenever $x_i \in C$ and $\alpha_i = 0$ whenever $x_i \notin C$.

The observation we will use is stated formally as a lemma.

LEMMA 4. *The set of characteristic vectors of the cliques of G contains each feasible solution of the zero-one linear program P.*

We spell out explicitly Lemma 5 as a corollary to Lemma 4.

LEMMA 5. *The value of each optimal solution of the zero-one linear program P is at most the weight of a maximum weight clique in the graph G.*

Any of the maximum weight clique solvers in [2], [4], [5], [6], [7] can be deployed to locate a maximum weight clique in the agreement graph G. This clique does not necessarily provide a feasible solution of the original zero-one linear program P. What is certain that we can establish upper bound for the optimal solution of the zero-one linear program P.

The Carraghan-Pardalos algorithm [3] is capable of listing all maximum weight cliques in the weighted agreement graph G. The algorithm maintains a partially constructed clique C and a list consisting of nodes that can be added to C to get a larger clique. With a slight modification of the procedure we may also check if C can be part of a feasible solution of the given zero-one program P. Thus, the modified Carraghan-Pardalos algorithm could locate a clique in G, which has maximum weight among the feasible solutions of P. In short, a clique problem solver can solve moderate size zero-one linear programs.

3. KERNELIZATION

A node of the graph G is referred to as a full degree node if it is adjacent to each other node of G. Let v be a full degree node of G and let G' be the subgraph of G induced by the nodes distinct from v. In plain English we get G' from G by deleting the node v.

LEMMA 6. *(Full degree rule) If C' is a maximum weight clique in G', then $C = C' \cup \{v\}$ is a maximum weight clique in G.*

Lemma 6 suggests to remove full degree nodes from the weighted conflict graph, then after locating a maximum weight clique in the reduced graph we can construct a maximum weight clique in the original weighted agreement graph.

We say that node v dominates node u of the weighted agreement graph G if u, v are distinct, $N(u) \subseteq N(v)$ and the weight of u is not larger than the weight of v. (Remember that $N(v)$ is the set of neighbors of the node v in G.)

We say that the edge $e = \{u, v\}$ dominates edge $f = \{v, w\}$ in the weighted agreement graph G if the unordered pair $\{u, w\}$ is not an edge of G, $[N(v) \cap N(w)] \subseteq [N(u) \cap N(v)]$ and the weight of w is not larger than the weight of u.

More generally, we say that the edge $e = \{u, v\}$ dominates edge $f = \{x, y\}$ in the weighted agreement graph G if at least one of the unordered pairs

$$\{u, x\}, \{u, y\}, \{v, x\}, \{v, y\}$$

is not an edge of G, $[N(x) \cap N(y)] \subseteq [N(u) \cap N(v)]$ and the sum of weights of x and y is not larger than the sum of weights of u and v.

The following result is proved in [8].

LEMMA 7. *If node v dominates node u, then node u can safely deleted from G when we are looking for a maximum weight clique in G.*

LEMMA 8. *If edge e dominates edge f, then edge f can safely deleted from G when we are looking for a maximum weight clique in G. (We do not delete any of the endpoints of the edge f.)*

Deleting a node from G means that we may fix the value of the corresponding variable of P on level zero. Deleting an edge from the weighted agreement graph G means that we may enter a new edge into the original unweighted conflict graph H. Applying the extension rule in H may result fixing variables or fathoming.

3.1 Coloring the vertices

In this section we will show how coloring of the nodes of the weighted agreement graph G can be used for preprocessing the zero-one linear program P.

We say that a coloring of the vertices of the graph G is a proper coloring if each node is colored exactly one color and the two end points of each edge of G receive distinct colors. Usually we use the numbers $1, \ldots, k$ as colors. The nodes of G receiving colors i give the elements of the color i-th color class C_i. A coloring of the nodes of G can be given by the color classes $C_1, \ldots, C_k$. From the color class C_i we pick a node with a maximum weight. Summing up these weights for each i, $1 \leq i \leq k$ we get a number which we call the weight of G with respect to the given coloring of the nodes of G.

Let v be a vertex of G. We consider the subgraph L of G induced by the set $N(v)$. Using a greedy algorithm we

properly color the vertices of L. To the vertex v we assign the weight of the coloring of L and call this number the color index of v.

Let $e = \{u, v\}$ be an edge of G. We consider the subgraph M of G induced by the set $N(u) \cap N(v)$. Using a greedy algorithm we properly color the vertices of M. To the edge e we assign the weight of the coloring of M and call this number the color index of e.

Using a greedy procedure we locate a clique C in G. The larger of the weight T of C is the better. Clearly, T is a lower bound of the weight of any maximum weight clique in G.

The basic observation we use for preprocessing is stated as a lemma.

LEMMA 9. *Let v be a vertex of G. If* $\text{weight}(v)+\text{index}(v) < T$*, then v can be deleted safely from G when we are looking for a maximum weight clique in G.*

Let $e = \{u, v\}$ be an edge of G. If $\text{weight}(u) + \text{weight}(v) + \text{index}(e) < T$*, then e can be deleted safely from G when we are looking for a maximum weight clique in G. (We do not delete any of the endpoints of the edge e.)*

4. PARALLELIZATION

Let us turn to the parallelization result. Let W_1, W_2, W_3 be subsets of the nodes of the finite simple graph G and assume that V is the set of nodes of G. Suppose W_1, W_2, W_3 are pair-wise disjoint and $V = W_1 \cup W_2 \cup W_3$. If in addition there is no edge of G is going from W_1 to W_3, then we say that the triple (W_1, W_2, W_3) is a splitting partition of G.

Let G_1 be the subgraph of G induced by the set of nodes $W_1 \cup W_2$ and let G_3 be the subgraph of G induced by the set of nodes $W_2 \cup W_3$.

The next result is proved in [8].

LEMMA 10. *If C is a maximum weight clique in the graph G, then C is a maximum weight clique in either G_1 or in G_3.*

In the particular case when both of the sets W_1, W_3 has more than one elements Lemma 10 offers a way to replace the original zero-one linear program P by two smaller programs P_1 and P_3. The program P_1 is constructed from program P by deleting variables corresponding the elements of the set W_3. Similarly, the program P_3 is constructed from program P by deleting variables corresponding the elements of the set W_1.

Sytematic ways to construct splitting partitions are presented and tested in [10] and [11].

5. ACKNOWLEDGMENTS

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6. REFERENCES

[1] A. Atamtürk and M. W. P. Savelsbergh, Conflict graphs in solving integer programming problems, *European Journal of Operation Research* **121** (1994), 40–45.

[2] E. Balas, J. Xue, Weighted and unweighted maximum clique algorithms with upper bounds from fractional coloring, *Algorithmica* **15** (1996), 397–412.

[3] R. Carraghan, P. M. Pardalos, An exact algorithm for the maximum clique problem, *Operation Research Letters* **9** (1990), 375–382.

[4] S. W. Cai and J. K. Lin, Fast solving maximum weight clique problem in massive graphs. In *Proceedings of 25th International Joint Conference on Artificial Intelligence*, IJCAI, (2016) 568???574.

[5] D. Kumlander, A new exact algorithm for the maximum weight clique problem based on a heuristic vertex-coloring and a backtrack search. In *Proceedings of Modeling, Computation and Optimization in Information Systems and Management Sciences, MCO, 202????208.* Hermes Science Publishing 2004.

[6] P. R. J. Östergård, A new algorithm for the maximum-weight clique problem, *Nordic Journal of Computing* **8** (2001), 424–436.

[7] P. Prosser, Exact algorithms for maximum clique: A computational study, *Algorithms* **5** (2012), 545–587.

[8] S. Szabó, Parallel algorithms for finding cliques in a graph, *Journal of Physics: Conference Series* **268** (2011)

[9] S. Szabó, Conflict graphs in implicit enumeration, *Pollack Periodica* **7** (2012), 145–156.

[10] S. Szabó, Metric space method for constructing spiltting partitions of graphs, *Acta Univ. Sapientiae, Informatica* **11** (2019), 131–141.

[11] S. Szabó and B. Zavalnij, Splitting partitions and clique search algorithms, *Middle-European Conference on Applied Theoretical Computer Science 2019*, 75–78.

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Borut Žalik, Matjaž Gams

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Ljubljana, Slovenija

PREDGOVOR

V 2022 smo poskusili z novim konceptom promovirati slovensko računalništvo in informatiko. Imenuje se »Legende računalništva in informatike« (Krajše »Legende RI« ali kar »legende«) s podnaslovom »Galerija slavnih slovenskega računalništva in informatike«, angleško »Hall of fame of Slovenian computer science and informatics«.

Motiv je, da stroka sama da priznanja pomembnim raziskovalcem, razvojnikom in inženirjem na področju RI, hkrati pa zberemo pomembne avtobiografske prispevke v obliki zapisa slovenske zgodovine RI, torej sledimo dvema ciljema hkrati. Strokovnost brez politike in ideologije, demokratičnost in transparentnost so dominantne komponente postopka Legend RI. Škoda bi bila tudi, da ne bi nekateri pomembni posamezniki nikjer zbrano predstavili svojega dela. Po drugi strani pa poglejmo samo Alana Turinga, ki je eden najpomembnejših računalničarjev vseh časov, a je bil namesto nagrade obsojen in kaznovan zaradi svoje usmerjenosti, ne da bi komurkoli storil kaj žalega. Pričakujemo, da bo programski odbor nagradil vse pomembne računalnikarje s priznanjem "Legenda" glede na njihov dejanski prispevek.

Vsak začetek je težak, zato je bilo tudi nekaj začetniških spodrsljajev, a sedaj imamo programski odbor, ki odloča z glasovanjem o vseh pomembnih točkah. Tako je bilo izglasovano ime dogodka, da so dobitniki nagrade Michie-Turing brez glasovanja sprejeti po poslanem referatu na konferenco, ki hkrati služi kot avtobiografska zgodovina. Podobno naj bi veljalo za zelo pomembne mednarodne nagrade (o zadostni pomembnosti glasuje programski odbor) ne pa tudi za nacionalne nagrade. Nagrad naj bi bilo prvo leto med 10 in 20. Absolutna zgornja meja naj bi bila nekaj nad 50, zagotovo manj kot 100 legend. Ker naj bi preprečili, da kdorkoli glasuje zase, bo volilna komisija multikonference Informacijska družba (IS) preverila vsako volilnico posebej.

Pošiljanje predlogov je odprto, pričakovano pa predvsem s strani društev ACM Slovenija in SLAIS. Volilna komisija legend je kar standardna IS komisija. Rezultati so predani naprej samo v zbirni obliki, to je v številu glasov. Predlog je potrjen, ko je zanj več oddanih glasovnic ZA kot NE in ne presega dogovorjene letne ali absolutne meje – v tem primeru odloča vrstni red.

Predlog za legendo mora biti v obliki 2-4 stranskega prispevka za konferenco IS v pravem formatu, podkrepljen z literaturo. Predlog lahko poda vsak zase, kandidira pa lahko tudi koga drugega. Vsak lahko hkrati napiše več predlogov. Pri posthumni kandidaturi je potrebno pridobiti soglasje najbližjih svojcev. Prispevek velja urediti podobno kot življenjepis oz. CVI, s tem da izpostavljamo dosežke in ne osebne lastnosti. Dosežke velja strukturirati, recimo znanstveno, prenosi v prakso, pedagoško, organizacijsko, a zaenkrat je tu precej svobode. V bodoče bi bilo morda smiselno strukturo tudi poenotiti,

S tem novim mehanizmom skušamo dodatno razviti slovensko računalništvo in informatiko ter informacijsko družbo. Prosiva za sodelovanje, podporo, ali vsaj za strpnost in razumevanje. In seveda, iskrena hvala vsem sodelujočim in čestitke sedanjim in bodočim nagrajencem!

Borut Žalik in Matjaž Gams

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POVZETEK

V prispevku so opisani dosežki avtorja.

1 UVOD

Zaprošen sem bil, naj opišem svoj prispevek na IT področju v Sloveniji. Zapisano je pravzaprav samo spomin na dogodke, kot se je pač ohranil v moji glavi in ni povsem verodostojen dokument. Na tem delam in še ni končan.

2 ŽIVLJENJEPIS

Rojen sem 1. julija 1951 v Ljubljani očetu šoferju in materi gospodinji. Že v osnovni šoli sem tekmoval na tekmovanjih iz matematike in po osnovni šoli nadaljeval izobraževanje na Bežigrajski gimnaziji v matematičnem razredu. Vseskozi sem bil »politično aktiven«, bil predsednik razreda, pionirske in mladinske organizacije v osnovni šoli in gimnaziji, vedno kot neka alternativa prevladujoči politiki. V četrtem letniku gimnazije sem skupaj s še tremi sošolci, gotovo kot prvi, protestno izstopil iz ZSMS. Zdela se nam je premalo napredna.
Študij sem nadaljeval na Fakulteti za naravoslovje in tehnologijo, na smeri tehnična matematika in leta 1976 diplomiral. Računalniško programiranje je predaval dr. Egon Zakrajšek. Praktično delo, programiranje v FORTRAN-u, smo študenti opravljali na sistemih IBM 1130 in CDC Cyber 72. Skupaj s sošolcem in prijateljem Igorjem Fakinom sva kot seminarsko nalogo izdelala program, ki je uspešno poiskal maksimalni pretok usmerjenega grafa. Ta moja prva izkušnja me je na zanimiv način spremljala skozi vse življenje.
Po odsluženju vojnega roka sem se leta 1977 zaposlil v ISKRI Commerce, kjer sem imel štipendijo. Moj prvi računalnik, do katerega sem imel neomejen pristop, je bil Philips P320. Sistem je bil namenjen računovodstvom. Glavna podatkovna vhodno/izhodna enota pa je bila magnetna kartica formata A4 za magnetnim trakom ob strani. Uspelo mi je izdelati program za optimizacijo cene krmnih mešanic za podjetje Emona. Nenavadno za strogo namensko napravo.

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Iz dolgoletnega sodelovanja ISKRE in CDC-ja se je v tem času zgodil nakup licence za proizvodnji mini računalnika za poslovno uporabo Cyber C-18. Čisto slučajno sem leta 1978 postal član skupine 21-tih mladih, v glavnem diplomiranih inženirjev elektrotehnike in matematike, ki jih je ISKRA poslala na šolanje v ZDA. Naša naloga je bila, da spoznamo HW in SW komponente sistema. Imeli smo dostop do vse izvorne kode, vseh informacij in odličnih poznavalcev sistema.
Cyber-18 je imel izredno napreden 16-bitni procesor. deloval je v dveh načinih - batch in interaktivno. V batch načinu je izvajal programe zaporedno, podobno kot IBM-360 z operacijskim sistemom MSOS 5.0. Interaktivno delo z do 16 terminali je bilo podprto z operacijskim sistemom ITOS 1.2 (Interactive Terminal Oriented System). Hkratno delo ni bilo mogoče. Sistem je imel maksimalno 256 KB spomina. Na pamet mi je prišel način, kako brez velikih sprememb programja doseči sočasno delovanje obeh operacijskih sistemov. Moj predlog je bil sprejet in v manjši skupini še dveh sodelavcev Lada Peternela in Janeza Kožuha, ki je našel način, kako razširiti spomin na 512KB in podpreti 32 terminalov, smo idejo izpeljali. Hkrati smo izvedli spremembe za podporo šumnikov in odstranili vrsto napak v File Manager podsistemu, ki so povzročale občasne ustavitve sistema. Nov sistem smo poimenovali ITOS 2.0 in v CDC-ju so nam celo formalno priznali avtorstvo sistema. Razvoj je ob zelo intenzivnem delu trajal manj kot leto dni. V ISKRI so računalnike imenovali ISKRADATA C-18 in C-19 in jih uspešno prodajali po vsej Jugoslaviji. Med mnogimi pomembnimi aplikacijami je bila tudi glavna knjiga v vseh temeljnih bankah NLB. Lasten razvoj smo nadaljevali in implementirali zanesljiv prenos datotek po protokolu IBM 3780 preko telefonskih linij. Zadnji razvoj, pri katerem sem kreativno sodeloval, je bila implementacija najpogosteje uporabljene kode (memory scheduler) z »native mode« instrukcijami. Prav kmalu smo namreč ugotovili, da je celoten sistem deloval v emulaciji asemblerja, v katerem je bil napisan sistem MSOS. Tudi pri največji obremenitvi je bil sam procesor sano polovično izkoriščen. Po spremembi je procesor deloval z okoli četrtino zmogljivosti. Na naše presenečenje pa sistem ni deloval prav nič hitreje. Problem j bila organizacija diska. Moj predlog za reorganizacija dika ni bil sprejet, ker je v tem času celoten projekt ISKRADATA v ISKRI počasi ugašal in bil nadomeščen s projektom DELTA.
Zame je bil ta čas pomemben tudi zaradi dogodkov, povezanih s prvo možnostjo, da bi ISKRA izvozila svoje znanje v Mehiko, veliki državni firmi DICONSA SA, ki je takrat imela preko 80 računalnikov C-18, s katerimi so upravljali oskrbovanje z

osnovnimi živili po celi Mehiki. Ker sem dobro poznal File Manager, sem tudi natančno vedel, zakaj se CDC C-18 sistemi na videz slučajno ustavijo brez kakršnega koli obvestila. To se je v DICONSI redno dogajalo in CDC je to s pridom izkoriščal. Ob vsaki napaki so v Mehiko poslali tehnika, jih v glavnem obtožili, da ne znajo uporabljati programja, in jim »odpravo napake« zasoljeno zaračunali. Kljub moji intervenciji pri odgovornih v CDC se je tako početje nadaljevalo. V naši verziji operacijskega sistema smo te napake odpravili.

Slučajno sem spoznal nekega managerja iz DICONS-e in mu povedal, kaj se dogaja. Predlagal sem demonstracijo na njihovem sistemu v Tijuani, okoli 120 km iz San Diega. Demonstracija bila več kot uspešna in dogovorili smo se za posodobitev vseh 85 sistemov na ITOS 2.0 z možnostjo softverske podpore in razvoja aplikacijskega programja za podjetje. Ko smo s to možnostjo seznanili vodstvo v Kranju in Ljubljani, so v San Diego poslali managerja, ki je na hitro uspel izničiti vse naše uspehe in napovedal prekinitev sodelovanja s CDC-jem.

Takrat sem se zarekel, da bom nekoč ustanovil podjetje, ki bo z dobičkom prodajalo softver v ZDA. Trajalo je celih 12 let, da so se moje želje uresničile.

V začetku 80-tih let sem, med prvimi v Sloveniji, pokazal, da se da s programiranjem tudi dobro zaslužiti. Z dovoljenjem direktorja in delavskega sveta sem skupaj z Zoranom Zagorcem, ki je pozneje postal soustanovitelj HERMES SoftLab-a, izpeljal optimizacijo delovanja programov na računalnikih ISKRADATA v NLB (10-kratno pohitritev obdelav zaključka glavne knjige NLB) in zaslužili smo 40.000 DEM – veliko denarja za tisti čas.

Ker je program ISKRADATA ugasnil, sem se leta 1984 pridružil podjetju HERMES, ki je zastopalo podjetje Hewlett-Packard v Jugoslaviji z dogovorom, da bom pomagal ustanoviti softversko podporno službo, ki do takrat ni obstajala. Kmalu so se pridružili še Andrej Kuščer, Zoran Zagorc in Tomaž Schara. Sam sem bil odgovoren za programsko podporo za poslovni sistem HP3000, sodelavci pa za LINUX oziroma kasneje HPUX – UNIX sistem na računalnikih HP9000 RISC. Kmalu smo se ob šolanju v HP-ju spoznali s tehnologijo in z več zanimivimi rešitvami težjih tehničnih problemov tudi pridobili toliko zaupanja odgovornih v HP-ju, da smo leta 1988 pridobili prvi razvojni projekt. Delo smo opravili v glavnem izven rednega delovnega časa in zaslužili 250.000 DEM. Ker je denar prišel ravno pred novim letom, se je delavski svet prav na hitro odločil, da je neprimerneje ta denar porabiti za dodatno »božičnico« za vseh 300 takrat zaposlenih v HERMES-u. Prav nič ni ostalo za kak nov računalnik za razvoj. V praksi sem občutil, da je nadzor nad dobičkom in njegovo smotrno vlaganje izjemno pomemben. Tega sem se, morda še preveč, držal celo svojo kasnejšo poslovno kariero.

Bil sem tudi aktivno udeležen pri ustanovitvi prvega slovenskega softverskega podjetja v mešani lasti Mikro Ade, katerega direktor je bil Igor Omerza. Družbeni kapital je zastopala takratna ZSMS. Ker se nisem želel izpostavljati, je bila med zasebnimi ustanovitelji moja žena Sonja in sestra Janeza Janše. JJ je bil uslužbenec podjetja. Preko Mikro Ade smo od začetka 1988 do osamosvojitve prodajali programski sklop RIP (Rentabilnost Investicijski Projektov) po celi Jugoslaviji. Ta je izjemno pohitril tedaj obvezen izračun investicij in ga je sestavljalo skoraj 500 med seboj povezanih LOTUS razpredelnic, ki sem jih lastnoročno napisal. Vsebinsko je metodologijo obvladal moj sošolec, ekonomist Boris Šefman, pri distribuciji in šolanju strank pa je sodeloval Savo Tatalović. To je bil eden prvih primerov res uspešnega in koristnega programskega paketa, ki je prinesel okoli 750.000 DEM prihodka. To Mikro Adi, tudi pri njeni širši vlogi, ni škodilo.

Ko se je v letu 1990 pokazala možnost ustanovitve zasebnih družb, se je uspešno podjetje HERMES razdelilo v 13 družb. Sodelavci v prodaji in servisu zastopstva HP-ja so ustanovili podjetje HERMES Plus. Andrej Kuščer, Tomaž Schara in Zoran Zagorc smo ustanovili podjetje HERMES SoftLab. Nanj smo prenesli že v HERMES-u sklenjeno pogodbo s HP-jem in dobili 6.000 USD popotnice v obliki kredita z zmanjšano obrestno mero. Ne gre pozabiti, da je bil takrat čas hiperinflacije. Prav anekdotično je, da smo kasneje morali zaradi te zmanjšane obrestne mere plačati kazen za »oškodovanje družbenega premoženja«.

Razvojno delo za HP se je hitro povečevalo in zaslužek je bil odličen. Dobiček smo vlagali v nove ljudi, njihovo vsestransko izobraževanje in nakup opreme. Nekatere posle smo prevzeli z veliko rizika, saj naše znanje ni bilo preverjeno dovolj dobro. Zelo pomemben dosežek je bila izdelava sistema za zaščito podatkov OmniBack, ki je postal svetovna uspešnica s kompletnim razvojem v Ljubljani. Uporabljale so ga številne največje družbe na svetu (npr. DHL, Boeing). Razvoj je vodil Andrej Kuščer. S HP-jem smo sklenili dogovor s katerim nam je HP zagotovil razvojno HW in SW okolje mi pa smo financirali razvojno delo. To bi bilo plačano samo v primeru, da razvoj uspešno zaključimo. Uspelo nam je in zaslužili smo prvi milijon mark.

Kot solastnik in prvi investitor v HERMES SoftLab sem nam je pridružil tudi Karlheinz Weiland, projektni vodja v HP, Boeblingen.

Prevzeli smo sodoben način vodenja in v podjetje prenesli dobre prakse softverskega inženirstva v HP-ju. Leta 1993 smo prejeli naziv Podjetniki leta. V letu 1998 smo, kot prvi, prejeli slovensko priznanje za poslovno odličnost. Prav tako smo leta 1998 v Parizu prejeli priznanje za uvrstitev med štiri najboljša podjetja po sistemu upravljanja kakovosti EFQM Business Excellency Award.

Od samega začetka smo izrazito podpirali ZOTK-o, ki je bila organizator slovenskega državnega tekmovanja v računalništvu. Zmagovalce smo pošiljali v razvojne laboratorije v HP. Ker so bili res dobri, je to pripomoglo k našemu dobremu imenu.

Kmalu smo ustanovili podjetje v ZDA v mestu Mountain View v Santa Clari, v bližini Palo Alta, kjer je sedež Heweltt-Packarda. V Sloveniji smo imeli prostore in sodelavce v Novi Gorici in Mariboru, v Bosni in Hercegovini pa smo takoj po Daytonskem sporazumu ustanovili podjetji v Sarajevu in Banja Luki. V Srbiji smo imeli svoje podjetje v Kragujevcu.

Kmalu po osamosvojitvi leta 1992 smo za potrebe bivše SDK, ki jo je takrat vodil Igor Omerza, razvili program za optimalen večstranski pobot. S pomočjo matematičnega bistreca Tomaža Schare in z vrhunsko implementacijo smo dosegli bistveno višji pobot za desetino prejšnje cene pobota, ki ga je SDK izvajala na Hrvaškem v centru SRCE, kjer je bil takrat najhitrejši IBM-ov računalnik. Nekaj časa je to bil to pomemben del prihodka podjetja. Z njim smo prebrodili začetne težave in napake.

V letu 1993 smo s lotili prenove plačilnega pometa v Sloveniji. Med prvimi v svetu smo za transakcijsko poslovno aplikacijo uporabili operacijski sistem UNIX, relacijsko bazo podatkov in client/server arhitekturo. Na našo pobudo so v SDK kot prvi

državnih organizacijah uvedli masovno uporabo elektronske pošte. Sistem je bil zelo uspešno uveden leta 1997. Celoten razvoj je za HSL pomenil 3,5 m DEM prihodka, ki pa ni pokril vseh stroškov. Prav gotovo najcenejši razvoj nacionalnega plačilnega sistema do takrat. Na žalost je bil v uporabi samo nekaj let in je s prehodom na medbančni plačilni promet zamrl. Njegovo različico še danes uporabljajo na UJP.

Zelo uspešno je HSL sodeloval z Mobitelom. Zelo zgodaj smo prepoznali pomembnost podatkovnega prenosa na mobilnem omrežju čeprav je bila hitrost prenosa v začetku majhna.

Izdelali smo SMS komunikacijski portal M-vrata s podsistemoma SMS-poštar in Ključna beseda s katerima je takrat Mobitel bil praktično vodilni v svetu na področju negovornih mobilnih storitev. Danes nas mnogo uporablja sistem pri akcijah zbiranja pomoči, glasovanjih, reklamah in prenosu raznoraznih informacij preko SMS-ov.

Mobitel je tudi financiral razvoj sistema MojAlbum s katerim smo, takoj po pojavu prvih kamer na NOKIA mobilnih telefonih, omogočili prenos in shranjevanje slik na Mobitelovi infrastrukturi. Ideja ni bila prav dobro sprejeta, ker so se pojavili dvomi o zaščiti zasebnosti. Poskus, da bi Mobitel omogočil individualiziran pristop do shranjenih slik in podprl še druge e-storitve za svoj stranke je bil preveč vizionarski za tedanje razmere.

V HSL smo se leta 1998-1999 reorganizirali v privatno delniško družbo z namenom, da se pripravimo na vstop na NASDAQ leta 2004. V ta namen smo organizirali ugleden nadzorni svet z mednarodno priznanimi, uglednimi posamezniki kot je bil na primer Joel Birnbaum, oče RISC procesorja, vodilni znanstvenik v HP in direktor HPLabs, in dr. Zvonko Fazarinc. Podjetje smo leta 2000 dokapitalizirali z 10M EUR za 18% solastniškega deleža uglednih novih solastnikov HP, EBRD, Charlemagne Capital, NLB in Triglav. Namen je bil dvigniti verodostojnost podjetja za nastop na največji tehnološki borzi na svetu in pridobiti nove stranke kjer so imeli novi lastniki vpliv. Vse to smo počeli kot pionirji, saj v Sloveniji takega poslovnega dejanja še ni bilo. Prav pomanjkanje prakse in izkušenj pi sklepanju delniških pogodb nas je, takratne lastnike, ob prodaji podjetja drago stalo.

Poleg podjetja HP smo našli še druge velike kupce naših storitv. Za podjetje Softlab iz Muenchna smo na primer opravili preverjanje celotne izvorne kode za Y2K problem njihovega ogromnega AMADEUS rezervacijskega sistema za potniški letalski promet. Zaradi velikosti sistema smo za nalizo izdelali specializirano programsko opremo z našimi najboljšimi strokovnjaki.

Nova stranka je postalo tudi rent-a-car podjetje SIXT. Zanj smo razvili veliko aplikacij vključno z eno prvih prodaj rabljenih avtomobilov na internetu. Slovensko podjetje RESULT še dandanašnji opravlja razvojno in vzdrževalno delo za njihove IT potrebe.

V letu 2000 je HSL kupil podjetje ZASLON, ki je izdelalo takrat najbolj napredno aplikacijo za mobilno bančništvo. Iz te zasnove so nastale danes poznane aplikacije kot sta NLB Klik in Proklik ter SKB Net in še vrsta drugih.

Potem je prišla kriza celotne informacijske in telekomunikacijske industrije konec leta 2000. NASDAQ indeks je dramatično padel. IPO trg je povsem zamrl. Leta 2004 nismo dosegli predvidene vrednosti na borznem trgu, čeprav smo rasli in leta 2002 presegli 42M EUR prihodkov in preko 700 zaposlenih.

Podjetje sem vodil kot direktor do leta 2002, ko sem odstopil, ker nisem sprejel ultimata finančnih investitorjev, da takoj odpustimo 50% zaposlenih in maksimiramo dobiček. Domače banke niso sprejele mojih predlogov, da financirajo 14M EUR, s katerimi bi izplačali neizprosne finančne vlagatelje in ohranili podjetje v slovenski lasti.

V podjetju sem nadaljeval delo kot svetovalec v prodaji in bil vpet v (neuspešen) projekt za DURS leta 2008 kjer smo na javnem razpisu kljub daleč najboljši ponubi izgubili proti navezi SAP/IBM. Velika zamujena prilika, da bi v Sloveniji razvili izdelek vreden vsaj 20M EUR in ga tržili po svetu drugim državam. Zadnji večji (tudi neuspešen) poskus je bil javni razpis za informacijski sistem nove pediatrične klinike leta 2009. Na njem je zmagal Marand. Poskus poeenotenja informacijskih sistemov v slovenskih bolnišnicah je bil tako uspešno preprečen in še dandanašnji ostal nerešen.

V podjetju, ki ga je leta 2008 kupil srbski podjetnik Veselin Jevrosimović za 35M EUR pretežno financiranim s kreditom italijanske banke. Podjetje je izgubilo svojo indentiteto s popolno integracijo v Comtrade oktobra leta 2012. Organizacijsko in upravljalsko je ostalo praktično nespremenjeno s povdarkom na širitvi dejavnosti izdelave in prodaje lastnih izdelkov. Ocenjujem, da je podjetje v prvih 20 letih izvozilo vsaj za 500M EUR programske opreme.

Sedaj posvečam svoje delo poskusom, da bi v svetu uveljavili večstranski pobot kot pomoč pri reševanju vse večje notranje zadolženosti v mnogih državah sveta. To bi bil pravi, globalno potreben in pozitiven prispevek matematike in računalniške tehnologije k reševanju dolžniške krize na globalni ravni.

LITERATURA

[1] Podjetnik: Rudi Bric - izvoznik domače pameti (podjetnik.si)

Dosežki kandidata M. Gamsa

Achievements of the candidate M. Gams

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POVZETEK

V prispevku so opisani dosežki avtorja v smislu zgodovine in v smislu kandidature za "Dvorano slavnih slovenskega računalništva in informatike".

KLJUČNE BESEDE

Doživljenjski dosežki, znanost, gospodarstvo, slovarji, družbeno delo

ABSTRACT

Life achievements of the author are presented in several areas from science to industry, dictionaries and public work as part of historical autobiographical achievements and also as candidacy for the "Hall of the fame of Slovenian computer science and informatics".

KEYWORDS

Life achievements, science, industry, dictionaries, relevancy

writing in Slovene, add English keywords below the Slovene ones, keyword, keyword, keyword

1 UVOD

V letu 2021 smo izvedli konferenco oz. dogodek »Pionirji računalništva in informatike« v okviru multikonferenca Informacijska družba [1]. Takrat se je porodila tudi zamisel o Galeriji ali Dvorani slavnih, tj. »Hall of fame«. V svetu obstajajo podobni mehanizmi tako za športnike kot za druga področja. Osnovna zamisel je, da strokovnjaki s področja mimo ideologije in politike, ki vse preradi sodelujeta pri priznavanju dosežkov všečnih posameznikov, sami povemo, kateri posamezniki so v resnici dosegli zelo pomembne dosežke. Poglejmo samo Alana Turinga [1], ki danes velja za računalniškega Einsteina, in njegovo ime nosi poglavitna računalniška nagrada [1], pa je bil obsojen za neko malenkost in je namesto priznanj ali nagrade v procesu prevzgoje leta 1954 ugasnil svečko. Kljub težavam pri zagonu je motiv jasen: pomembni slovenski računalniški ali informacijski strokovnjaki naj svoje dosežke za zgodovino opišejo v obliki referatov, priznanje stroke pa naj se manifestira na omenjeni način. Zakaj ne bi računalništvo imelo mehanizmov drugih pomembnih ustaljenih področjih? Se pa še spotoma učimo in denimo - razmišlja se o konkretni izvedbi konference/mehanizma naprej v bodočnost.

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2 Pedagoški dosežki

Povprečna pedagoška obremenitev od doktorata dalje je 3-4 ure predavanj tedensko, zadnja leta po nekaj dni na semester. Je dolgoletni zunanji sodelavec FRI - Fakultete za računalništvo in informatiko, kjer je bil asistent pri okoli 10 predmetih. Po docenturi je poučeval na dodiplomski stopnji na Pedagoški fakulteti in Fakulteti za družbene vede ter na podiplomski stopnji na Ekonomski fakulteti. Sodeloval je tudi pri izvajanju tretjestopenjskega študija v Vojvodini, na Hrvaškem in v Nemčiji leta 2002. Izvedel je tudi več vabljenih predavanj na tujih inštitucijah. Sodeluje pri mentoriranju in ocenjevanju doktorskih, magistrskih in diplomskih del na ljubljanski, mariborski univerzi in MPŠ. Kot mentor ali komentor je sodeloval pri 12 magisterijih, kot mentor 10 doktorandom in bil komentor pri 7 doktoratih.
Bil je tudi zunanji izvajalec za Novomeško visoko šolo, kjer je tudi poučeval več predmetov. V Kopru je sodeloval z dvema pedagoškima inštitucijama - za management in pomorstvo.
Skupno je aktivno poučeval na 14 pedagoških inštitucijah, na nekaj računalniških tečajih itd. [1]:

1. Fakulteta za računalništvo in informatiko, Ljubljana,
2. Ekonomska fakulteta, Ljubljana,
3. Evropsko središče, Maribor,
4. Filozofska fakulteta, Ljubljana,
5. Fakulteta za družbene vede, Ljubljana,
6. Pedagoška fakulteta, Ljubljana,
7. Fakulteta za management, Koper,
8. Fakulteta za pomorstvo in promet, Ljubljana / Portorož,
9. University of applied sciences, Zweibrücken, Nemčija,
10. Mednarodna podiplomska šola Jožefa Štefana, Ljubljana,
11. Visoka šola za upravljanje in poslovanje, Novo mesto,
12. Evropsko središče, predhodnik AME, Maribor,
13. Alma Mater Europea, Maribor,

14. Gimnazija Bežigrad, Ljubljana.

Pedagoškega dela je precej manj kot pri rednih profesorjih, npr. pri prof. F. Solini, prof. D. Trčku ali prof. Bratku, je pa kar obsežna za raziskovalca po osnovni usmeritvi, medtem ko je število pedagoških inštitucij, kjer je kandidat predaval, precej nadpovprečno.

3 Raziskovalno-razvojno delo

Kandidat je vodja Odseka za inteligentne sisteme na IJS s preko 30 zaposlenimi, je vrsto let vodil raziskovalno skupino na IJS znotraj programske skupine, ki se izvaja na IJS in FRI. V ocenjevanju leta 2015 je bila skupina ocenjena kot najboljša na svojem področju. Kandidat se ukvarja z raziskavami in razvojem na področju inteligentnih sistemov, inteligentnih agentov, poslovne inteligence, kognitivnih sistemov, informacijske družbe ter računalništva in informatike. Skupni imenovalec je uvedba inteligentnih metod v računalniške sisteme in s tem novih sposobnosti, recimo izboljšano klasifikacijo ali boljšo sposobnost komunikacije. Z uvajanjem tovrstnih sistemov, predvsem inteligentnih agentov, se pospešuje prehod družbe, še posebej slovenske, v informacijsko družbo. S stališča povsem bazičnih znanosti kandidat ocenjuje kot najbolj zanimive raziskave inteligentnosti in zavesti v relaciji človek-stroj. Poglavitna kandidatova teza, začenši z doktoratom, je, da je potrebno sedanje računalniške sisteme bistveno dograditi v smislu t.i. mnogoterega znanja [1] – prepletanja več procesov, ki aktivno interaktirajo med seboj. S tem pridobimo načeloma večjo računsko sposobnost kot s Turingovimi stroji. Nenavadna podobnost te informacijske teorije je s fizikalno teorijo mnogoterih svetov. Prve odmevne raziskave, povezane z doktoratom, pa so bile na področju patologije – kdaj se pri globljem preiskovanju pojavijo slabši rezultati [1]. Poleg raziskav je pomemben prenos znanj v slovenski prostor, kjer je avtor med bolj aktivnimi pisci strokovnih besedil in drugih aktivnosti, ki dvigujejo nivo Slovenije. Primer bi bila strokovna knjiga o kvalitetnem programiranju [1]9]. S tovrstnimi objavami se je spodbujalo računalniška znanja v Sloveniji.

Princip mnogoterega znanja pravi, da je optimalno znanje mnogotero (beseda redundantno ni prava, čeprav je mnogotero znanje običajno precej redundantno), da torej ansambelske metode v strojnem učenju dosegajo boljše rezultate (empirično potrjeno), da skupina ljudi bolje deluje kot posameznik, itd. Ta princip je v navideznem nasprotju z Ockhamovim principom, ki pravi, da je optimalno porezati vse redundantno. Za dobre rezultate pa je potrebno smotrno sestaviti skupno znanje več modelov znanja, ki so čim bolj kvalitetni in čim bolj različni. Nekaj zaključkov je precej nenavadnih: skoraj vedno obstaja več enot, recimo več planetov ali več galaksij / vesolij. Ali ta, da ni mogoče doseči prave inteligence z obstoječo računalniško arhitekturo, ker je premalo mnogotera. Morda omogoča simulacije mnogoterosti, vendar najbrž preveč težko. Paradoks pa pravi, da lahko mnogotere modele združimo v enega, a to je v dinamičnem svetu zahtevna naloga; lažje je v stacionarnem.

Zadnja leta se aktivno ukvarja s študijem človeške civilizacije – katere nevarnosti grozijo in kaj je potrebno narediti, da se nevarnostim izognemo. Poglavitne nevarnosti so: jedrska vojna (ni analize), umetna inteligenca, demografija, družbeni propad, biološki agenti, torej je kar precej nevarnosti našlo pot v analize in objave kandidata. Demografija je, podobno kot misli Elon Musk, med najnevarnejšimi in najbolj urgentnimi. Po desetletjih, ko je grozila prevelika rast, sedaj grozi prevelik upad in posledično v nekaj sto letih izumrtje malih evropskih narodov. Slovenski avtohtoni narodi kot Slovenci ali Hrvati naj bi po projekcijah izumrli v 200 letih, če ne bo prišlo do pomembnih sprememb. Analize tudi pokažejo, kaj je potrebno narediti: ojačati mehanizem družine in še marsikaj drugega. Pri študiju COVID-19 je bilo doseženo drugo mesto (vodja ekipe Mitja Luštrek, kandidat predlagal nekaj novih algoritmov) in nagrada 250.000$ v XPRIZE tekmovanju. Analize pokažejo, da umetna inteligenca dosega 20% boljše rezultate pri krotenju pandemij, a hkrati se je izkazalo, da je ljudje (politiki, zdravniki) nočejo uporabljali, čeprav smo sistem zastonj ponudili EU ministrstvom. Pri družbenem propadu se je izkazalo, da ob stagnaciji oz. propadu civilizacij istočasno prihaja do napetosti v družbi, medsebojnemu sovraštvu, idej, ki nimajo stika z realnostjo oz. produktivnimi odnosi. To se v precejšnji meri kaže v sodobni družbi, recept za umiritev razmer pa je jasen. Obsežne analize na osnovi Drakove enačbe kažejo, da bomo ljudje slej ko prej izumrli, če ne bomo osvojili presenetljivo veliko drugih planetov. Po svoje je to logično, vendar je zanimivo, da formalne analize matematičnih modelov, temelječe na opazovanjih naše galaksije, kažejo tako. Torej preprosto povedano: človeštvo mora stremeti k temu, da gre na Mars in izven našega osončja, hkrati mora umiriti medsebojne konflikte, izrojene ideje in z uravnavanjem rojstev preko sistema družine in sorodnih ukrepov doseči trajnostjo rast oz. skrb za okolje. Znanstvene analize umetne inteligence in zdrava pamet kažeta enako.

4 Objave

Bibliografija dr. Gamsa [1]10] zajema čez 1600 postavk v COBISSU, od tega 157 objav v 1.01, skupaj s v zbornikih konferenc in knjigami preko 900 objav. Nekatere objave so v najkvalitetnejših tujih revijah s področja računalništva in informatike [1]11]. Vseh citatov je po Google scholarju čez 4500, medtem ko je tam h-indeks 32, na internetu najdemo preko 40.000 omemb. Je soavtor 8 patentov oz. vlog. V rubriki 1.04 Professional article in 1.05 Popular article je 290 vnosov.

Pri objavah je kar nekaj raziskovalcev z višjim h-indeksom v računalništvu, recimo Sašo Džeroski ali Ivan Bratko. Po številu vseh objav in po številu vseh vnosov v Cobiss pa kandidat dosega enega najboljših rezultatov v računalništvu in informatiki v Sloveniji, prav tako po številu omenjanj na spletu. Podobno po številu poljudnih objav, kjer izstopajo redni komentatorji kot Žiga Turk, pa tudi Denis Trček ima precej zanimivih objav. Pri pedagoških knjigah po številu izjav verjetno izstopata Ivan Bratko in Vladislav Rajkovič, po največjem številu izvodov v tujini Ivan Bratko. Po branjih poljudnih člankov je kandidat verjetno med odličnimi, saj je v povprečju prispevek bran/klikan okoli 10.000-krat, rekord pa je okoli 200.000 klikov prispevka.

5 Uredniško

Je vodja in sodelavec večjega števila domačih in mednarodnih raziskovalnih projektov, skupno nekaj sto. Je član več društev (ACM, ECCAI, IEEE) in uredniških odborov mednarodnih revij, skupno se jih je nabralo okoli 15. Največ energije nameni slovenski mednarodni reviji Informatica [1]12] kot izvršni kontaktni urednik revije od leta 2017 dalje, prej pa vrsto leto pridruženi izvršni urednik, kjer je po uredniškem stažu drugi za prof. Železnikarjem. Vsako leto je v povprečju član okoli deset organizacijskih odborov konferenc, med drugimi tudi svetovno najbolj slovečih kot IJCAI ali AAAI. Je desetletja glavni organizator tradicionalne konference Informacijska družba, ene največjih te vrste v Evropi z nekaj sto letnimi prispevki in podelitvami nagrad Michie-Turing.

6 Organizacijsko

Soustanovil je društvo za umetno inteligenco, društvo za kognitivne znanosti, društvo ACM Slovenija, društvo za tehniško-naravoslovne vede SATENO in inženirsko akademijo IAS. V letih 1996–2004 je bil pomočnik vodje Odseka za računalniške sisteme na Institutu "Jožef Stefan" (IJS); 2004– vodja Odseka za inteligentne sisteme na IJS; 2009–2011, član nacionalnega Programskega sveta CRP; član UO IJS, večkrat predsednik Elektronike na IJS in član Znanstvenega sveta IJS. 2008-2012 (pod)predsednik društva ACM Slovenija; soustanovitelj in 11 let tajnik društva SATENA in tedanje IAS; 2010 in 2x po 4 leta predsednik konference SVIZ za fakultete in inštitute; podpredsednik SVIZ s 40 000 člani; soustanovitelj in predsednik več društev, med drugim Društva za kognitivne znanosti, Društva za umetno inteligenco in ACM Slovenija. Član več nacionalnih svetov, med drugim Nacionalnega sveta za znanost in tehnologije. Bil predstavnik v evropski zvezi za umetno inteligenco EurAI, sedaj predstavnik v IFIP Technical Committee 12. Trenutno poskušamo ustanoviti svetovno združenje za umetno inteligenco. Od leta 2018 dalje Državni svetnik za raziskovalno dejavnost, kjer je dosegel za znanost in visoko šolstvo zelo pomembne rezultate, recimo preprečil sprejem slabih verzij raziskovalnega zakona in podprl sprejem sedanje dobre verzije. Moto je bil in je : Več znanosti v politiko in manj politike v znanosti.

V letih 2000 in 2001 je dr. Gams postal član Programskega sveta za informatizacijo šolstva in član Strateškega sveta za informacijsko družbo, ki ga je ustanovil dr. Drnovšek. V tem obdobju so bili postavljeni temelji slovenske informacijske družbe. Bil je tudi član več nacionalnih svetov, med drugim član strateškega Sveta za znanost in tehnologijo Slovenije. Med bojem za osamosvojitev Slovenije med drugim organiziral dopis v Sobotni prilogi Dela za vse inštitute, ki se je pojavil hkrati z dopisom Univerze in cerkvenih predstavnikov. V sindikatu SVIZ si je kot predsednik konference visokega šolstva in znanosti aktivno prizadeval za izenačitev pedagoških in raziskovalnih poklicev z zdravniškimi, ter s tem doseči primeren status in dohodke v obeh sferah. V času pritiskov na fakultete in inštitute smo z analizo objav po Šanghajski študiji pokazali, da so slovenske inštitucije od univerz do inštitutov v svetovnem vrhu, če upoštevamo rezultate na zaposlenega (ali glede na GDP), ne pa absolutno. Podobno smo ob kritikah visokega znanja z nekaj analizami in objavami pokazali, da je visoko znanje (visoko šolstvo, znanost, patenti, delež v izvozu) med najpomembnejšimi relacijami z GDP države.

Po položaju izstopajo Peter Tancig kot minister ali Cene Bavec kot državni sekretar, kljub temu je kandidat med najbolj vplivnimi pri sprejemanju zakonov in promociji informacijske družbe ter zagovarjanju znanosti in visokega šolstva, hkrati je ustanovil največ ključnih računalniških in informacijskih društev ter drugo nacionalno akademijo IAS. Po številu mandatov v društvih morda izstopa Niko Schlamberger, po društveni aktivnosti po širini najbrž kandidat.

7 Gospodarstvo

Izpeljal cca 10 aplikacij na svetovnem nivoju, kjer so po nekih rezultatih presegali konkurenčne. Zaposlovalni agent na internetu, ki je govoril slovensko in angleško, je dosegel peto najbolj brano mesto med slovenskimi na spletu, je prvi na svetu v katerikoli državi nudil prek 90% vseh nacionalnih prostih delovnih mest preko spleta. Z ekipo razvil cca 300 inteligentnih asistentov za razne naročnike. Prvi razvili sistem TTS za slovenski jezik »Govorec«, kjer je sodeloval tudi Jure Leskovec. V letu 2000 dan v prosto uporabo vsem slepim in slabovidnim Slovenije. Sistem pri železarni Jesenice je prek kvalitete oljne emulzije skoraj desetletje nadziral kvaliteto površine pri produkciji 100.000 t jekla letno, tj. praktično vso proizvodnjo v Sloveniji. Vpeljava inteligentnega sistema VIDA za DURS, za svetovanje v slovenščini pri izpolnjevanju davčnih napovedi. Za Lotrič razvit nadzor hladilnih naprav, v celoti cca 100 prototipov, od katerih so se nekateri uporabljali leta oz. največ kakšno desetletje.

8 Slovenski jezik

Skupaj z nekaj deset sodelavci s cele Slovenije, zlasti pa z dvema sodelavcema FRI, dr. Kodekom in dr. Vilfanom, je sodeloval pri izdaji Računalniškega slovarčka, prvega leta 1985 [1]13], Leksikona "Računalništvo" in Velikega leksikona Cankarjeve založbe. S ponatisi in razširjenimi izdajami so v skupni nakladi okoli 50.000 izvodov postavili temelje slovenskega računalniškega izrazoslovja. Sedaj je računalniški slovarček z 12.000 izrazi največja zbirka angleško-slovenskih izrazov v obliki Wiki slovarčka http://dis-slovarcek.ijs.si/. Pri slovarjih in leksikonih je v tej kategoriji verjetno na prvem mestu, še danes je ključni urednik spletnega Računalniškega slovarčka, največjega nabora slovensko-angleških terminov iz računalništva in informatike.

9 Tekmovanja

Prvo mesto na svetovnem tekmovanju EvAAL v 2013; 2014, uvrstitev med prvih 10 na tekmovanju Tricorder z nagradnim skladom 10 milijonov $; nekaj prvih nagrad; 2009, 1. nagrada na Forumu inovacij, 1. in 2. mesto na tekmovanju Sussex-Huawei, 2. mesto na tekmovanju XPRIZE za kovid ukrepe in nagrado 250.000 $. 6 zmag od 10 udeležb na svetovnih tekmovanjih, nikoli slabše kot četrto mesto. Po uspehih na tekmovanjih v zadnjih letih se le nekaj laboratorijev na svetu lahko kosa oz. je boljše kot kandidatov.

10 Zaključek

Na vsakem področju posamezno so marsikje odlični posamezniki, ki so tam dosegli več kot kandidat, ponekod celo precej več, zato je nekaj posameznikov navedenih. Najbrž so doseženi rezultati kandidata zanimivi predvsem kot integralna aktivnost v vseh omenjenih področjih. Po tem kriteriju je najbrž malo posameznikov v Sloveniji s podobnimi dosežki. Značilna je tudi izvirnost novih tez, ki marsikje naleti na odpor, kar pa je bil najpogostejši odnos do marsikaterega misleca v zgodovini. Vprašanje seveda je, kako se bodo omenjenih dosežkov spominjale naslednje generacije in ali bodo omenjeni dosežki dejansko vplivali na razvoj človeške civilizacije. Trenutne analize kažejo, da je najbolj verjetna življenjska doba človeške civilizacije med 1.000 do 10.000 leti, ker kljub starosti naše galaksije 4.6 milijarde let ni nobenega sledu o obstoječi civilizaciji ali civilizaciji, ki bi za seboj pustila kakšno sled. Verjetnost, da smo prva civilizacija v galaksiji, je minorna, verjetnost povprečnega preživetja civilizacije kot ocenjeno. Zato je za dolgoročno preživetje ključnega pomena, da gremo na Mars in nato na druga osončja. Temu bi moralo človeštvo posvetiti osrednjo pozornost in se izogniti stranpotem.

Najpomembnejše odkritje je verjetno princip mnogoterega znanja, ki preprosto povedano pravi, da je več virov/modelov znanja, pametno kombiniranih skupaj, bolje kot najboljši posamezni vir/model. Princip je v navideznem konfliktu z Ockhamovim rezilom (britvijo) in tudi paradoksom mnogoterega znanja, omogoča pa razumevanje, zakaj so ljudje bolj inteligentni kot računalniki in zakaj tega konflikta v resnici ni. Inherentno ta princip uporabljajo tako nevronske mreže kot ansambelski učni algoritmi.

ZAHVALA

V prvi vrsti bi se zahvalil mentorju prof. dr. Ivanu Bratku, pa tudi nekaj 10 profesorjem in raziskovalcem iz njegove generacije. Vsi so pomembno vplivali na moj razvoj. Nato bi se zahvalil vsem sodelavcem, predvsem na Institutu »Jožef Stefan« ter vsem sodelavcem z drugih inštitucij, tako akademskih kot iz gospodarstva.

REFERENCES

[1] Multikonferenca Informacijska družba, https://is.ijs.si/
[2] Hodges, A. 2014. Alan Turing: The Enigma. Princeton University Press.
[3] Gams, M. 2021. ACM Turing Award for 2020 Honors Alfred Vaino Aho and Jeffrey David Ullman, Informatica, vol. 45, no. 5, Editorial. https://www.informatica.si/index.php/informatica/issue/view/226/showToc
[4] Domača stran M. Gamsa: https://dis.ijs.si/mezi/
[5] Gams, M. 2001. Weak intelligence: through the principle and paradox of multiple knowledge, (Advances in computation, vol. 6). Huntington: Nova Science.
[6] Gams, M. 1988. Principi poenostavljanja v sistemih za avtomatsko učenje : disertacija. Ljubljana.
[7] Luštrek, M., Gams, M., Bratko,I. 2006. Is real-valued minimax pathological?. Artificial intelligence, ISSN 0004-3702, vol. 170, str. 620-642.
[8] Bratko, I., Gams, M. 1982. Error analysis of the minimax principle. V: CLARKE, M.R.B. (ur.). Advances in computer chess. 3, (Pregamon chess series). Oxford [etc.]: Pergamon Press, vol. 3, str. 1-15.
[9] Matjaž Gams, M., Kos, B., (illustrator) 1985. Osnove dobrega programiranja : metode, tehnike, principi. Ljubljana: Cankarjeva založba.
[10] Literatura M. Gamsa v COBISSU: http://izumbib.izum.si/bibliografije/Y20220905175100-08501.html
[11] Gjoreski, Martin, Janko, Vito, Slapničar, Gašper, Mlakar, Miha, Reščič, Nina, Bizjak, Jani, Drobnič, Vid, Marinko, Matej, Mlakar, Nejc, Luštrek, Mitja, Gams, Matjaž. Classical and deep learning methods for recognizing human activities and modes of transportation with smartphone sensors. Information fusion, ISSN 1566-2535, 2020, vol. 62, str. 47-62, doi: 10.1016/j.inffus.2020.04.004.
[12] Revija Informatica, https://www.informatica.si/index.php/informatica
[13] GAMS, Matjaž (Author, Editor), JAKOPIN, Primož, KANIČ, Ivan, KODEK, Dušan, MOHAR, Bojan, VILFAN, Boštjan, DIVJAK, Saša, RAPOŠA, Kazimir (Editor). Računalniški slovarček : angleško-slovenski, slovensko-angleški. Ljubljana: Cankarjeva založba, 1985. 226 str. [COBISS.SI-ID 15631617]

Opis dosežkov Tomaža Gornika

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1 UVOD

V nadaljevanju so opisani moji dosežki kot podlaga kandidature za "Dvorano slavnih slovenskega računalništva in informatike". Zadnjih štiridesetih letih se večinoma ukvarjam s tem področjem, najprej kot srednješolski zanesenjak in tekmovalec na republiških tekmovanjih, nato študent zatem pa vodja razvoja, podjetnik in lastnik podjetij, ki razvijajo programsko opremo. V nadaljevanju sledi kratek povzetek ključnih mejnikov te zgodovine.

2 PODJETJE MARAND

1990-1999
Proti koncu študija računalništva in informatike na ljubljanski FRI sem leta 1989 soustanovil podjetje Marand. V začetnem obdobju sem skrbel za prodajo programske opreme, kjer smo kot prvi v takratni Jugoslaviji tržili cenovno dostopno programsko opremo predvsem podjetja Borland. Kot zanimivost naj povem, da smo ob predstavitvi novih različic Quattro Pro in Paradox leta 1991 napolnili Galusovo dvorano. Uspeli smo legalizirati veliko kopirane programske opreme in uvesti Quattro Pro v slovensko šolstvo.

Zatem sem v podjetju prevzel vodenje razvoja programske opreme. Začeli smo z razvojem zdravstvenih informacijskih sistemov za potrebe bolnišnic, takrat predvsem onkološnega inštituta v Ljubljani. Med prvimi smo v zdravstvu uporabili nove ahitekturne pristope in tehnologije kot so odjemalec-strežnik (1993), relacijske baze podatkov (1993), javanski programski jezik (1997), tro-slojno arhitekturo (1998), popolnoma spletne uporabniške vmesnike (2000). Slednja aplikacija, Webdoctor, je na onkološkem inštitutu v uporabi še danes.

S širitvijo interneta sredi 90 let smo začeli sodelovati s ponudniki tovrstnih storitev v Sloveniji (SiOL) in na Hrvaškem (HiNET) za katere smo razvili sistem za upravljanje s strankami (CRM) in obračun storitev. V nadaljevanju smo razvili ter integrirali vrsto storitev za ponudnike vsebin (Mobitel: glasovno pošto, orodja za konfiguracijo glasovnih storitev - IVR, mVstopnica, video portali, mobilno plačevanje na Petrolu, STA in Siol: uredniški sistem za portale). Pri tem smo uporabili nove pristope kot je bil VoiceXML in nato rešitev preko podjetja HP prodali operaterjem Megafon (Rusija) ter Etisalat in DU (Dubaj).

2000-2010
V začetku novega tisočletja smo s pomočjo ljubljanske FRI razvili in uvedli metodologijo razvoja aplikacij Marand Application Framework (MAF) in Marand Agile Process (MAP). S tem smo poenotili in predvsem pospešili razvoj kompleksnih aplikacij.

Prav tako smo razširili sodelovanje s Telekomom Slovenije. Postavili smo sodobno centralno informacijsko infrastrukturo, ki je temeljila na modularnosti, aplikacijskih strežnikih, orodjih za upravljanje poslovnih procesov (BPM) in podatkovnih skladiščih. Razvili smo ključne modularne komponente, kjer so bili podatki in programska koda združeni okoli ključne entitete (Poslovni Partner, Zahtevki, Pogodbe, Storitve, Stiki), Komponente smo nato povezali z BPM platformo s katero smo integrirali tudi več kot deset drugih ključnih sistemov (regletna knjiga, finanančni sistem SAP, obračunski sistem, ipd). Sistem je vseboval 700 različnih procesov s katerimi je 1,500 uporabnikov zagotavljalo podporo 1,2M strank. Takšno storitveno usmerjeno (SOA) arhitekturo Telekom uporablja še danes.

Vedno smo strmeli k inovativnim pristopom, ki poskušajo neko področje standardizirati ter zagotoviti ponovno uporabo že razvitih komponent. Zato smo se velikokrat pridružili organizacijam kot je naprimer Telemanagement Forum. Vsled sodelovanja s TMF je le ta za obračun storitev kot standard sprejel podatkovni model, ki smo ga razvili v podjetju Marand.

Po zagotovitvi ključnih komponent smo se na podlagi omenjenega podatkovnega modela lotili še obračuna storitev. Kot zamenjavo za staro, tujo rešitev smo razvili popolnoma nov obračunski sistem, ki je temeljil na porazdeljeni arhitekturi, orodjih za poslovna pravila (BRMS) in procesiranju v pomilniku. Sistem se je pokazal kot izjemno zmogljiv, saj je več kot 1M faktur iz 100M zapisov o klicih za posamezen mesec pripravil v manj kot štirih urah. Tudi ta sistem je v uporabi še danes, po več kot 15 letih.

Hkrati z aplikacijami za podporo ponudnikom telekomunikacijskih storitev smo naprej razvijali tudi informacijske sisteme na področju zdravstva. Pri tem naj omenim nacionalne projekte kot so register raka ter preventivne

programe za rak materničnega vratu (ZORA) in rak dojk (DORA), ter zaledni sistem za preverjanje zavarovanja pacientov ZZZS OnLine.

Tretje področje je bilo zavarovalništvo. Za Zavarovalnico Triglav smo zagotovili sistem za obračun premij in depozitov naložbeno življenskega zavarovanja. Tudi to sodelovanje še vedno traja, že skoraj 20 let.

Omeniti velja še, da sem leta 2014 prevzel tudi vodenje podjetja Marand.

2010-2019
Z uspehom na razpisu za nov informacijski sistem pediatrične klinike UKC Ljubljana se je začelo novo obdobje, kjer smo se ponovno osredotočili na zdravstveno informatiko. Zagrabili smo priložnost in razvili popolnoma nov sistem, ki je temeljil na platformi za upravljanje podatkov v odprtem formatu openEHR.

Sistem smo dograjevali in razmišljali o prodoru v tujino. Konkurenca na področju EHR (electronic health record) sistemov je izredna, uvedba zahteva tudi veliko storitev prilagoditve in integracije. Kot majhno podjetje na tujih trgih ne bi uspeli zagotavljati tovrstnih storitev, zato smo se odločili, da se osredotočimo na dve ključni komponenti EHR sistemov - platformo za upravljanje s kliničnimi podatki ter aplikacijo za upravljanje z zdravili.

Hitro smo dosegli prve uspehe,. Največji je bil odločitev mesta Moskve, da vse klinične podatke 10M prebivalcev za 1,000 zdravstvenih inštitucij hrani v naši platformi.

Platformo smo uporabili tudi v Sloveniji, pri projektu Integracijske Hrbtenice, ki je jedrna infrastruktura eZdravja. V njej se hranijo vsi podatki (odpustna pisma, napotnice, recepti, povzetki zdravljenja, cepljenja, ipd), kar je omogočilo, da smo ob nastopu pandemije na nivoju države lahko pravočasno zagotovili SMS obveščanje o rezultatih cepljenja in digitalno zeleno potrdilo za COVID19.

3 PODJETJE BETTER D.O.O.

2019 -
Za podporo ambicijam prodora na tujih trgih smo se morali osredotočiti na zdravstvo. Zato smo leta 2019 razdružili podjetje Marand. Nastalo podjetje Better, ki je v moji lasti, je tako prevzelo razvoj aplikacij za področje zdravstva in se usmerilo predvsem na tuje trge. V letu 2021 smo od 10.6M EUR prihodkov 90% realizirali v tujini, večinoma na razvitih trgih severne Evrope. Tam imamo lastna podjetja (Velika Britanija, Nemčija in Irska) in 20 partnerjev, med njimi ugledna podjetja kot so Accenture, Atos, CGI, EY, NTT Data in T-Systems.

Z obema poduktoma smo v teh letih dosegli lep uspeh:

- platformo uporablja več kot 150 strank v 18 državah, med drugim nacionalni sistemi Slovenije, Walesa, Malte in kmalu Cipra, mesta Moskva in London, ter vrsta uglednih bolnišnic kot so Heidelberg, Charite, Oxford in Christie.
- aplikacijo za upravljanje z zdravili uporablja deset bolnišnic v Veliki Britaniji, regija v Novi Zelandiji, v Sloveniji pa Onkološki Inštutut in UKC Ljubljana.

Bolj pomembno pa je to, da prinašamo nov koncept ločevanja podatkov od aplikacij, ki povečuje innovativnost, razbija monopole in omogoča zdravstvu postopen prehod na nove tehnologije. Pri tem smo vodilni v svetovnem merilu, kar kažejo tudi zgoraj omenjene reference.

Prav tako smo vodilni ponudnik nizko-kodnih (low-code) rešitev specializiranih za področje zdravstva. To je prepoznal tudi Gartner Group in nas uvrstil med inovativna podjetja s tega področja.

Več o podjetju na www.better.care

4 ZAKLJUČEK

Vseskozi skušam uvesti novosti v razvoj aplikativne programske opreme, v zadnjem času predvsem na področju zdravstvene informatike. Nekaj novosti, kjer smo bili pri uvedbi med prvimi (če ne čisto prvi) na svetu:

- popolnoma spletni odjemalec aplikacije za bolnišnice (Webdoctor) leta 2000
- standardni podatkovni model sistema za zaračunavanje telekomunikacisjkih storitev (TMF)
- pristop Postmodern EHR - uvedba inovacijske platforme ob obstoječih (legacy) sistemih
- arhitektura, ki ločuje klinične podatke od aplikacij
- nizkokodna platforma specializirana za zdravstvene aplikacije
- Design sistem za zdravstvene aplikacije

Večina teh inovativnih rešitev je opisana v prispevkih, ki so dostopni tukaj.

Ko pogledam nazaj ugotavljam, da so praktično vsi razviti sistemi še vedno v uporabi pri naročnikih, kar je presentljivo, saj jih je veliko starih skoraj 20 let! Prav vsi temeljijo na (takrat) novih pristopih in konceptih, ki so se skozi obdobje uporabe izkazali za pravilne.

Potrebno je poudariti, da nobenega od teh produktov nisem ustvaril sam. Za največji dosežek štejem dejstvo, da mi je v teh letih uspelo pridobiti okrog 150 sodelavcev, ki jih lahko brez zadržka postavim ob bok najboljšim s tega področja.

LITERATURA

Mednarodne organizacije/Konference/predavanja

Skozi celotno 30 letno kariero sem redno nastopal na številnih konferencah s področja informatike, telekomunikacij in zdravstva. Med njimi so:

- INFOS - programski odbor
- Skladišča Podatkov - organizator (s profesorjem Krisperjem) in programski odbor
- Telemanagement Forum - predavanja
- Dnevi Slovenske Informatike - programski svet, predavatelj
- HealthDay - ustanovitelj, progranski odbor, predavatelj
- openEHR - organizator, programski odbor, predavatelj
- HIMSS (Health Information Management Systems) - predavatelj
- Veterans Affairs ViSTA Conference – predavatelj
- World of Health IT – predavatelj
- HLTH – predavatelj
- ViVE health – predavatelj
- ReWired Health – predavatelj
- Health 2.0 - predavatelj
- eHealth Week – predavatelj
- NHS Digital Academy - predavatelj
- European Connected Health Alliance - predavatelj

Kot vabljeni predavatelj vsako leto pripravim predavanje na podiplomskem študiju Univerity of Toronto, letos tudi na University of Pittsburg. Enako na nekaj slovenskih fakultetah - Medicinski, Ekonomski, FRI.

Še posebej sem ponosen na to, da sem bil pred leti izvoljen za sopredsedujočega upravnemu odboru neprofitne organizacije openEHR International, ki ima sedež na UCL v Londonu. openEHR si že 25 let prizadeva za standardizacijo kliničnih podatkov s ciljem povečanja izmenljivosti in uporabnosti podatkov.

Nagrade

Nekaj nagrad, prejetih za informacijske rešitve:

- Best Innovation at HP Communications WorldBest Innovation at HP Communications World Issued by 2008 HP Communications World, Vienna, Austria · Nov 2008
- Več nagrad za informacijske projekte na Dnevih Slovenske Informatike
- 2014 Best eHealth Solution by EU SME2014 Best eHealth Solution by EU SME Issued by HIMSS/World of Health IT 2014, Nice, France · Apr 2014
- EU SME Instrument Horizon 2020- Maj 2014
- Nominacija DIGITALEUROPE's Future Unicorn Award 2021

Druge vsebine

Better Intro slides
Better Design System: video
Anatomy Mapper Demo video
SNOMED concept linking: video
In-app communication - video
Better Digital Health Platform Whitepaper
Press Release: The Christie goes live with ePROMs patient portal
Press Release: The Christie, the largest cancer trust in Europe adopts Better Platform.
Press Release: Shared care planning solution is deployed across London
Press Release: Better awarded £3.1m for London-wide shared care solution
Press Release: Suffolk and North East Essex ICS work with Better on care planning platform

Presentations/Videos:

- Tomaz Gornik: Better Intro; video, slides
- Ian McNicol, Tomaz Gornik - openEHR intro
- Oliver Heinze, Deputy CIO Heidelberg University Hospital – The HighMed Project
- HiGHmed Symposium: openEHR and FHIR- Friends or Foes?
- John Meredith, Architect NWIS Wales – openEHR Case Study
- Somerset NHS Trust: Building and deploying COVID-19 forms using Better Platform

Articles/Whitepapers:

- DigitalHealthnet: Rethinking the architecture of health IT to unlock potential
- Gartner: Hype Cycle for Healthcare Providers 2020
- EY: How will you design information architecture to unlock the power of data?
- EY: Three essential shifts to build and elevate a smarter health experience
- EY: Connected Health Cloud Placemat
- Open Data Institute: Standards for data and interoperability
- Apperta Foundation: Defining an open Platform
- Apperta Foundation: A Blueprint for a Co-Produced Personal Health Record (CoPHR) Ecosystem
- WHO, ITU: Digital Health Platform Handbook: Building a Digital Information Infrastructure (Infostructure) for Health
- NHS Wales Informatics Service (NWIS): What is openEHR and why is it important?
- Matt Hancock: Speech at Rewired on separating data from applications

Blogs:

To better understand our thinking, please have a look at blog posts on

- Microsoft blog: Supporting openEHR with Azure Health Data Services
- Introducing FHIR Connect
- FHIR + openEHR
- Building a design system for digital solutions in healthcare
- Why openEHR is eating healthcare
- Accelerating innovation in healthcare using low-code development
- Turning healthcare IT architectures inside out
- A transformation architecture for regional health and care systems
- Re-thinking the IT architecture of health and care
- Building better applications faster
- Momentum building for a new approach to EHRs,
- the Postmodern EHR, the enablers, the data layer,
- the feral systems dilema and
- application centric vs. data centric interoperability.

Opis dosežkov Tomaža Kalina

Tomaž Kalin

tomaz@kalin.si

1 UVOD

Tomaž Kalin [1,2], rojen 22.11.1936, je končal diplomski in podiplomski študij na Fakulteti za naravoslovje in tehnologijo. Izpopolnjeval se je na Rensellaer Polytechnic Instiute, Troy, New York kot Fullbrightov štipendist, in nato doktoriral v Ljubljani.

Po diplomi se je zaposlil na Inštitutu "Jožef Stefan" v Ljubljani, kjer je vpeljal računalniško zbiranje eksperimentalnih podatkov.

Skozi to delo je prešel na področje računalništva in nato k računalniškim komunikacijam in mrežam in je delal na RRC (Republiški računalniški center), ki je deloval v okviru Inštituta Jožef Štefan, kot sistemski menažer. Tu je posebej treba omeniti, tudi v širšem okolju, prvo strokovno utemeljeno dogradnjo (takrat velikega) računalnika CYBER tvrdke CDC, ki je potekalo z najeto programsko opremo za simulacijo računalnika. Podatke o bremenu je zbiral eden od perifernih processorjev. Iz teh je bilo zgrajeno sintetično breme, kot vhodni podatek za simulacijo dogradnje. Rezultat je bil presenetljiv: namesto povečanja pomnilnika in perifernih enot je bil predlagan nakup še enega dodatnega računalnika. Upravni odbor RRC je to nekonvencionalno in tvegano rešitev sprejel in se je izkazala kot uspešna.

V letih 1977 / 1978 je bil zaposlen kot pomočnik direktorja projekta COST 11 (European Informatics Network), na National Physical Laboratory, Teddington, Velika Britanija. To je bila prva mednarodna eksperimentalna računalniška mreža sploh. Bazirala je na datagramski infrastrukturi, na višjih nivojih pa na ISO modelu.

Od 1981 do 1984 pa je bil vodja nadaljevalnega projekta COST 11bis, s pisarno v Joint Research Centru (Evropskem skupnem raziskovalnem centru) v Italiji.

Po povratku v Slovenijo, leta 1984, ga je Znanstveni svet inštituta "J.Stefan" imenoval za direktorja inštituta. To funkcijo je opravljal dva mandata, do leta 1992.

Že pred odhodom v Italijo, in vsa leta, ko je bil direktor IJS, je predaval na Fakulteti za elektrotehniko in računalništvo predmete iz področja računalniških komunikacij in mrež, na dodiplomski in podiplomski stopnji. Prvemu podiplomskemu kurzu iz Računalniških komunikacij in mrež, v Sloveniji sploh, so se kasneje pridružili analogni predmeti na dodiplomski stopnji. Pri tem je bil član doktorskih komisij, mentor pri diplomah, magisterijih in doktoratih študentov, ki so pozneje pomembno krojili informacijsko področje v Sloveniji in posebej za razvoj nacionalne akademske mreže, ARNES, zaslužna mgr. M. Bonač in mgr. A.Jauk.

V letu 1992 je postal Generalni sekretar Evropskega združenja akademskih in univerzitetnih računalniških mrež, s sedežem v Amsterdamu s štiriletnim mandatom.

Po vrnitvi v domovino, leta 1996, je najprej pol leta delal kot neodvisen konzultant, nato pa je sprejel vabilo, da se vrne na IJS, kot pomočnik direktorja. To funkcijo je opravljal do konca leta 2000. V tem času je v okviru KORISA sodeloval pri definiciji koncepta novega zakona o raziskovalni dejavnosti in dodelavi tega dokumenta.

Decembra 2000 ga je Vlada republike Slovenije imenovala za državnega sekretarja na Ministrstvu za informacijsko družbo, kjer je bil odgovoren za komunikacijsko infrastrukturo. Tam je s skupino v nekaj mesecih pripravil ZTEL-1, zakon, ki je uskladil slovensko zakonodajo na področju telekomunikacij z evropsko, ki je šla, ob hudem nasprotovanju monopolnega Telekoma Slovenije, radikalno daleč, recimo obveznosti, da nudi operater s pomembno tržno močjo, na razpolago konkurenci, tudi kanale in drogove (kar je imela tedaj le Kanada). Pozneje pa je s sodelavci prenesel v Slovenijo tudi nov zakon o poštnih storitvah, ki je dal podlago za sedanjo konkurenco na tem področju tudi pri nas, v Sloveniji.

Koncem leta 2002 je sprejel, vabilo, da za omejen čas (dve leti) vodi neprofitno organizacijo DANTE, s sedežem v Cambridgeu, ki skrbi za GEANT, evropsko akademsko računalniško infrastrukturo, na katere se vežejo vse nacionalne akademske mreže.

Od septembra 2004 je neodvisen konzultant. Med projekti je vredno omeniti:

- TEIN 2, projekt povezave GEANT s kitajsko raziskovalno informacijsko infrastrukturo, ki ga EU so-financira z okrog 10 MEUR.
- Drugi projekt je svetovanje nemškemu ministrstvu BMBF okrog tehničnih elementu in politike pri

razvoju akademske komunikacijske infrastrukture v Nemčiji.

V času delovanja na področju elektronskih komunikacij je bil član različnih mednarodnih teles in delovnih skupin, kot:

- Information Society Technology Committee (nadzor IST v 5. Okvirrnem programu),
- ONP Committee (Svetovalni organ EC za področje komunikacij), in drugih.
- Je ustanovni član Internet Society (ISOC, Reston Virginia) in je bil dva mandata član njenega Upravnega odbora. In dva mandata podpredsednik.
- Od leta 2009 do 2013 je bil član in podpredsednik Nadzornega sveta Telekoma Slovenije.
- Posebno je ponosen, da je bil član delovne skupine, ki jo je ustanovila Komisija EU, za pripravo pomembnega dokumenta, ki je dokazal nujnost financiranja akademske komunikacijske infrastrukture s strani Komisije EU. Rezultat je organizacija GEANT, ki jo z nekaj dest milijoni letno sofinancira EU.

Brez posebnega olepševanja je mogoče, iz navedenega sklepati, da je Tomaž Kalin pomembno prispeval k razvoju informatike in elektronskih komunikacij v Sloveniji in tudi v širšem okolju.

LITERATURA

[1] Wikipedija https://sl.wikipedia.org/wiki/Toma%C5%BE_Kalin
[2] Splet elektronskih komunikacij https://www.386tele.com/content/view/5102/105/

Evolucija predmeta Računalništvo in informatika v obdobju dveh desetletij

Evolution of course Computer Science and Informatics in two decades

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POVZETEK

Prispevek obravnava evolucijo predmeta Računalništvo in informatika, ki sem ga predaval v obdobju 1998-2021 na Fakulteti za organizacijske vede Univerze v Mariboru tako na visokošolskem kot tudi na univerzitetnem programu. Predmet pa so moji predhodniki razvijali že od leta 1975 dalje, ko je bila formalno potrjena Računalniška usmeritev. Moje obdobje lahko razdelim v štiri faze: a) diskete in CD, b) lokalizacija in enostavne interakcije s sistemom za podporo učenja Moodle, c) integracija Moodle in videokonferenčnega sistema BigBlueButton ter d) oddaljeno namizje in vsebniki. Podane so značilnosti posameznih faz in usmeritve za prihodnost.

KLJUČNE BESEDE

Računalništvo in informatika, predmet, Fakulteta za organizacijske vede

ABSTRACT

The paper presents the evolution of the course Computer Science and Informatics, which I taught in the period 1998-2021 at the Faculty of Organizational Sciences, University of Maribor, both in the higher professional education and university programs. The course was developed by my predecessors from 1975 onwards, when the major study in Computer Science was formally approved. Personally, I see my teaching in four phases: a) floppy disks and CDs, b) localization and simple interactions with the Moodle learning management system, c) integration of Moodle and the BigBlueButton videoconferencing system, and d) remote desktop and virtualization. The characteristics of these phases and directions for the future are presented.

KEYWORDS

Computer Science and Informatics, course, Faculty of Organizational Sciences

*Article Title Footnote needs to be captured as Title Note
†Author Footnote to be captured as Author Note

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1 UVOD

Predmet z nazivom Računalništvo in informatika na Fakulteti za organizacijske vede Univerze Maribor ima začetke v letu 1975, ko so na takratni Visoki šoli za organizacijo dela v Kranju dobili dovoljenje za izvajanje študijske smeri, ki se je imenovala Računalniška usmeritev. Leta 1979, ko sem postal študent, je bil moj profesor Saša Dekleva. Starejša študenta Igor Korelič in Bojan Peček sta sodelovala pri izvedbi vaj, ki so potekale na Deltinem (PDP-11) računalniku z večuporabniškim operacijskim sistemom RSX-11M. Zaganjali smo programski jezik Basic, pa Datatrieve-11. S slednjim smo lahko definirali zapise in poizvedovali po podatkih. Po odhodu profesorja Dekleve v ZDA je predmet prevzel profesor Miro Gradišar. Pri vajah sta mu pomagala Polde Podlogar in Jožef Langerholz. Profesor Gradišar je napisal imeniten učbenik za predmet Računalništvo in informatika, ki so ga uporabljali med drugim tudi na Ekonomski fakulteti Univerze v Ljubljani. Tja se je okoli leta 1998 tudi prezaposlil. Ko mi je bil ponujen predmet Računalništvo in informatika, sem ga z velikim veseljem tudi prevzel. Bilo je 45 ur predavanj in 45 ur vaj, tako na višješolskem kot tudi na univerzitetnem študiju. Vsebino bi najprimerneje opisal kot uvod v računalništvo in informatiko. Ker je bil to skupni predmet 1. letnika za vse dodiplomske programe (kadrovska, proizvodna in računalniška usmeritev), je seveda obsegal mehkejši nabor z družboslovimi aspekti, nekaj zgodovine in principov v računalništvu, pa seveda praktične vaje s pisarniškimi orodji. Ker sem imel nekaj izkušenj s programskimi jeziki in bazami podatkov, sem to želel vpeljati. Takrat smo uporabljali računalnik VAX 750 in operacijski sistem VAX/VMS, katerega značilnost je bila, da je lahko disk postal dodaten pomnilnik. V računalniških učilnicah so bili osebni računalniki z operacijskim sistemom Windows 95 in Windows NT. Selitev fakultete v nove prostore leta 1999 je omogočila bistveno boljše študijske pogoje in odpirala nove možnosti.

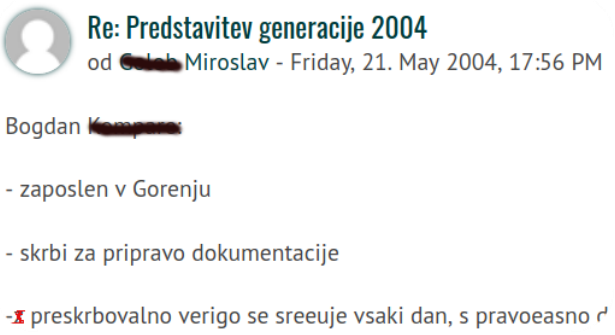
2 DISKETE IN CD (1998-2004)

Čeprav je bila to že doba interneta (na voljo so bili tudi strežniki FTP in HTTP), so se študijski materiali večinoma izmenjevali prek disket in CD. Študentom sem na teh medijih

dal zapiske predavanj v MS Powerpoint in MS Word, videoposnetke in razne programe kot sta prevajalnik GNU C++ in simulator mikroprocesorja SMS32. Slednjega je avtor Neil Bauers leta 2003 sprva kot preskusni program (shareware) naložil na spletno stran https://softwareforeducation.com (od leta 2022 ni več dostopna). Simulator je oponašal delovanje 8-bitnega mikroprocesorja z 256 bajti pomnilka in 6 vhodnimi/izhodnimi napravami. Napisan je bil v Borlandovem Turbo Pascalu (32-bitna verzija), zadnja leta pa je bil licenciran kot GNU GPL. Zato je bila dostopna tudi izvorna koda Omogočal je pisanje v zbirniku podobnem jeziku, izvajanje posameznih ukazov, prikazoval je stanje štirih splošnih in štirih specialnih registrov (v dvojiškem, desetiškem in šestnajstiškem sistemu) kot tudi pomnilnika (ASCII, izvorna koda, šestnajstiška predstavitev ukazov in operandov). Zelo zabavna možnost je bila direktno naslavljanje pomnilnika in spreminjanje vsebine – v izvornem programu je bil npr. ukaz za dodajanje (ADD), nato je ukaz MOV v pomnilniku zamenjal vsebino z šestnajstiško kodo drugea ukaza (npr. SUB). Program je namesto seštevanja izvajal odštevanje. Spreminjanje stanja naprav (npr. 64 znakovnega prikazovalnika, dveh semaforjev, koračnega motorja) je bilo prikazano v posebnih oknih. Ta simulator mikroprocesorja je bil na nek način napoved Interneta stvari in kiberfizičnih sistemov, ki sta se pojavila več kot deset let kasneje. Pomembno mi je bilo, da so študenti lahko "videli" delovanje procesorja in so lahko napisali preprost program v jeziku, ki je podoben zbirniku x86. V tej fazi evolucije predmeta smo poskušali tudi z jezikom C++, vendar so le redki študenti imeli svoj osebni računalnik, še redkejši pa so uspeli namestiti prevajalnik. V generacijah, ki so prihajale, so bile velike razlike v teoretičnem in uporabnem znanju informatike [1]. V naslednjih letih smo s soavtorji še večkrat proučevali ta fenomen. Za boljšo interakcijo s študenti in med študenti sem iskal orodje za celovito pomoč pri izvedbi študijskega procesa.

3 LOKALIZACIJA IN ENOSTAVNE INTERAKCIJE S SISTEMOM ZA PODPORO UČENJA MOODLE (2004-2013)

Moodle 1.3 sem 16.5.2004 namestil na strežnik z operacijskim sistemom Windows in ga testiral s podiplomskimi študenti. Na sliki 1 je prikazan del forumske diskusije, ki je bila namenjena predstavitvi sošolcev (vsak je po kratkem intervjuju predstavil drugega sošolca).



Slika 1: Uporaba foruma v letu 2004

Poleti istega leta sem Moodle prevedel v slovenski jezik in ga dal v splošno uporabo. Po začetnih težavah s kodno tabelo se je sistem za učno podporo Moodle začel širiti v osnovnih in , srednjih šolah. Tudi Univerza v Mariboru ga je okoli leta 2007 prepoznala kot primernega. Moodle smo s skupino podiplomskih študentov okoli leta 2007 še enkrat prevedli in dopolnili (verjetno je bila to verzija 1.7), nato pa so prevajanje prevzeli drugi. V tem obdobju je bil izveden prehod na Linux-ov strežnik (Ubuntu), uvedli smo protokol https, iz fizičnega strežnika prešli na virtualnega. To obdobje karakterizira enostavna interakcija profesor-študent in tudi študent-študent. Vsak študent je dobil uporabniško ime in geslo, s katerim je dostopal do učnih gradiv, sodeloval v klepetalnici in forumu ter oddal rešitev nalog. Čeprav je Moodle zelo hitro vključeval dodatne funkcije, je bila primarna naloga strežnika olajšati dostop do študijskih gradiv ter komuniciranje. Nekaj prvih let je bila silno zanimiva klepetalnica, ki je omogočala celi skupini študentov (nekaj deset) istočasno odzivanje, deljenje izkušenj, reševanje različnih težav pri dostopu do interneta, učnega strežnika in reševanja nalog. Dosežen je bil tudi vsebinski premik pri predmetu Računalništvo in informatika. Poleg prej omenjenega zbirnika in osnov jezika C++ sem vključil še PHP, Tega sem ga ob prevajanju Moodla dobro spoznal (skupaj z bazo podatkov). Rešitve "domačih" nalog so študenti že oddajali na Moodle. Pregledovanje oddanih rešitev je bilo zame zaradi velikih skupin (samo višješolcev je bilo preko sto) vse prej kot zanimivo. Predmet pa je bil v letu 2005 akreditiran v bolonjskem visokošolskem (6 ECTS) in univerzitetnem programu (7 ECTS) Organizacija in management informacijskih sistemov. V prvem letniku je bil obvezni predmet za bruce vseh dodiplomskih programov, fond kontaktnih ur pa se je zmanjšal zaradi varčevanja. Zaradi velikih razlik v predznanju študentov smo to analizirali in objavili v [2], [3], [4] in [5]. V [6] smo poročali tudi o preverjanju znanja s programom Perception in o izkušnjah z Moodlom v [7]. Ob koncu tega obdobja se je Slovenija še vedno ukvarjala s posledicami svetovne gospodarske krize, ki se je pri študentih manifestirala kot poglabljanje razlik med tistimi, ki so imeli na voljo IKT in tistimi, ki so zgolj slišali, da obstaja internet. Po naključju sem leta 2013 dobil v uporabo delovno postajo Supermicro (16 CPU, 24 GB pomnilnika in 1 TB diska) ter jo med počitnicami spremenil v videokonferenčni strežnik. V zadnjih letih tega

obdobja sem vse bolj uporabljal distribucijo Kubuntu tudi na osebnem računalniku, ob seveda prevladujočih oknih. Možnosti odprtokodnih alternativ so me vedno bolj navduševale.

4 INTEGRACIJA Moodle – BigBlueButton IN VIRTUALIZACIJA (2013-2018)

BigBlueButton (kratica BBB) v. 0.8 je tekel na operacijskem sistemu Ubuntu 10. Ker sem imel na voljo dovolj časa in ustrezno strojno opremo (prej navedeno delovno postajo), mi je uspelo videokonferenčni sistem poleti 2013 prenesti na operacijski sistem Ubuntu 12. Verjetno je bila to ena redkih implementacij na tem operacijskem sistemu v svetovnem merilu. Sprva sem BBB zaganjal na fizičnem strežniku, nato pa sem ga virtualiziral v VirtualBox-u. V Moodle (tudi že virtualiziran) sem vstavil vtičnik za videokonferenčni sistem BBB in že je bila odprta možnost za delo na daljavo. Seveda smo pri predmetu Računalništvo in informatika to takoj začeli uporabljati. Ob začetnem navdušenju, da zadeva deluje, pa so se pokazale nove možnosti. Transfer znanja med vrstniki se je izboljšal pri reševanju nalog v C++, Javi in SQL. Kot predavatelj sem lahko na daljavo demonstriral razvoj preprostih programov, delovanje različnih odprtokodnih rešitev na Linux-u. BBB je sprva kot uporabniški vmesnik uporabljal Adobe Flash Player. Ta je povzročal študentom kar nekaj začetnih težav, ko pa so uredili varnostne izjeme, slušalke in mikrofone, je bila omogočena zelo dobra komunikacija profesor-študent in študent-študent. BBB od verzije 2.0 uporablja odjemalca HTML5, kar omogoča tudi enostavno uporabo na vseh mobilnih napravah. V tem obdobju se je del kontaktnih ur (30-49%) pri predmetu Računalništvo in informatika že izvajal preko videokonference. To je bila zame zelo dobra priprava na spremembe pri predavanjih, ki jih je prinesel Covid-19. Analizirali smo uspešnost pri izpitih iz predmeta Računalništvo informatika s posebnim povdarkom na udeležbi študentov na klasičnih in videokonferenčnih predavanjih in vajah [8] in [9]. V tem obdobju sem za študente poleg gradiv na učnem strežniku pripravil tudi virtualiziran stroj z operacijskim sistemom Kubuntu (16.04 in 18.04). Študenti so si na svoje osebne računalnike naložili Virtualbox in nato uvozili pripravljen virtualni stroj. Ta je vseboval: prevajalnik C++, interpreter PHP, Javansko razvojno in izvajalno okolje (JDK in JRE), integrirano razvojno orodje NetBeans (C++, PHP, Java), lokalni spletni strežnik Apache, orodje phpmyadmin in simulator mikroprocesorja SMS32, ki je sicer aplikacija za operacijski sistem Windows. Zato je bil v virtualnem stroju nameščen emulator wine, ki je brez težav pognal datoteko EXE. Za študente sem pripravil tudi portfelj nalog, ki jih je možno rešiti s prej navedenimi orodji (odprtokodna). Glavne težave pri študentov so bile še vedno preskromna strojna oprema njihovih osebnih računalnikov ter tovarniško onemogočena virtualizacija (BIOS ali Windows). To je bil tudi glavni razlog za pripravo strežnika, ki bi omogočal študentom oddaljeno namizje.

5 ODDALJENO NAMIZJE IN VSEBNIKI (2018-2021)

Virtualni stroj, ki so si ga študenti nameščali na lastne osebne računalnike, je zasedel le okoli 10GB, vendar je bila včasih strojna oprema študentov še vedno preskromna. Leta 2018 smo skupaj s sodelavci Centra za informacijske tehnologije sestavili strežnik s 128 GB pomnilnika, 16 CPU /32 niti in 1 TB diska s tehnologijo NVMRAM. Kot hipervozor smo uporabili Proxmox, nanj pa sem namestil virtualni stroj (operacijski sistem Kubuntu 18). Na tem je imel vsak študent svoj uporabniški račun, omogočen oddaljen dostop in grafični uporabniški vmesnik KDE. Za potrebe študijskega procesa pri predmetu Računalništvo in informatika sem namestil C++, Javo, PHP, NetBeans, RStudio, Scilab, KDEnlive, SMS32, wine, GPG, GPA, Apache server, phpmyadmin, LibreOffice in številne druge. Portfelj nalog je bilo možno rešiti z navedenimi orodji zgolj z uporabo varne povezave preko VPN in odjemalca za oddaljeno namizje. Na oddaljenem strežniku je bil nameščen docker OpenProject s povezavo na strežnik LDAP (implementiran kot Linuxov vsebnik na hipervizorju). OpenProject je odprtokodni sistem za vodenje projektov, ki smo ga s skupino dodiplomskih študentov tudi lokalizirali v slovenski jezik. Za študente višjih letnikov sem za njihove razvojne projekte namestil tudi strežnik GitLab. Eden od rezultatov podiplomskega študenta Luka Berganta je simulator mikroprocesorja SMS32, implementiran v razvojnem okolju Lazarus za operacijski sistem Linux. Repozitorij projekta je na strežniku GitLab. S tem je prenesena koda iz leta 2003 v polni meri zasijala na distribuciji Kubuntu brez emulatorja wine.

Predmet trenutno obsega 39 ur predavanj in 24 ur vaj – oboje z aktivnim sodelovanjem preko videokonferenc in delom na oddaljenem namizju ter v računalniški učilnici. Od leta 2018 je na voljo tudi ena učilnica s tankimi odjemalci na platformi Raspberry PI. Vsebinsko predmet ponuja pregled informacijske družbe in digitalnega sveta, zgodovine in definicij v računalništvu in informatiki, pregled strojne, mrežne in programske opreme, seznanitev in delo z operacijskima sistemoma Windows in Linux, osnove programskih jezikov C++ Java in PHP, uvod v objektno programiranje z orodjem Greenfoot. Na vajah študenti delajo tudi s pisarniškimi orodji MS (Word. Powerpoint, Access). Portfeljske naloge zahtevajo uporabo spletnega brskalnika, video urejevalnika, Scilab, R, C++, Jave, PHP, baze mysql in orodja za malokodni razvoj spletnih aplikacij Oracle APEX [10]. Z izjemo slednjega so vsa orodja dostopna na oddaljenem namizju.

6 USMERITVE ZA PRIHODNOST

Zadnje obdobje prav gotovo zaznamuje koncept malokodnega programiranja, ki je že vključeno v študijske vsebine tudi pri predmetu Računalništvo in informatika. Odpirajo se možnosti uporabe oblačne infrastrukture kot storitve. Primer za to je Oracle Cloud Infrastructure. Ta omogoča vsakemu študentu vzpostavitev in zagon arhitekturnih virov: virtualnega omrežja, procesor,

pomnilnik, disk, bazo podatkov, podatkovno analitiko, razvoj in uporabo metod strojnega učenja in umetne intelligence.

Izkustveno in problemsko zasnovano učenje sta ključna za to, da študenti ne ostanejo zgolj kupci, temveč kreatorji novega znanja. Upam, da sem v zadnjih dveh desetletjih čimveč študentom odpiral to možnost tudi z vsebinami predmeta Računalništvo in informatika.

REFERENCES

[1] ZUPAN, Neja, LESKOVAR, Robert. Teoretično in uporabno znanje informatike ob vstopu na fakulteto. V: HERIČKO, Marjan (ur.), et al. Informacijska družba IS'2002 = Information society IS'2002 : zbornik D 5. mednarodne multi-konference, 14. do 18. oktober 2002, Ljubljana, Slovenia. Ljubljana: Institut Jožef Stefan, 2002. Str. 156. ISBN 961-6303-43-0. [COBISS.SI-ID 7506198]

[2] ZUPAN, Neja, LESKOVAR, Robert, MAYER, Janez. Influence of prior knowledge in information science on results at university. V: JAŠKOVÁ, Mária (ur.). *ECON '04 : [selected research papers]*. Ostrava: Technical University of Ostrava, Faculty of Economics, 2004. Str. 426-442. Research works proceedings, Vol. 11, 2004. ISBN 80-248-0674-6. ISSN 0862-7908. [COBISS.SI-ID 4389139]

[3] ZUPAN, Neja, LESKOVAR, Robert, BERNIK, Igor, MAYER, Janez. Znanje informatike visokošolskih študentov ob vstopu na fakulteto. V: RAJKOVIČ, Vladislav (ur.), URBANČIČ, Tanja (ur.), BERNIK, Mojca (ur.). Vzgoja in izobraževanje v informacijski družbi. Kranj: Moderna organizacija, 2004. Str. 500-506, tabele. Organizacija, Letn. 37, 2004, št. 8. ISSN 1318-5454. [COBISS.SI-ID 4179219]

[4] ZUPAN, Neja, LESKOVAR, Robert, BAGGIA, Alenka, MAYER, Janez, BERNIK, Igor. Spremljanje znanja iz informatike ob vstopu na fakulteto. V: *Management, knowledge and EU : proceedings of the 23rd International Conference on Organizational Science Development = Management, znanje in EU : zbornik 23. mednarodne znanstvene konference o razvoju organizacijskih ved, Slovenija, Portorož, 24.-26. marec 2004*. Proceedings of the 23rd International Scientific Conference on organizational Science Development, Slovenia, Portorož, March, 24th-26th 2004. Kranj: Moderna organizacija: = Modern Organization, 2004. Str. 279-287. ISBN 961-232-167-1. [COBISS.SI-ID 4124947]

[5] ZUPAN, Neja, LESKOVAR, Robert, BERNIK, Igor, MAYER, Janez. Znanje informatike visokošolskih študentov ob vstopu na fakulteto. V: RAJKOVIČ, Vladislav (ur.), URBANČIČ, Tanja (ur.), BERNIK, Mojca (ur.). Vzgoja in izobraževanje v informacijski družbi : zbornik referatov = Education in information society : conference proceedings. 7. mednarodna multi-konferenca Informacijska družba IS 2004, 15. oktober 2004, Ljubljana, Slovenija = 7th International Multi-Conference Information Society IS 2004, 15th October, 2004. Ljubljana: Ministrstvo za šolstvo, znanost in šport: Fakulteta za organizacijske vede: Institut Jožef Stefan: Zavod Republike Slovenije za šolstvo, 2004. 6 str., tabele. ISBN 961-6101-21-8. [COBISS.SI-ID 4180243]

[6] ZUPAN, Neja, MAYER, Janez, LESKOVAR, Robert. Elektronsko preverjanje znanja s programom Perception = Electronic testing of students using the Perception software. V: RAJKOVIČ, Vladislav (ur.). Management sprememb : zbornik 25. mednarodne konference o razvoju organizacijskih znanosti, Slovenija, Portorož, 15.-17. marec 2006 = Change management : proceedings of the 25th International Conference on Organizational Science Development, Slovenia, Portorož, March, 15th-17th 2006. Kranj: Moderna organizacija, 2006. Str. 350-362. ISBN 961-232-186-8. [COBISS.SI-ID 4829971]

[7] LESKOVAR, Robert. Podpora izvajanja študija s paketom "Moodle" - izkušnje in perspektive = Studies implementation support using the "moodle" package - experience and perspectives. V: KALUŽA, Jindřich (ur.). *Sinergija metodologij : zbornik 24. mednarodne konference o razvoju organizacijskih znanosti, Slovenija, Portorož, 16.-18. marec 2005 = Synergy of methodologies : proceedings of the 24th International Conference on Organizational Science Development, Slovenia, Portorož, March 16-18, 2005*. Kranj: Moderna organizacija, 2005. Str. 550-557. ISBN 961-232-175-2. [COBISS.SI-ID 4526867]

[8] LESKOVAR, Robert, BAGGIA, Alenka. Udeležba na predavanjih ter uspeh pri opravljanju izpita = Lecture attendance and exam performance. V: DOUCEK, Petr (ur.), NOVAK, Aleš (ur.), PAAPE, Björn (ur.). *Trajnostna organizacija : zbornik 35. mednarodne konference o razvoju organizacijskih znanosti = Sustainable organization : proceedings of the 35th International Conference on Organizational Science Development*. 35. Mednarodna konferenca o razvoju organizacijskih znanosti, Portorož, 16.-18. marec 2016. Kranj: Moderna organizacija, 2016. Str. 490-498. ISBN 978-961-232-285-4. [COBISS.SI-ID 7530003]

[9] LESKOVAR, Robert, BAGGIA, Alenka. Zločin in kazen : udeležba na avditornih in videokonferenčnih predavanjih ter uspešnost reševanja nalog = Crime and punishment : participation in auditoria and videoconference lectures and problem solving performance. V: BERNIK, Mojca (ur.), RAJKOVIČ, Uroš (ur.). *Vzgoja in izobraževanje v informacijski družbi - VIVID 2015 : zbornik referatov = Education in information society : conference proceedings*. 18. mednarodna multikonferenca Informacijska družba IS 2015, 28. in 29. september 2015 = 18th International Multiconference Information Society IS 2015, 28th & 29th September 2015, Ljubljana, Slovenia. Kranj: Fakulteta za organizacijske vede, 2015. Str. 287-296. ISBN 978-961-232-284-7. http://vivid.fov.uni-mb.si/sites/vivid.fov.uni-mb.si/files/VIVID2015-web.pdf. [COBISS.SI-ID 7510035]

[10] BAGGIA, Alenka, MALI, Aljaž, GRLICA, Andrej, LESKOVAR, Robert. Oracle APEX v visokošolskem izobraževanju = Oracle APEX in higher education. V: ARSENIJEVIĆ, Olja (ur.), et al. Organizacija in negotovosti v digitalni dobi : konferenčni zbornik = Organization and uncertainty in the digital age : conference proceedings. 37th International Conference on Organizational Science Development, 21st - 23rd March 2018, Portorož, Slovenia. 1. izd. Maribor: Univerzitetna založba Univerze, 2018. Str. 27-38, ilustr. ISBN 978-961-286-146-9.
http://press.um.si/index.php/ump/catalog/book/326. [COBISS.SI-ID 8000019]

Dosežki kandidata Domna Mongusa

Achievements of the candidate

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POVZETEK

V tem prispevku so predstavljeni dosedanji dosežki kandidata Domna Mongusa na pedagoškem, znanstveno-raziskovalnem in projektnem področju ter področju mednarodne vpetosti. Iz vsebinskega vidika predstavljeni dosežki obsegajo razvoj novih metodologij obdelave podatkov daljinskega zaznavanja, arhitektur podatkovnega zlivanja in metod lokacijske inteligence za razvoja naprednih geografskih informacijskih sistemov.

KLJUČNE BESEDE

Dosežki, znanstveno delo, raziskovalni prispevek, pedagoška aktivnost, izvedeni projekti

ABSTRACT

This paper presents the achievements of Domen Mongus from pedagogical, scientific, research and project perspectives, and in the light of his international involvement. The presented achievements include author's contributions to the development of novel remote sensing data processing methodologies, data fusion architectures and location intelligence methods for the development of advanced geographic information systems.

KEYWORDS

Achievements, scientific work, research contributions, pedagogic activities, completed projects

1 UVOD

Domen Mongus je kandidat za »galerijo slavnih na področju računalništva in informatike«. Njegovo delo obsega pedagoške, znanstveno-raziskovalne in projektne aktivnosti. V nadaljevanju je v kronološkem vrstnem redu podan povzetek najodmevnejših nagrad in priznanj, ki jih je za svoje delo kandidat prej v zadnjih desetih letih:

- 2012 – Nagrada za izjemne znanstvene dosežke, UM-FERI
- 2013 – Nagrada za pedagoško odličnost, UM-FERI
- 2014 – Nagrada za izjemen dosežek slovenske znanosti, Agencija za raziskovanje Republike Slovenije
- 2015 – Ime tedna, RTV Slovenija, Val 202
- 2015 – Mladi znanstvenik Podonavske regije, Inštitut za Podonavsko regijo in centralno Evropo (ang. Institute for the Danube Region and Central), Europe, Ministrstvo republike Avstrije za znanost, raziskovanje in ekonomijo (ang. Austrian Federal Ministry for Science, Research and Economy)
- 2015 – Nagrada za tekoče dosežke na področju informacijske družbe, Informacijska Družba 2015
- 2018 – Najvišja nagrada Univerze v Mariboru za Izjemne prispevke k znanstvenemu in pedagoškemu ugledu in odličnosti Univerze v Mariboru
- 2019 – Nagrada za izjemne raziskovalne dosežke na Fakulteti za Elektrotehniko Računalništvo in Informatiku, Univerze v Mariboru.

V nadaljevanju tega prispevka so predstavljeni nekateri pomembnejši prispevki kandidata po vsebinskih sklopih.

2 PEDAGOŠKO DELO

Domen Mongus deluje v okviru Laboratorija za geoprostorsko modeliranje, multimedijo in umetno inteligenco (GeMMA) na Fakulteti za elektrotehniko, računalništvo in informatiko, Univerze v Mariboru, kjer je pričel s pedagoškim delom kot asistent, v času raziskovalnega usposabljanja za mladega raziskovalca. Po uspešnem zaključenem doktorskem študiju je okoli pol leta deloval kot asistent z doktoratom s polno pedagoško obremenitvijo, po izvolitvi v naziv docenta pa je prevzel izvajanje treh predmetov na univerzitetnih študijskih programih Računalništvo in informatika (UM-FERI), Medijske komunikacije (UM-FERI) in Bioinformatika (UM-FZV) in nadaljeval z vodenjem vaj. Ob izvolitvi v naziv izrednega profesorja je v celoti prevzel delo predavatelja in opravljal 6-10 ur predavanj tedensko pri prej omenjenih študijskih programih ter predmetih iz programov ERASMUS. Poleg uspešno zaključenega mentorstva mlademu raziskovalcu je bil do danes mentor pri 13 magistrskih delih in 38 diplomskih delih.

V svojem pedagoškem delovanju je vodil več študentov, ki so dosegli opazne mednarodne dosežke. Med slednje lahko štejemo objave v najprestižnejših mednarodnih revijah (na primer IEEE transactions on neural networks and learning systems [6] in ISPRS Journal of Photogrammetry and Remote Sensing [4]) in nagrade za članke, objavljene na mednarodnih znanstvenih konferencah. Primer slednjega je

[*]Article Title Footnote needs to be captured as Title Note
[†]Author Footnote to be captured as Author Note

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dr. Marko Bizjak, ki je s člankom »Segmentacija oblaka točk z lokalnim prileganjem ploskev« zmagal na tekmovanju študentskih člankov na konferenci ERK 2015 in bil uvrščen med 5 najboljših člankov študentskega tekmovanja IEEE, Regije 8 – Evropa, Bližnji vzhod in Afrika.

Leta 2013 je Domen Mongus prejel tudi nagrado za pedagoško delo na Fakulteti za elektrotehniko, računalništvo in informatiko, Univerze v Mariboru.

3 RAZISKOVALNO DELO

V svojem dosedanjem raziskovalnem delu se je kandidat osredotočil na razvoj novih arhitektur zlivanja podatkov, pri čemer njegovi najpomembnejši raziskovalni dosežki obsegajo nove metodologije obdelave podatkov daljinskega zaznavanja, senzorskih podatkov ter implementacij naprednih geografskih informacijskih sistemov za namene podatkovno podprtega odločanja. V nadaljevanju so v kronološkem zaporedju predstavljeni ključni kandidatovi dosežki po tematskih sklopih.

3.1 Obdelava podatkov LiDAR

V času svojega doktorskega študija se je kandidat posvetil razvoju novih metod obdelave podatkov, zajetih s tehnologijo LiDAR (angl. Light Detection and Ranging), ki je takrat predstavljala enega večjih tehnoloških prebojev na področju zemeljskih opazovanj. Kandidat je pomembno prispeval k utemeljitvi uporabe tako imenovanih diferencialnih atributnih profilov, ki izhajajo iz teorije matematične morfologije in danes predstavljajo enega izmed ključnih orodij za luščenje značilk iz topološko nestrukturiranih oblakov točk. Njegovo delo na področju generiranja digitalnih modelov reliefa iz podatkov LiDAR, objavljeno v članku [1], danes velja za drugo najbolj citirano delo na področju glede na bazo Google Scholar. Nadaljevanje tega dela, objavljeno v članku [2], pa je prejelo nagrado *Odlični v znanosti 2013 s strani Agencije za Raziskovanje Republike Slovenije*. Za svoje delo na področju razpoznave dreves, objavljeno v članku [3], mu je Inštitut za Podonavsko regijo in centralno Evropo (ang. Institute for the Danube Region and Central Europe) v okviru Podonavske konference Združenega raziskovalnega centra Evropske komisije (angl. Joint Research Centre, European Commission) podelil naziv *Mlad znanstvenik Podonavske Regije 2015* (angl. Danubius Young Scientist Award 2015). Predstavljena metodologija pa, predvsem zaradi specifik učnih podatkov, tudi v dobi globokega učenja, še vedno spada med najučinkovitejše pristope k obdelavi podatkov LiDAR.

Razvito metodologijo je kandidat izdal v obliki programskega paketa *gLiDAR* [4], s katerim je bil izveden prvi in do sedaj edini nacionalni projekt zajema podatkov LiDAR celotne Slovenije. Ključen rezultat slednjega predstavlja uraden digitalni model reliefa Slovenije v visoki ločljivosti, ki predstavlja temeljno izhodišče številnih splošno uporabljenih podatkovnih slojev, vključno z natančnimi mapami rečnih strug, cestišč, objektov in ostalih geografskih entitet. Predstavljen programski paket pa je bil kasneje uporabljen v številnih mednarodnih projektih, med drugim ga je za svoj projekt obogatitve podatkovne baze naslovov z okoljskimi podatki o geometriji stavb uporabila tudi pošta Republike Irske. Uporabljen koncept učinkovite predstavitve podatkov LiDAR pa ima mednarodno zaščito s podeljenim patentom v ZDA [5]. Za programski paket gLiDAR je Domen Mongus leta 2015 prejel tudi nagrado IS za tekoče delo.

3.2 Arhitekture zlivanja podatkov za luščenje značilk

Svoje delo na področju obdelave podatkov LiDAR je kandidat kasneje nadgradil z razvojem novih arhitektur podatkovnega zlivanja in luščenja značilk iz komplementarnih podatkovnih virov. Nizkonivojski pristopi k časovno-prostorski podatkovni poravnavi in strukturiranju podatkovnih slojev, ki jih je v tem kontekstu razvil kandidat, danes predstavljajo ogrodje zaledne informacijske infrastrukture več nacionalnih distribucijskih sistemov prostorskih podatkov. Kandidat je tako med drugim načrtoval nacionalni distribucijski sistem prostorskih podatkov Geodetske Uprave Republike Slovenije (GURS), Sistem medopravilne infrastrukture Ministrstva za okolje in prostor (MOP) in Sistem za obvladovanje naravnih nesreč (angl. disaster risk management system) Republike Srbije.

Na mednarodnem nivoju je kandidat razvite arhitekturne koncepte zlivanja podatkov za področja obdelave velepodatkov (angl. BigData), interneta stvari (angl. Internet of Things) in odprtih podatkov (angl. Open Data) predstavil tudi v obliki usmerjevalnih člankov, ki jih je izdala Krovna evropska organizacija za geografske informacije EUROGI (angl. European Umbrella Organisation for Geographic Information) [7].

Iz teoretičnega vidika pa je nedavno razvil novo metodologijo učenja razložljivih značilk [7] in jo objavil v reviji *IEEE transactions on neural networks and learning systems* s faktorjem vpliva IF = 14,255.

3.3 Lokacijska inteligenca

Razvite koncepte podatkovnega zlivanja kandidat pri svojem trenutnem delu nadgrajuje v celostne sisteme lokacijske inteligence. Rezultati tega dela pa so že vidni v večih večjih operativnih sistemih, ki temeljijo na konceptih tako imenovanih digitalnih dvojčkov.

Kandidat je tako osnoval in skupaj s sodelavci uspešno razvil in vpeljal v operativno okolje podjetja ELES d.o.o. prvi digitalni dvojček naravnega ekosistema v svetovnem merilu. Slednji omogoča samodejno izgradnjo digitalnih modelov daljnovodnih koridorjev iz podatkov daljinskega zaznavanja in, podprt z simulacijami rasti vegetacije, predvidevanje groženj za varnost daljnovodov ter optimizacijo delovnih nalogov z minimizacijo stroškov posegov. Rezultate rabe sistema pa je v soavtorstvu z uporabniki objavil v članku [8]. Podoben koncept samodejnega (skoraj) realno-časovnega zlivanja podatkov za luščenje komplementarnih značilnic je danes v razvoju tudi za optimizacijo vzdrževanja avtocest podjetja DARS d.d., pri čemer je v tem primeru arhitekturna zasnova

digitalnega dvojčka izrabljena za predvidevanje stanja prometa.

Zadnji večji uspešno zaključen projekt, ki ga je vodil kandidat, je sistem celostnega nadzora teritorija Slovenije in bojišč Slovenske Vojske za odkrivanje potencialnih nevarnosti. Enote Slovenske Vojske trenutno vpeljujejo razvit sistem na taktičnem nivoju izvidniških operacij. Slednje pa jim omogoča realno-časovno obdelavo podatkov, zajetih z izvidniškimi brezpilotnimi letalniki, ter neposredno kartiranje civilnih in vojaških enot, vozil in objektov. V bližnji prihodnosti je predvidena raba sistema tudi v civilnih operacijah, kot na primer odkrivanje ponesrečencev, zaznavanje požarov ter iskanje oseb in predmetov v kritičnih situacij.

4 MEDNARODNE IN OSTALE AKTIVNOSTI

Raziskovalni rezultati kandidata se odražajo tudi v njegovi močni vpetosti v mednarodne strokovne in znanstvene mreže. Od leta 2013 do 2019 je tako kandidat deloval dva mandata kot član izvršnega odbora krovne Evropske organizacije za geografske informacije EUROGI, kjer so ga za svojega zastopnika izbrale naslednje krovne nacionalne organizacije: AGORIA (Belgija), AM/FM-GIS Belux aisbl (Luksemburg), Geo-SEE Inštitut (Makedonija), HI-Norden (Norveška), IGIS (Hrvaška) in ISPik (Polska). Od 2020 pa je član izvršnega odbora mednarodne organizacije »Geographical Information Systems International Group (GISIG)«.

Kandidat je tudi reden udeleženec in vabljen predavatelj na mednarodnih dogodkih, predavanjih TEDx ter član uredniškega odbora dveh mednarodnih znanstvenih revij, ki glede na faktor vpliva spadajo v kategorijo A1 ali A2.

Za svoje delo v nacionalnem in mednarodnem okolju je leta 2018 prejel tudi najvišjo nagrado Univerze v Mariboru za Izjemne prispevke k znanstvenemu in pedagoškemu ugledu in odličnosti Univerze v Mariboru.

5 ZAKLJUČEK

Predstavljeni rezultati nedvomno uvrščajo kandidata med uglednejše raziskovalce na področjih lokacijske inteligence in geografskih informacijskih sistemov v Evropskem merilu ter računalništva in informatike v splošnem. Slednje pa kandidat razume predvsem kot dobre temelje za nadaljnje delo in prispevek k uveljavitvi naprednih metodologij obdelave podatkov za namene podatkovno podprtega odločanja.

Medtem, ko so v tem prispevku predstavljeni zgolj dosedanji dosežki, je kandidatove nadaljnje prispevke k utrditvi položaja slovenske računalniške in informacijske stroke v Slovenskem in mednarodnem merilu moč pričakovati tudi na osnovi njegovih tekočih projektnih in raziskovalnih aktivnosti, rezultati katerih še niso javno objavljeni. Kandidat trenutno nastopa kot vodilni tehnološki partner v dveh projektih, financiranih iz programa Horizont Evropa, vodi štiri industrijske projekte večjega obsega in aplikativni raziskovalni projekt ARRS.

ZAHVALA

Za svoje dosežke se v prvi vrsti želim zahvaliti svojemu mentorju prof. dr. Borutu Žaliku, ki je soustvarjal tako mojo profesionalno, kakor tudi osebnostno rast. Posebna zahvala gre tudi vse sodelavcem v laboratoriju GeMMA ter strateškim industrijskim partnerjem, brez katerih ne bi bilo mogoče osnovati in uspešno izvesti navedenih raziskovalnih in projektnih idej.

REFERENCES

[1] Domen Mongus and Borut Žalik, 2012. Parameter-free ground filtering of LiDAR data for automatic DTM generation. *ISPRS journal of photogrammetry and remote sensing*, vol. 67, str. 1-12.

[2] Mongus, Domen, Lukač, Niko, Žalik, Borut, 2014. Ground and building extraction from LiDAR data based on differential morphological profiles and locally fitted surfaces. *ISPRS journal of photogrammetry and remote sensing : official publication of the International Society for Photogrammetry and Remote Sensing*, vol. 93, str. 145-156.

[3] Domen Mongus and Borut Žalik, 2015 . An efficient approach to 3D single tree-crown delineation in LiDAR data. ISPRS journal of photogrammetry and remote sensing : official publication of the International Society for Photogrammetry and Remote Sensing, vol. 108, str. 219-233.

[4] Domen Mongus in Denis Horvat, 2015. *gLiDAR*. COBISS.SI-ID: 19366166.

[5] Žalik, Borut and Mongus, Domen, 2016. Light detection and ranging (Lidar)data compression and decompression methods and apparatus. *United States Patent and trademark office*, Appl. no.: 13/289.839.

[6] Vlahek, Dino and Mongus, Domen, 2021. An efficient iterative approach to explainable feature learning. *IEEE transactions on neural networks and learning systems*, 13.

[7] Barbieri, Maurice and Mongus, Domen, 2015. EUROGI policy papers : internet of things, big/linked data & open data. *Geospatial World forum*, Lisbon, Portugal. 2015.

[8] Mongus, Domen, Brumen, Matej, Žlaus, Danijel, Kohek, Štefan, Tomažič, Roman, Kerin, Uroš, Kolmanič, Simon. A complete environmental intelligence system for LiDAR-based vegetation management in power-line corridors. *Remote sensing*. 2021, vol. 13, iss. 24, 15 str.

Prispevek za zgodovino slovenske informatike

Osebni pogled

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Povzetek

Prispevek obravnava razmeroma spregledan del razvoja informatike v Sloveniji. Medtem ko so teoretična informatika, informatika v šolstvu in proizvodnja računalniških naprav z zgodovinskega vidika razmeroma dobro opisani, je poslovna informatika praktično spregledana. Pričujoči članek poskuša to pomanjkljivost popraviti vsaj v delu, ki zadeva finančno dejavnost, posebej bančništvo in plačilni promet, avtor pa upa, da bo spodbudil katerega od razvijalcev poslovnih aplikacij, ki so bili aktivni v času uvajanja računalnikov v poslovanje, saj so pomembno prispevali k učinkovitejšemu poslovanju tedaj in so s tem zaslužni za to, da današnja slovenska poslovna informatika ne zaostaja za tisto v razvitih državah.

Ključne besede
poslovna informatika, plačilni promet

1. Uvodna pojasnila

O uvajanju računalnikov v znanstvenoraziskovalno delo v Sloveniji v sedemdesetih letih prejšnjega stoletja je že kar nekaj napisanega [3] in tega na tem mestu ne bi ponavljali. Manj ali skoraj nič pa ni napisanega o uvajanju računalnikov v istem obdobju. To je tako rekoč bela lisa v zgodovini slovenske informatike, ki jo skuša ta članek vsaj nekoliko zmanjšati. Pri tem naj pojasnimo, da pisanih virov, ki bi pokrivali obravnavano tematiko, skorajda ni. Redka izjema je opis razvoja slovenske računalniške industrije [1], ki pa se poslovne informatike le bežno dotika. Avtor se zato naslanja na svoje delovanje in izkušnje iz tistega obdobja, zato je tudi podnaslov članka *Osebni pogled*.

V sedemdesetih letih prejšnjega stoletja je imelo podjetje Intertrade zastopstvo računalniškega velikana IBM. Poleg prodaje računalniških naprav IBM je razvilo še dve pomembni dejavnosti: tehnično podporo uvajanja in vzdrževanja računalniških sistemov IBM in usposabljanje računalniških kadrov (tedaj organizatorjev, programerjev in operaterjev) v izobraževalnem centru, ki ga je ustanovilo v Radovljici, kamor so prihajali tečajniki iz vse Jugoslavije. Poenostavljeno, vendar točno bi se lahko reklo, da so bili to začetki organiziranega razvoja poslovne informatike. Šele več desetletij zatem je bil na Ekonomski fakulteti Univerze v Ljubljani ustanovljen Inštitut za poslovno informatiko, za kar gre skoraj izključna zasluga in pohvala tedanjemu profesorju (in kasnejšemu prorektorju ljubljanske univerze) dr. Andreju Kovačiču, dokazuje pa njegovo daljnovidnost in razumevanje pomena informatike za – najširše rečeno – razvoj moderne družbe.

Ko obravnavamo uvajanje prvih računalnikov v tedanja podjetja, današnje gospodarske družbe, ne smemo spregledati nekaterih, ki so navedene v nadaljevanju. To so bili Elan, Begunje; Emona, Ljubljana; Gorenje, Velenje; Lisca, Sevnica; Grosist, Nova Gorica; Salonit, Anhovo; Kovinotehna, Celje; Zlatorog, Maribor; Merkur, Kranj; Astra, Ljubljana; Ljubljanska banka, Ljubljana; Služba družbenega knjigovodstva, Ljubljana. Te navedbe so je daleč od popolnega pregleda in obsegajo le računalniške sisteme IBM, res pa je, da je bila večina računalnikov v gospodarstvu te znamke. Nekaj je bilo tudi računalniških sistemov proizvajalcev NCR, Honeywell, kasneje še Burroughs, Fujitsu, Unisys in VAX. Za njihovo uvedbo je treba priznati zasluge tedanjim odločevalcem, ki so verjeli, da je računalnik lahko pomembno, če že ne bistveno orodje za učinkovitejše vodenje in izvajanje poslovnih in proizvodnih procesov.

Poslovne aplikacije na teh sistemih so v tistem času obsegale pretežno obdelave podatkov, kjer je bilo ročno delo zamudno, delovno intenzivno in kjer je bila zahtevana ročnost in točnost rezultatov. Tipične take obdelave so bile knjigovodstvo, obračun plač, fakturiranje, vodenje stanja skladišč in podobne. Manj je bilo takih, ki bi izboljševale proizvodne ali

poslovne procese. Posebno področje, kjer je bila računalniška obdelava spoznana kot nepogrešljiva za ažurno obdelavo velikega števila podatkov, so bile finančne dejavnosti, katerih izvajalci so bili do leta 1991 izključno banke, pošta in Služba družbenega knjigovodstva. Slednji je posvečena večina tega zapisa, ker obstaja v primerjavi z drugimi poslovnimi aplikacijami razmeroma precej dokumentacije ([1], [7]), deloma zato, ker je bil avtor na tem področju dlje časa aktiven, ne nazadnje pa tudi zato, ker so bili za njeno delovanje razvite aplikacije in programi, ki še danes veljajo za vrhunske strokovne dosežke tedanje informatike.

2. Plačilni promet

Plačilni promet bi lahko kratko in poljudno opredelili kot izvajanje finančnih transakcij preko poslovnih subjektov, ki so za to pooblaščeni. Vsako nakazilo denarja, plačilo računa, dviga ali polog denarja s kakršnim koli plačilnim instrumentom (plačilni nalog, kreditna kartica, ček in drugi, [2]) je finančna transakcija ([4]), ki se odraža v knjigovodskih sistemih udeležencev v tej transakciji, torej pri izvajalcu transakcije, prejemniku sredstev in plačniku. Izvajalec transakcije si svoje delo, ki ga ima z njo, poplača s provizijo v breme enega ali drugega udeleženca v tej transakciji. Spet poenostavljeno in poljudno bi lahko rekli, da je finančna transakcija informacijska preslikava poslovnega dogodka. Ta kratki opis je potreben za razumevanje nadaljevanja tega zapisa.

Pred letom 1991 je bila udeleženka vsake finančne transakcije v notranjem plačilnem prometu še Služba družbenega knjigovodstva, ki je po tedanjih ustavi in zakonu izvajala plačilni promet, to je tisti, kjer je nastopala domača valuta. Razlog za ustanovitev take institucije je bilo spoznanje politike, verjetno intuitivno, da je denar v bistvu informacija. Eden od vodilnih teoretikov James Martin je namreč šele v osemdesetih letih prejšnjega stoletja v svojem delu opisal in dokazal, da je denar informacija. Kdor vidi denarne tokove, ta vidi vse, kar tudi pojasnjuje, zakaj kriminal posluje z gotovino – le-ta se pretaka mimo uradnih denarnih tokov. Do tega spoznanja pa se je politika dokopala že prej in ga institucionalizirala tako, da je bila ustanovljena organizacija, ki je imela nadzor nad vsemi denarnimi transakcijami – Služba družbenega knjigovodstva, še danes ne pozabljeni SDK. Vsaka finančna transakcija v notranjem plačilnem prometu je bila tako zabeležena v SDK, po zakonu pa je morala biti obdelava podatkov plačilnega prometa zaključena vsak delovni dan. Država je torej naslednji dan zjutraj razpolagala z natančnim stanjem dinarskih vplačil, izplačil in stanja.

Podobne institucije so poznane v Evropi že od druge polovice 18. stoletja (clearing house, clearing bank, Girocentrale), vendar je bilo njihovo poslanstvo drugačno, reklo bi se poslovno orientirano, ker je bil glavni namen pobotanje plačil in terjatev ([6]).

Poleg plačilnega prometa je opravljal SDK tudi druge naloge – statistiko, analize, inšpekcijo in poročanje, večina tega pa je bila omogočena prav zaradi razpoložljivih podatkov o plačilnem prometu.

3. Obdelava podatkov plačilnega prometa

V primerjavi z današnjim številom poslovnih subjektov, obsegom poslovanja in finančnih transakcij bi najprej pomislili, da je bilo v 70. letih prejšnjega stoletja tega malo. Mogoče; vendar je bilo dnevno število plačilnih nalogov samo v podružnici SDK Ljubljana okoli 300.000, včasih tudi do pol milijona, v vseh 14 podružnicah SDK v Sloveniji pa reda velikosti en milijon dnevno, kar je bilo za tedanje možnosti tehnologije zelo zahtevno za obdelavo, bilo pa je tudi izjemno delovno intenzivno. V SDK Jugoslavije je bil sicer razvit program AROPS[1], ki je imel tri funkcionalne sklope: zajem podatkov, kontrola podatkov in priprava podatkov za obdelavo na računalniškem sistemu. Prejšnje ročne postopke, to je tiste, ki so se izvajali s pomočjo elektromehanskih naprav, je bistveno izboljšal, vendar je imel mnogo pomanjkljivosti. Glavne so bile počasna računalniška obdelava (reda velikosti 1.000 transakcij na uro), zahtevni postopki za odpravljanje napak in zamudna priprava podatkov za nadaljnjo obdelavo. Precej razmišljanja je bilo torej, kako postopke pospešiti s pomočjo računalnika, konkreten predlog pa so izdelali Mladen Trobec[2], Matjaž Čadež[3] in Wolfgang Jung[4].

Njihova rešitev je temeljila na tedaj izjemno naprednega načina z uporabo metode direktnega

[1] Automatizacija rednih operativnih poslova službe
[2] Tedaj SDK podružnica Ljubljana
[3] Tedaj Intertrade IBM
[4] Tedaj IBM Regional Office Europe Central and East

pristopa do podatkov na diskovnih pomnilnikih[5]. Pogledano z današnjimi očmi bi bilo seveda učinkoviteje uporabiti relacijske ali objektne podatkovne baze, kar pa je bilo v tistem času zaradi ne dovolj zmogljivih računalniških naprav neizvedljivo. Indikativno je tudi ime rešitve – Tezaurus[6][10], ki dokazuje, da so bili njeni avtorji vrhunski informatiki, razumeli pa so tudi pomen podatkov[7][11].

Čeprav so bili tedaj na razpolago že programski jeziki tretje generacije, pri IBM tipično PL/1, so bili programi napisani v asemblerju, ki je bil nezahteven glede porabe virov, hkrati pa dovolj hiter pri izvajanju. Računalniški sistem podružnice SDK Ljubljana je bil IBM serije 370 model 138 z operacijskim sistemom DOS/VS, s 64KB pomnilnika in enotami magnetnih diskov IBM 2314 zmogljivosti 27MB. Upoštevaje zgolj ti dve značilnosti in dejstvo, da je bili treba obdelati dnevno ažurno ca 1.000.000 plačilnih nalogov ob vseh drugih obdelavah za potrebe SDK (statistika, analize in druge), je očitno, da so morali biti avtorji rešitve izjemno kreativni. Razvijalci so se torej srečevali z omejitvami, na katere današnji niti ne pomislijo, saj so viri naprav praktično neomejeni. Diskovni pomnilnik zmogljivosti 1 TB je bil tedaj v domeni znanstvene fantastike, danes pa je na notesniku že običajen. Vseh podrobnosti rešitve Tezaurusa na tem mestu ne moremo navajati, saj so podrobno opisane v razpoložljivi literaturi [9]. Navedemo pa naj vendar nekaj podrobnosti, ki bodo ilustrirale zgornjo oceno.

Za kar najhitrejše izvajanje programov so bili uporabljeni makroukazi. Ker je bil pomnilnik centralne procesne enote daleč premalo zmogljiv, so bili programi napisani v tehniki prekrivanja (overlay). Krmilni del programa je osnovni in je ves čas v pomnilniku, glede na potrebe pa prikliče z zunanjega pomnilnikom ustrezni del programa (podprogram), ki izvede zahtevano funkcijo. Posebna tehnika je bila razvita za zapis podatkov na zunanji disk, ki je dala zapis natančno take dolžine, da je bil disk izkoriščen natančno do poslednjega bajta.

Poleg te najbolj obsežne aplikacije naj omenimo še nekaj drugih dosežkov. Franc Potočnik in Ivan Turk sta razvila program ELKA[8], ki je omogočal analitikom, da so pregledovali podatke in izdelovali poročila brez posredovanja programerjev. Razvila sta tudi podoben program za spremljanje investicij. Skupina razvijalcev je proti koncu 80. let sprogramirala in demonstrirala prvo elektronsko plačilo v notranjem plačilnem prometu. Vse tri inovacije so bile priznane kot take in razvijalci zanje tudi nagrajeni.

4. Namesto zaključka

Pričujoči prispevek se omejuje na zelo posebno področje obdelave podatkov plačilnega prometa. Poleg oseb, ki so imenoma navedene v članku, so pri razvoju in izboljšavah sodelovali številni informatiki in strokovnjaki z drugih področij, ki so ostali vse do danes neopaženi in, če se lahko izrazimo nekoliko bolj slikovito, neopevani junaki poslovne informatike. Poudariti pa je treba, da je obravnavano področje zgolj eno in da so dosežki poslovne informatike nezasluženo spregledani in zamolčani. Seveda obstaja razlaga tudi za to. Medtem ko se od raziskovalcev zahteva, da svoja dognanja in dosežke objavljajo, se od informatikov zahteva zgolj to, da njihove rešitve delujejo, za kaj več pa pretežno zmanjka časa in energije. Njihovi prispevki na nacionalnih konferencah prikazujejo skoraj izključno tekoče dosežke. Avtor upa, da bo s svojim prispevkom spodbudil še koga, ki bi lahko prispeval svoj kamenček za mozaik, iz katerega bi se nekoč izoblikovala zgodovina slovenske informatike.

5. Zahvala

Avtor se najprijazneje zahvaljuje
- Mladenu Trobcu za pomoč pri odkrivanju in pridobivanju virov, posebej pa še za vzpostavitev domačih strani (vira [8] in [10]), ki sta dragocen prispevek za dokumentiranje razvoja poslovne informatike, za kritični pregled in izboljšave, in
- prof. dr. Matjažu Gamsu za spodbudo za pisanje tega prispevka.
Brez njiju bi bila zgodovina slovenske informatike revnejša vsaj za ta članek.
Hvala obema.

[5] Direct Access Method, DAM
[6] V informacijski tehnologiji so tezavri baze podatkov, na področju umetne inteligence pa se jim reče tudi ontologije.
[7] "treasury, storehouse," from Latin *thesaurus* "treasury, a hoard, a treasure, something laid up," from Greek *thēsauros* "a treasure, treasury, storehouse, chest," …
[8] ELementi in KAzalci

6. Viri

[1] Marijan Frković, Franci Pivec, Niko Schlamberger, Janez Grad: A contribution to the history of computing and informatics in West Balkan countries, Uporabna informatika 2016/4, URN:NBN:SI:DOC-UAGSD7MU

[2] Aleš Zelenik, Zdenko Mezgec: Zaščita negotovinskih oblik plačevanja, Uporabna informatika 2009/4, URN:NBN:SI:DOC-ZSUPALYC

[3] Janez Grad: Razvoj računalništva in informatike na Univerzi v Ljubljani, s poudarkom na pomenu RRC in RCU, Uporabna informatika 2018/3, URN:NBN:SI:DOC-SWR9IXMO

[4] https://www.bsi.si/placila-in-infrastruktura/placilne-storitve-in-elektronski-denar/placilni-instrumenti-in-placilni-nalogi (obisk 15.9.2022)

[5] Osebni zapiski avtorja

[6] Dušan Drofenik: Clearing houses, clearing bank, girozentrale, Obvestila SDK, maj 1991

[7] http://sdk-tezaurus.blogspot.com/2011/07/kontrolni-program-tezaurus.html, obisk 13.9.2022

[8] http://sdk-tezaurus.blogspot.com/2011/07/zakaj-tezaurus.html, obisk 13.9.2021

[9] Kontrolni program Tezaurus, SDK Ljubljana, 1980

[10] https://sl.wikipedia.org/wiki/Tezaver (obisk 14.9.2022)

[11] https://www.etymonline.com/search?q=thesaurus (obisk 24.9.2022)

Pregled mojega raziskovalnega dela

Overview of my research work

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POVZETEK

V članku podajam pregled mojega raziskovalnega dela od konca 70-tih let 20. stol. do leta 2022. Moji začetki so bili na področju analize biomedicinskih signalov, med študijem v ZDA sem se začel ukvarjati z računalniškim vidom. Moje glavno raziskovalno področje je 3D interpretacija slikovnih informacij in uporaba računalniškega vida pri uporabniških vmesnikih. Glavni aplikacijski področji katerim sem se posvetil pa sta dediščinska znanost, kjer metode računalniškega vida postajajo neobhodne za dokumentacijo najdišč in raznoraznih artefaktov, in sodobna novomedijska umetnost, kjer posebej pri interaktivnih instalacijah računalniški vid omogoča interakcijo z okoljem in obiskovalci.

KLJUČNE BESEDE

Analiza EKG, računalniški vid, rekonstrukcija volumetričnih modelov, superkvadriki, uporabniški vmesniki, dediščinske znanosti, podvodna arheologija, analiza podatkov v letalstvu, novomedijska umetnost

ABSTRACT

In this article I give an overview of my research work from the late 1970s to 2022. My beginnings were in the field of biomedical signal analysis, and I started working on computer vision while studying in the USA. My main research area is 3D interpretation of image information and the application of computer vision to user interfaces. The main application areas I have focused on are heritage science, where computer vision methods are becoming indispensable for the documentation of sites and various artefacts, and contemporary new media art, where, especially in interactive installations, computer vision enables interaction with the environment and visitors.

KEYWORDS

ECG analysis, computer vision, reconstruction of volumetric models, superquadrics, user interfaces, heritology, underwater archaeology, data analysis in air traffic, new media arts

1 ANALIZA SIGNALOV EKG

Moja prva raziskovalna izkušnja sega v leto 1979, ko sem izdelal svojo diplomsko nalogo v *Laboratoriju za avtomatiko in kibernetiko* pod mentorstvom akad. prof. dr. Ludvika Gyergyeka [1]. Delal sem na računalniški analizi elektrokardiogramov in naša raziskovalna skupina je bila interdisciplinarno sestaljena. V istem laboratoriju sem nato naredil tudi svojo magistrsko nalogo, kjer sem se posvetil analizi srčnih aritmij [2]. Objavili smo nekaj člankov na mednarodnih konferencah [3], naša skupina pa je leta 1982 tudi dobila *Nagrado Sklada Borisa Kidriča* za razvoj mikroprocesorskega analizatorja EKG [4]. Več o tem obdobju sem napisal v [5].

2 REKONSTRUKCIJA SUPERKVADRIKOV IZ GLOBINSKIH SLIK

Po obveznem služenju vojaškega roka, ki sem ga opravil v *Hidrografskem inštitutu Jugoslovanske vojne mornarice* v Splitu v letu 1982/83, sem s pomočjo Fulgrightove in IREXove štipendije odpravil na *Pensilvansko univerzo* v Filadelfijo, ZDA. V svoj laboratorij *GRASP* (General Robotics, Automation, Sensing & Perception Lab) me je sprejela prof. dr. Ruzena Bajcsy. Prof. Bajcsy [6], po rodu iz Slovaške, je svoj drugi doktorat znanosti dobila na Univerzi Stanford pod mentorstvom prof. Johna McCarthya [7], enega od pionirjev umetne inteligence. Zato se lahko pohvalim, da je moj akademski "dedek" eden od začetnikov umetne inteligence [8].

V svoji doktorski disertaciji sem se ukvarjal z rekonstrukcijo volumetričnih modelov iz globinskih slik, ki navdih išče v teoriji človeškega zaznavanja slik. Rekonstrukcija vidne scene iz vizualnih podatkov je temeljno področje raziskav na področju računalniškega vida. Njegov glavni cilj je čim bolj natančno rekonstruirati opazovano okolje z opisom različnih predmetov v prizoru. Eden od prevladujočih pristopov k rekonstrukciji temelji na predstavitvi kompleksnih prizorov s pomočjo množice preprostih geometrijskih oblik, znanih tudi kot volumetrične primitivne oblike. Tako predstavljena okolja lahko nato avtonomni agenti uporabljajo za različne naloge, kot sta navigacija po okolici ali prijemanje predmetov, kar je praktično uporabno npr. v skladiščih in v proizvodnji. Opisani pristop rekonstrukcije, ki temelji na volumetričnih primitivih, je znan kot rekonstrukcija od spodaj navzgor. Superkvadriki so volumetrični 3D modeli, ki za oblikovanje različnih oblik potrebujejo le nekaj parametrov oblike, drugi parametri pa opisujejo njihovo velikost ter položaj in orientacijo v prostoru. V računalniško grafiko jih je vpeljal Alan Barr, v računalniški vid pa Sandy Pentland. Na osnovi njunih idej sem v svojem doktorskem delu razvil metodo rekonstrukcije superkvadrikov iz globinskih slik na osnovi minimizacije funkcije prileganja. Minimizacija je zahtevala iterativen postopek reševanja, saj je šlo za izrazit nelinearen problem. Kljub relativno kompleksni rešitvi, se je moja metoda uveljavila na zelo različnih aplikacijskih področjih, od robotike, medicine, pa celo antropologije za modeliranje človeških lobanj, kar priča okoli 2000 citatov na Google učenjaku.

Članek na osnovi mojega doktorata so sprejeli na prvi mednarodni konferenci iz računalniškega vida (ICCV), ki je bila 1987 v Londonu [9], kasneje sem članek objavil tudi reviji IEEE PAMI

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[10]. Konec leta 1987 sem zagovarjal svojo disertacijo [11]. Do avgusta 1988 sem nato imel na UPenn še status podoktoranta, nato sem se vrnil v Ljubljano na FE in začel s predavanji na študijskem programu računalništva in informatike. V Ljubljani sem nadaljeval z delom na rekonstrukciji superkvadrikov. Leta 1991, ravno v času osamosvajanja Slovenije, sem na fakulteti ustanovil tudi lasten *Laboratorij za računalniški vid*. S svojima doktorskima študentoma Alešem Leonardisem in Alešem Jakličem sem izpopolnil metodo rekonstrukcije superkvadrikov tako, da je vključevala še segmentacijo kompleksnih predmetov na več superkvadrikov [12]. O tem našem delu smo napisali monografijo, ki je izšla pri založbi Kluwer, oziroma kasnejšem Springerju [13]. Tematika superkvadrikov pa s tem ni čisto zamrla, saj sem s svojim doktorskim študentom Jako Krivicem razvil zanimivo metodo prepoznavanja objektov na osnovi superkvadrične rekonstrukcije [14]. Superkvadrike smo uporabili tudi pri dokumentiranju arheoloških artefaktov v kontekstu dediščinske znanosti [15, 16].

Po dolgem premoru smo se superkvadrične obnove pred parimi leti ponovno lotili, pri čemer nas je navdihnil izjemni napredek na področju globokega učenja. Ti najsodobnejši pristopi zaobidejo računsko intenzivnost zgodnjih iterativnih rešitev. Obravnavajo tudi rekonstrukcijo iz različnih vrst podatkov, kot so oblaki točk, globinske slike in celo kombinacija intenzitetnih in barvnih slik. Da bi dosegli uspešne rekonstrukcije, vsi pristopi sprejmejo učne cilje, ki vključujejo določeno raven geometrijskih informacij. Pokazali smo, da je z uporabo globokega učenja mogoče rekonstruirati superkvadrike iz ene same globinske slike [17], pri čemer smo se pri ocenjevanju velikosti, oblike, položaja in rotacije upodobljene superkvadrike oprli na napovedovalnik CNN. Razvili smo tudi metodo rekonstrukcije superkvadričnih modelov iz intenzitetnih in barvnih slik [18]. Da bi to dosegli, smo sledili splošni zamisli metode, ki temelji na globinskih slikah, vendar smo naredili korak naprej in raziskali uporabo modelov globokega učenja za rekonstrukcijo superkvadrikov iz ene same slike RGB. Z globokimi nevronskimi mrežami smo se lotili tudi problema sočasne segmentacije in rekonstrukcije superkvadričnih modelov [19]. Prednost metod z uporabo CNN je predvsem veliko hitrejša rešitev, kar omogoča uporabo teh metod tudi takrat, ko je potrebno poiskati rešitev v realnem času, kot na primer pri avtonomni vožnji.

3 UPORABA RAČUNALNIŠKEGA VIDA V UPORABNIŠKIH VMESNIKIH

Če je še v 80-tih letih zajem slik z računalnikom zahteval dodatno strojno opremo, pa je v 90-tih letih vse več računalnikov imela že vgrajeno kamero. Zajem slik in s tem njihova uporaba je postala enostavna. Zato me je začela zanimati uporaba slik v kontekstu uporabniških vmesnikov. Razvili smo poseben uporabniški vmesnik za kontrolo zajema video slike na daljavo. Z enostavno robotsko roko je bilo možno premikati kamero levo-desno in gordol. Na ta način smo lahko zajeli panoramsko sliko [20] in tudi globinsko panoramsko sliko [21]. Ker nas je zanimala detekcija obrazov, smo razvili tudi enostavno metodo detekcije na osnovi barve kože, ki se je prilagajala različnim vrstam osvetlitve [22]. Prav zaradi preprostosti je ta naša metoda postala zelo popularna, saj ima na Google učenjaku skoraj 1000 citatov.

Preučevali smo tudi uporabo metod računalniškega vida za analizo gledanosti digitalnih oglasov [23] in novo vrsto dinamične anamorfoze, ki se prilagaja poziciji opazovalca v prostoru [24]. Preučevali smo tudi uporabniške vmesnike za ljudi s kognitivnim deficitom [25] in problem manjkajočega kontakta z očmi med uporabniki videokonferenčnih sistemov [26] in vizualizacijo glasbe [27].

4 UPORABA RAČUNALNIŠKEGA VIDA V DEDIŠČINSKI ZNANOSTI

Kot sem že omenil, so metode računalniškega vida postale skoraj neobhodne v arheologiji in dediščinski znanosti, tako pri zajemu 3D podatkov (npr. večslikovna fotogrametrija, Lidar) kot pri modeliranju in analizi teh podatkov. Z našo metodo rekonstrukcije superkvadrikov smo modelirali kamnite sarkofage, ki jih je prevažala rimska ladja, ki se je potopila na severni strani otoka Brača [15]. Superkvadriki so zaradi rotacijske simetrije tudi zelo pripravni modeli za modeliranje amfor [16]. Sodelovali smo tudi pri dokumentiranju in analizi rimske ladje s pomočjo fotogrametrije v reki Ljubljanici pri Sinji Gorici [28, 29]. V kontekstu podvodne arheologije se vedno znova pojavi problem ohranjanja mokrega lesa. Na primeru 40.000 let stare paleolitske lesene osti, ki jo je našel v reki Ljubljanici naš sodelavec arheolog Miran Erič, smo preučevali spremembe, ki nastanejo med konzerviranjem takih predmetov [30].

5 ANALIZA PODATKOV V LETALSTVU

Marko Hrastovec, moj doktorski študent, me je potisnil na področje analize letalskih podatkov. Hrastovec je zaposlen na Slovenski kontroli poletov in ima tako dostop do podatkov, ki se zbirajo v centrih za kontrolo poletov. Za svojo magistrsko nalogo je postavil informacijski sistem, ki meteorološke podatke, ki jih letala preko radarskih povezav pošiljajo v kontrolne centre, posreduje naprej meteorološkim središčem, ki z obogatenimi podatki o temperaturah ozračja, hitrosti vetrov in vlažnosti lahko povečajo natančnost meteoroloških napovedi [31]. Z bolj natančnimi meteorološkimi podatki in drugimi podatki o posameznih letih, pa s pomočjo strojnega učenja lahko izboljša napovedi o trajanju posameznih poletov [32].

6 NOVOMEDIJSKA UMETNOST

Kmalu po mojem povratku na Univerzo v Ljubljani sem se povezal s Srečom Draganom, pionirjem video umetnosti v tedanji Jugoslaviji in profesorjem na Akademiji za likovno umetnost in oblikovanje. Povod za najino sodelovanje je bil spletni portal *Slovenska virtualna galerija* [33], ki je na nov način predstavil slovensko likovno umetnost. S Srečom Draganom sva začela dolgoletno plodno sodelovanje na področju umetnosti novih medijev [34]. V sodelovanje sva pritegnila tudi najine študente na FRI in ALUO. V interdisciplinarnem duhu in z uporabo tehnologij, ki smo jih razvijali v našem laboratoriju, smo eksperimentirali z novimi tehnologijami in jih preizkušali v kontekstu novomedijske umetnosti. Z našimi projekti smo se redno udeleževali *Mednarodnega festivala računalniških umetnosti* v Mariboru, festivalov *Speculum Artium* v Trbovljah, se pojavljali na drugih razstavah ali organizirali lastne letne preglede naše novomedijske dejavnosti in študentskih umetniških projektov. Opažen je bil tudi naš prispevek v okviru evropskega meseca kulture leta 1997 v Ljubljani [35]. Novomedijska umetnost, ki je življensko odvisna od računalniške tehnologije, se je izkazala kot zelo primerno eksperimentalno polje tudi za preizkušanje novih metod računalniškega vida [36].

Sčasoma sem začel razvijati tudi lastne novomedijske projekte. Moj prvi odmeven projekt je bil *15 sekund slave*, ki so jo navdihnili portreti znanih ljudi Andyja Warhola [37]. Prvič je bila razstavljena leta 2002 na *Mednarodnem festivalu računalniških*

umetnosti v Mariboru, kasneje pa še velikokrat, tudi na samostojni razstavah [38]. Instalacija s samodejnim zaznavanjem obrazov iz nakljućno izbranih obrazov obiskovalcev galerije, ki stojijo pred instalacijo, ustvari pop art portrete. Ti portreti se nato za 15 sekund prikažejo na računalniškem monitorju, ki je oukvirjen kot umetniška slika. Instalacija je bila ustvarjena, še preden se je začela doba selfijev, vendar je že odlično naslovila potrebo ljudi po samospoznavanju in samopotrditvi. Na primeru te instalacije smo tudi preučevali vzdrževanje novomedijske umetnosti [39].

Pred desetimi leti, leta 2012, sem začel bolj po naključju kipariti v kamnu in lesu morda iz želje, da bi z rokami počel kaj več kot le tipkal in sedel za računalniškim zaslonom. Po nekaj kiparskih delavnicah pod vodstvom akademskih kipark Alenke Vidrgar in Dragice Čadež Lapajne sem začel delati samostojno. Moje dosedanje kiparsko delo je bilo nedavno predstavljeno na samostojni razstavi, ki je bila jeseni 2020 v Galeriji DLUL v Ljubljani [40]. Svoje znanje računalništva poskušam združiti s kiparstvom. Raziskujem, kako lahko kip obogatimo z virtualno vsebino. V preteklosti so umetniki kamnite skulpture pogosto postavljali v vodno okolje - bodisi v stoječo vodo, v kateri se je skulptura zrcalila, bodisi kombinirali s tekočo vodo v obliki različnih fontan, ki so vnašale dinamičen element. Za serijo skulptur Svetlobna fontana — doslej sem v tej seriji izdelal dve skulpturi, *Sonce* in *Galaksijo* [41] — sem za zajem 3D-oblike skulpture uporabil Kinectov globinski senzor. Te informacije o 3D-obliki se lahko nato uporabijo za izračun gibanja vodnih kapljic, ki navidezno padajo na skulpturo. Ker gre le za virtualne vodne kaplje, jih predstavljajo svetlobne točke, ki se prek videoprojekcije projicirajo na skulpturo. Te svetlobne točke se dejansko gibajo kot vodne kapljice, saj drsijo po površini skulpture v smeri največjega nagiba [42]. O kreativnosti v znanosti in umetnosti in kako se povezujeta ti dve področji pa sem pisal v [43]. Po bolonjski reformi sem začel redno predavati tudi na ALUO, smer Video in novi mediji.

7 SKLEP

Moje strokovno in organizacijsko delo po ustanovitvi samostojne Fakultete za računalništvo in informatiko leta 1996 je bolj podrobno opisano v zborniku, ki je izšel ob 20-letnici fakultete [44]. Naj na kratko omenim le, da sem se kot dekan fakultete med leti 2006 in 2010 posvetil predvsem bolonjski reformi in arhitekturnim načrtom nove stavbe. Pri bolonjski reformi sem si prizadeval, da bi tudi umetna inteligenca dobila svoj zaslužen del študijskega programa na FRI, ki ga do tedaj ni imela, čeprav je prav umetna inteligenca prispevala največ raziskovalnih rezultatov. Pri novi stavbi pa smo od arhitektov predvsem želeli prostore, ki bodo omogočali lažje srečevanje ljudi in tako spodbujali večje sodelovanje.

LITERATURA

[1] Franc Solina. "Računalniška analiza ravninskih in prostorskih zank VKG signalov". Diplomska naloga. Fakulteta za elektrotehniko, Univerza v Ljubljani, 1979.

[2] Franc Solina. "Računalniška prepoznava motenj srčnega ritma". Magistrska naloga. Fakulteta za elektrotehniko, Univerza v Ljubljani, 1982.

[3] Krunoslav Turkulin, Ludvik Gyergyék, Marjan Vezjak, Franc Solina, Vojko Valenčič, Janez Trontelj in Slobodan Ribarić. "Automatska analiza elektrokardiograma u opterećenju". V: *Neinvazivne metode u kardiologiji: međunarodni simpozij pod pokroviteljstvom Evropskog kardiološkog društva.* (Dubrovnik). Ur. Krunoslav Turkulin. Udruženje Kardiologa Jugoslavije, 1980, str. 25–33.

[4] Damjan Zazula, Marjan Vezjak, Ludvik Gyergyék, Franc Solina in France Mihelič. "A microcomputer for on-line analysis of exercise electrocardiographic signals". V: *Mini and microcomputers and their applications: proceedings of the ISMM international symposium.* (Sant Felâiu de Guixols, Spain). Ur. E. Luque. Universidad Autonoma de Barcelona, 1985, str. 307–310.

[5] Franc Solina. "Moje računalniško izobraževanje = My computer science education". V: *50-letnica poučevanja računalništva v slovenskih srednjih šolah: 6. oktober 2021, Ljubljana, Slovenia.* Ur. Saša Divjak in Alenka Krapež. Institut "Jožef Stefan", 2021, 34–37. URL: http://library.ijs.si/Stacks/Proceedings/InformationSociety/2021/IS2021_Volume_I.pdf.

[6] *Ruzena Bajcsy — Wikipedija, prosta enciklopedija.* URL: https://sl.wikipedia.org/wiki/Ruzena_Bajcsy (pridobljeno 12. 9. 2021).

[7] *John McCarthy — Wikipedia, The Free Encyclopedia.* URL: https://en.wikipedia.org/w/index.php?title=John_McCarthy_(computer_scientist)&oldid=1041515367 (pridobljeno 12. 9. 2021).

[8] *Mathematics Genealogy Project — Ruzena Kucera Bajcsy.* URL: https://genealogy.math.ndsu.nodak.edu/id.php?id=39957 (pridobljeno 12. 9. 2021).

[9] Ruzena Bajcsy in Franc Solina. "Three dimensional object representation revisited". V: *First International Conference on Computer Vision, ICCV'87.* (London, UK). IEEE Computer Society, 1987, str. 231–240.

[10] Franc Solina in Ruzena Bajcsy. "Recovery of parametric models from range images: the case for superquadrics with global deformations". V: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 12.2 (1990), str. 131–147. DOI: 10.1109/34.44401.

[11] Franc Solina. "Shape recovery and segmentation with deformable part models". Doktorska disertacija. Philadelphia, PA: University of Pennsylvania, 1987. URL: https://repository.upenn.edu/dissertations/AAI8804963.

[12] Aleš Leonardis, Aleš Jaklič in Franc Solina. "Superquadrics for segmenting and modeling range data". V: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 19.11 (1997), str. 1289–1295. DOI: 10.1109/34.632988.

[13] Aleš Jaklič, Aleš Leonardis in Franc Solina. *Segmentation and Recovery of Superquadrics.* Computational Imaging and Vision. Springer Dordrecht, 2000. DOI: 10.1007/978-94-015-9456-1.

[14] Jaka Krivic in Franc Solina. "Part-level object recognition using superquadrics". V: *Computer Vision and Image Understanding* 95.1 (2004), str. 105–126. DOI: https://doi.org/10.1016/j.cviu.2003.11.002.

[15] Aleš Jaklič, Miran Erič, Igor Mihajlović, Žiga Stopinšek in Franc Solina. "Volumetric models from 3D point clouds: The case study of sarcophagi cargo from a 2nd/3rd century AD Roman shipwreck near Sutivan on island Brač, Croatia". V: *Journal of Archaeological Science* 62 (2015), str. 143–152. DOI: 10.1016/j.jas.2015.08.007.

[16] Žiga Stopinšek in Franc Solina. "3D modeliranje podvodnih posnetkov". V: *SI robotika.* Ur. Marko Munih. Slovenska matica, 2017, 103–114.

[17] Tim Oblak, Jaka Šircelj, Vitomir Štruc, Peter Peer, Franc Solina in Aleš Jaklič. "Learning to Predict Superquadric

Parameters From Depth Images With Explicit and Implicit Supervision". V: *IEEE Access* 9 (2021), str. 1087–1102. DOI: 10.1109/ACCESS.2020.3041584.

[18] Darian Tomašević, Peter Peer, Franc Solina, Aleš Jaklič in Vitomir Štruc. "Reconstructing Superquadrics from Intensity and Color Images". V: *Sensors* 22.14 (2022). ISSN: 1424-8220. DOI: 10.3390/s22145332. URL: https://www.mdpi.com/1424-8220/22/14/5332.

[19] Jaka Šircelj, Tim Oblak, Klemen Grm, Uroš Petković, Aleš Jaklič, Peter Peer, Vitomir Štruc in Franc Solina. "Segmentation and recovery of superquadric models using convolutional neural networks". V: *Proceedings of the 25th Computer Vision Winter Workshop Conference, Rogaška Slatina, February 3-5, 2020*. Ur. Alan Lukežič, Domen Tabernik in Klemen Grm. Slovensko društvo za razpoznavanje vzorcev, 2020, 74–81. URL: http://data.vicos.si/cvww20/CVWW20-proceedings.pdf.

[20] Bor Prihavec in Franc Solina. "User interface for video observation over the internet". V: *Journal of Network and Computer Applications* 21.4 (1998), str. 219–237. DOI: https://doi.org/10.1006/jnca.1999.0074.

[21] Peter Peer in Franc Solina. "Panoramic Depth Imaging: Single Standard Camera Approach". V: *International Journal of Computer Vision* 47.1/2/3 (2002), 149–160. DOI: 10.1023/A:1014541807682.

[22] Jure Kovač, Peter Peer in Franc Solina. "Human skin color clustering for face detection". V: *The IEEE Region 8 EUROCON 2003. Computer as a Tool.* Zv. 2. 2003, str. 144–148. DOI: 10.1109/EURCON.2003.1248169.

[23] Robert Ravnik in Franc Solina. "Audience Measurement of Digital Signage: Quantitative Study in Real-World Environment Using Computer Vision". V: *Interacting with Computers* 25.3 (feb. 2013), str. 218–228. DOI: 10.1093/iwc/iws023.

[24] Robert Ravnik, Borut Batagelj, Bojan Kverh in Franc Solina. "Dynamic Anamorphosis as a Special, Computer-Generated User Interface". V: *Interacting with Computers* 26.1 (apr. 2013), str. 46–62. DOI: 10.1093/iwc/iwt027.

[25] Erika Pavlin, Žiga Elsner, Tadej Jagodnik, Borut Batagelj in Franc Solina. "From illustrations to an interactive art installation". V: *Journal of Information, Communication and Ethics in Society* 13.2 (2015), str. 130–145. DOI: 10.1108/jices-02-2014-0007.

[26] Aleš Jaklič, Franc Solina in Luka Šajn. "User interface for a better eye contact in videoconferencing". V: *Displays* 46 (2017), str. 25–36. DOI: https://doi.org/10.1016/j.displa.2016.12.002.

[27] Peter Ciuha, Bojan Klemenc in Franc Solina. "Visualization of concurrent tones in music with colours". V: *Proceedings of the 18th ACM international conference on Multimedia*. ACM. Firenze, 2010, str. 1677–1680.

[28] Miran Erič, Andrej Gaspari, Katarina Čufar, Franc Solina in Tomaž Verbič. "Zgodnjerimska ladja iz Ljubljanice pri Sinji Gorici = Early Roman barge from the Ljubljanica River at Sinja Gorica". V: *Arheološki vestnik* 65 (2014), 187–254. URL: http://av.zrc-sazu.si/Si/65/Eric_AV_65.html.

[29] Miran Erič, Enej Guček Puhar, Žiga Stopinšek, Aleš Jaklič in Franc Solina. "The significance of detailed analysis of 3D cloud points which include data that the human eye can overlook: the case of a flat-bottomed ship from the Ljubljanica river". V: *Skyllis* 19.1/2 (2019), 29–40.

[30] Enej Guček Puhar, Lidija Korat, Miran Erič, Aleš Jaklič in Franc Solina. "Microtomographic Analysis of a Palaeolithic Wooden Point from the Ljubljanica River". V: *Sensors* 22.6 (2022). DOI: 10.3390/s22062369.

[31] Marko Hrastovec in Franc Solina. "Obtaining meteorological data from aircraft with Mode-S radars". V: *IEEE Aerospace and Electronic Systems Magazine* 28.12 (2013), str. 12–24. DOI: 10.1109/MAES.2013.6693664.

[32] Marko Hrastovec in Franc Solina. "Prediction of aircraft performances based on data collected by air traffic control centers". V: *Transportation Research Part C: Emerging Technologies* 73 (2016), str. 167–182. DOI: https://doi.org/10.1016/j.trc.2016.10.018.

[33] Andrej Lapajne, Bor Prihavec, Aleksander Ruben, Žiga Kranjec in Franc Solina. "Slovenian Virtual Gallery". V: *Proceedings 4th Electrotechnical and Computer Science Conference ERK*. Zv. A. 1995, str. 3–6.

[34] Franc Solina in Srečo Dragan. "Novomedijski umetniški projekti kot most med realnim in virtualnim svetom". V: *Robotika in umetna inteligenca*. Ur. Tadej Bajd in Ivan Bratko. Slovenska matica, 2014, str. 187–230. URL: http://eprints.fri.uni-lj.si/2861/1/Poglavje_SM_Solina-Dragan.pdf.

[35] Srečo Dragan, Franc Solina, Bor Prihavec, Slavko Korenč in Bojan Nemec. "Netropolis — the Cyborg's eye: project". V: *Programme of the European cultural month: May 15 to July 5, 1997*. Municipality of Ljubljana, 1997, str. 36.

[36] Franc Solina. "New media art projects, panoramic images and live video as interface between real and virtual worlds". V: *DESIDOC Journal of Library & Information Technology* 34.2 (2014), str. 110–124.

[37] Franc Solina. "15 seconds of fame". V: *Leonardo* 37.2 (apr. 2004), str. 105–110. DOI: 10.1162/0024094041139274.

[38] Franc Solina. *15 sekund slave = 15 seconds of fame*. Ur. Aleš Vaupotič in Narvika Bovcon. Galerija spomeniškovarstvenega centra, Trg francoske revolucije 3, Ljubljana, 1.-12. 2. 2005. ArtNetLab - društvo za povezovanje umetnosti in znanosti, 2005, str. 20. URL: http://eprints.fri.uni-lj.si/194/.

[39] Borut Batagelj in Franc Solina. "Preservation of an interactive computer-based art installation - a case study". V: *International Journal of Arts and Technology* 10.3 (2017), str. 206–230. DOI: 10.1504/IJART.2017.086669.

[40] Franc Solina. *Skulpture / Sculptures 2012–2020, 2. izdaja / 2nd Edition*. Ljubljana: Društvo likovnih umetnikov Ljubljana, Fakulteta za računalništvo in informatiko, 2021. DOI: 10.51939/0001.

[41] Franc Solina. *Light Fountain II – Galaxy*. 2022. URL: https://youtu.be/y6NAiXlNm20 (pridobljeno 1. 9. 2022).

[42] Franc Solina in Blaž Meden. "Light fountain – a virtually enhanced stone sculpture". V: *Digital Creativity* 28.2 (2017), str. 89–102. DOI: 10.1080/14626268.2016.1258422.

[43] Franc Solina. "Creativity in Science and Art". V: *Creativity*. Ur. Sílvio Manuel Da Rocha Brito in João Thomaz. Rijeka: IntechOpen, 2022. Pogl. 29. DOI: 10.5772/intechopen.101955.

[44] Miha Bejek, Vesna Gračner, Vida Groznik, Viljan Mahnič in Franc Solina, ur. *FRI 20: 1996-2016: 20 let Fakultete za računalništvo in informatiko Univerze v Ljubljani*. Ljubljana: Fakulteta za računalništvo in informatiko, 2016. URL: http://eprints.fri.uni-lj.si/3655/1/Zbornik_FRI20_web_100.pdf.

INFORMATIKA NARODU

Computer science to the nation

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POVZETEK

Takoj po drugi svetovni vojni je začel izhajati časopis "Tehnika narodu". Naši očetje so v želji po obnovi domovine zagnali vsesplošno gibanje, da bi spodbudili prenovo ne samo na podlagi delovnih brigad (na mišice) temveč tudi na krilih tehnoloških inovacij. Ob mojem vstopu v gimnazijo me je preveval občutek, da moram odkriti "perpetum mobile". Kasneje ob študiju na fakulteti pa sem bil prepričan, da sem našel kar, sem iskal, to je bila informacijska tehnologija. Obilica projektov, ki sem jih speljal v preteklosti, mi je danes dokaz, da se nisem motil, saj je informatika danes glavna sila, ki poganja svet in tudi moj osebni inovacijski motor. Prepričan sem, da bi domovini Sloveniji sila koristilo, da vzpostavi **logiko in informatiko kot predmet že v osnovno šolo**. To je tudi rdeča nit skozi vse moje javne nastope.

KLJUČNE BESEDE

Radio Študent, Moj Mikro, Računalniški klub, Mikrohit, Špica, ZITex, Informatika narodu, Zlata Nit

1 RAČUNALNIŠKI KROŽEK

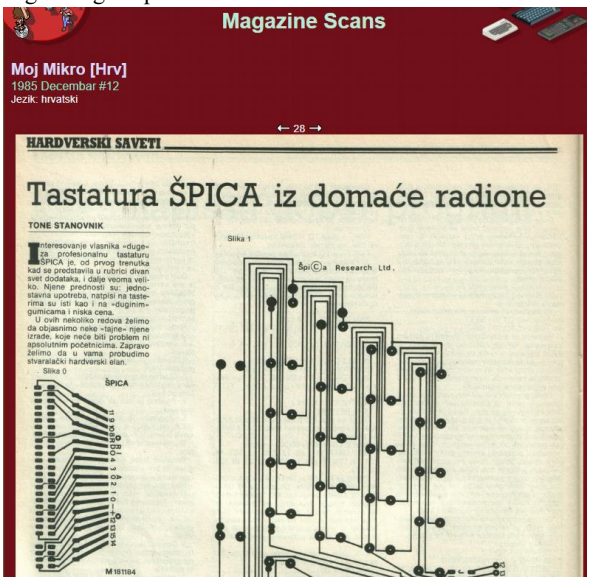
Moje prvo srečanje z informatiko je bilo v Šentviški gimnaziji, kjer sem se skupaj z nekaj sošolci vključil v računalniški krožek. Naučili smo se osnove računalniškega jezika Fortran in nato dobili kratek termin v kleti Vegove srednje šole v mestu. Program, ki smo ga zasnovali na papirju, smo pretipkali v luknjač in rezultat je bil šop "luknjanih" kartic (za vsako vrstico programa je bila ena kartica). Nato smo svoj šop kartic pustili, da so jih v prostem času spustili skozi obdelavo in čez nekaj dni smo zopet z mestnim avtobusom prišli po izpis. Pogosto se je izkazalo, da je bilo še polno napak in tako smo ponavljali, dokler nismo prišli do končnega rezultata. Moj prvi program, se spominjam, je izračunal število prehojenih stopnic iz danega šolskega urnika v Šentviški gimnaziji, ki je bila takrat v dveh stavbah. Večkratno potovanje z avtobusom v center in nazaj me takrat ni posebej fasciniralo, a ker smo to počeli v družbi s sošolci, se mi je zdelo zelo zabavno. Saj smo drug drugemu pomagali pri odpravi napak in debatirli ter delili izkušnje.

2 RADIO ŠTUDENT

V času študija je moja prijava za tonskega tehnika na Radiu Študent ključnega pomena za mojo usmeritev v informatiko. Pa ne toliko zaradi tehnike kot zaradi svobodomiselnosti, ki sem se je nalezel od sodelavcev na radiu. Zdelo se mi je, da se je pred menoj odprl popolnoma nov svet. To je bilo ravno v času, ko je na zahodu stopilo na pohod "mikroračunalništvo". S starejšimi kolegi na fakulteti in nekaj entuziasti iz Iskre Delte smo ustanovili mikroračunalniški klub in poskušali kar sami sestavit svoj prvi mikroračunalnik. Na Radiu Študent pa smo zagnali posebno računalniško sekcijo in po končanem programu vsak dan predvajali zvočni zapis programske opreme, ki smo jo takrat na začetkih lahko posneli iz radia kar na kasete.

3 ŠKUC

To je bilo obdobje, ko si morali imeti svoj Punk bend ali pa vsaj mikroračunalniško delavnico v garaži. Ker še ni bilo možnosti, da bi kar odprl podjetje, sem pa imel nekaj inovativnih idej, sem se znašel tako, da sem v ŠKUCu takrat na Kersnikovi 4 dobil kartico svobodnega umetnika, kot so jo dobili vsi takratni Punk bendi. Tako smo lahko kupovali potrebno opremo in material brez davka. Seveda smo tudi takrat potrebovali inicialno investicijo in ker ni bilo investitorjev za vsakim vogalom kot so danes, sem se znašel tako, da sem noč in dan na ulicah prodajal takrat zelo popularno Tribuno in Mladino ter posebej v decembrskem času, ko so ljudje bolj radodarni, prišel do nujnega zagonskega kapitala.



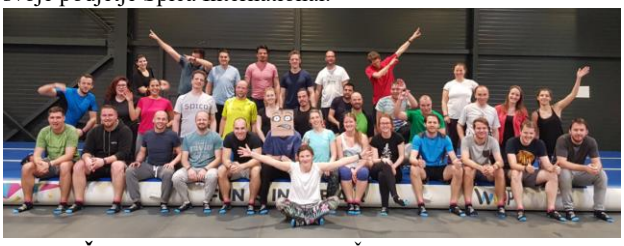
Slika 1: Članek objavljen 1985 v takrat sveži reviji Moj Mikro

4 ŠPICA

Ob zaključku študija je postal posebej v regiji zelo popularen mikroračunalnik Spectrum, ker je bil tako majhen kot knjiga, smo jih Slovenci pridno kupovali v Munchnu in jih tihotapili preko meje pod sedeži ter se tako izognili plačilu carine. Glavna slabost tega za tiste čase zelo uporabnega računalnika je bila gumi tipkovnica, ki je onemogočala hitro dvoprstno tipkanje. Prišel sem na idejo, da bi izdelal profesionalno tipkovnico, ki se jo priključi na ta mali računalnik in to je bil **poslovni začetek ŠPICE. Leta 1984** sem ŠPICA tipkovnico že prvič razstavil na sejmu SODOOBNA ELEKRONIKA, o čemer je pisala tudi Mija Repovž v Delu. Ker pa se mi je bližal čas, ko sem moral v vojsko, sem se znašel tako, da sem v reviji Moj Mikro objavil moj načrt za samoizdelavo tipkovnice in je med mojo odsotnostjo vse sestavne dele pošiljala po povzetju moja šošolka iz gimnazije. Tako je vse funcioniralo tudi v času moje vojaščine.

5 MIKROHIT

Tudi v vojski nisem miroval, saj mi je oče poslal Spectrum in mini televizijo Shiljaris, s katerim sem vodil Računalniške urice in si izboril nekaj dodatnih dni dopusta in vojsko lahko prej zaključil. Po povratku z vojske sem se zopet prijavil kot razstavljalec na sejem Sodobna Elektronika **in na razstavni prostor** povabil tudi MIKROHIT takrat prvo slovenko mikroračunalniko podjetje v nastajanju. Vzameno sem po sejmu dobil mesto vodje razvoja v tem mladem dinamičnem podjetju. Že takoj na začetku smo začeli razvijati HW in SW izdelke za izvoz in nastopati na največjem računalniškem sejmu CeBIT.
Na sejmu smo izborili odlično pozicijo takoj pri vhodu North1 in mnogi Slovenski obiskovalci sejma so imeli tu miting-point.
Ker pa je bil Mikrohit ustanovljen še kot družbena lastnina, smo jo po nekaj letih štirje sodelavci mahnili na svoje in ustanovili svoje podjetje Špica International.



Slika 2: **Šport** je bil vedno rdeča nit Špice, in nas tesno povezuje še danes. Saj smo tudi ponosni sponzorji Benija Savška od mladih nog.

6 ŠPICA INTERNATIONAL

Nov začetek po relativnem obilju, ki nam je bil na voljo v Mikrohitu, je bil seveda težak, a kot pravi angleško reklo: Scarcity breeds clarity - Pomanjkanje zbistri pogled na ključne prioritete. Tako že samo ime ŠPICA ponazarja, da smo zastavili svojo ponudbo ozko nišno in podaljšek imena INTERNATIONAL, da želimo prodreti geografsko široko v svet.
Odločili smo se, da svoje rešitve razvijemo takrat nastajajoči IDentifikacijski tehnologiji črtne kode in kasneje RFID. Na tej tehnologiji pa sta se uspešno razvili dve prepoznavni diviziji:

- SCM Suplay Chain management / Logistika
- WFM Work Force management / Evidenca Delovnega Časa

Kot eno prvih manjših slovenskih IKT podjetij smo dali pod streho tudi ISO9001 in tako že na samem začetku nakazali smer delovanja, ki ni zasnovana samo na količinah in hitri rasti, temveč tudi na kakovosti, ki je ključna za dolgoročni uspeh.

7 EXPORT

Majhna podjetja so bila v tistih časih izvozno najbolj uspešna v radiju 500 km. In tudi Špici smo geografsko najprej postavili svoje bazne tabore – svoja podjetja v glavnih mestih regije LJ, ZG, BG, SA, SK ter vzpostavili partnersko sodelovanje s podjetji v Romuniji, Bolgariji in Madžarski. Z biometrično identifikacijo pa smo se uspešno prebili tudi na trge Bližnjega Vzhoda, kjer so še danes naše največje implementacije Evidence delovnega časa in kontrole dostopa v podjetjih preko 10.000 zaposlenih. Že leta 2002 smo postavili tudi zelo napredno web storitev www.myhours.com ki je izredno uspešna predvsem v Ameriki in je neke vrste podlaga za našo današnjo uspešno metamorfozo v SaaS podjetje. Leta 2017 smo prejeli laskavo nagrado IZVOZNIK LETA, ki jo podeljuje organizacija SPIRIT

Slika 3: Podelitev nagrade za izvoznika leta 2017 (agencija SPIRIT Slovenija)

8 ZITex

V želji, da izvozno ambicijo prenesem na širši krog slovenskih računalniških podjetij sem v okviru gospodarske zbornice GZS zagnal slovensko prebojno izvozno IKT sekcijo – ZITex, katere prvi predsednik sem postal in popeljal v tujino nekaj uspešnih izvoznih delegacij. Za dosežke na omenjenem področju sem leta 2010 dobil tudi nagrado gospodarske zbornice za posebne dosežke v gospodarsvu.

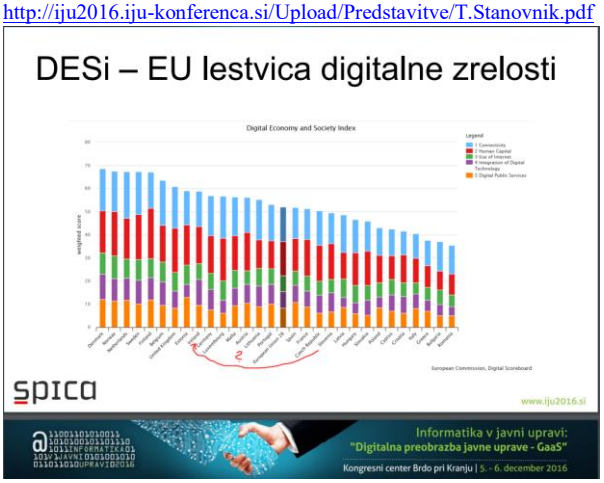
Slika 4: Podelitev nagrade za izjemne gospodarske dosežke (GZS Gospodarska Zbornica Slovenije)

9 GaaS

Government as a Service - Slovenski državni aparat kot gonilo digitalnega razvoja. Nastop na IJU 2016 - Informatika v Javni Upravi sem usmeril v pobudo, da se do 2025 na DESI lestvici iz trenutnega 20 mesta prebijemo med TOP10 EU držav s pobudo da:

- Da država postane generator sprememb na področju digitalne preobrazbe, kar se je z e-Računi tudi zgodilo, a kasneje žal zastalo
- Da vsako od TOP1000 SLO podjetji investira v 3 startup-e in tako pridemo do 3.000 startup-ov kot nekoč do 3.000 mladih raziskovalcev
- Vzpostavimo predmet Logika in informatika že v osnovni šoli

Slovenija se je v teh zadnjih letih tudi uspešno približala prvi deseterici.
http://iju2016.iju-konferenca.si/Upload/Predstavitve/T.Stanovnik.pdf



Slika 5: **DESI lestvica 2016** z ponazoritvijo planiranega preboja naprej v naslednjih 10 letih.

10 INFORMATIKA NARODU

Počaščen sem bil s povabilom takratne ministrice za šolstvo k sodelovanju v delovni skupini RINOS, ki se s svojimi aktivnostmi trudi za povečanje prisotnosti logike in informatike v osnovni šoli, saj je to ključnega pomena za dolgoročno uspešnost Slovenije v bodočem svetu. Ker se zavedam, da je šolski kurikulum precej težko spremenit, sem spodbujal, da poskusimo priti v šolo skozi tehnični pouk. Ocenjujem, da je to ključno področje mojega delovanja na področju računalništva, saj ima najbolj dalnosežen vpliv na bodoči uspeh Slovenije. Svojo pobudo sem kronal z nastopom na SAZUju
http://videolectures.net/posvetRIN2017_stanovnik_informatika/

Slika 6: **Logiko in informatiko približati mladini**

11 PRODUKTIVNOST

Kot pionir uvajanja črtne kode v Sloveniji sem seveda tehnologijo vedno želel vpeti v celovite rešitve, ki jih kupci potrebujejo za izbolšanje svojega rezultata. Pogosto še danes naletim na trditev kakšnega direktorja, ki ga srečam v dvigalu " Stanovnik mene ne zanima čas, mene zanimajo samo rezultati". Jaz seveda poskušam prepričat, da je rezultat potrebno delit s časom in tako pridemo do produktivnosti in učinkovitosti. Zato menim, da je spremljanje časa na projektih ključno za dvig učinkovitosti in posledično dodane vrednosti, ki vpliva tudi na debelino kuverte, ki jo delavci konec meseca odnesejo domov. Informatika je ključno orodje in vodstvo je zadolženo za digitalno transformacijo, ki posledično pripelje do dviga učinkovitosti v podjetju.

12 METAMORFOZA ŠPICE

Špica trenutno prehaja skozi največjo metamorfozo v svojem življenju. Pripravljamo podjetje za prehod v naslednjo generacijo in krepko smo zajahali tehnologijo CLOUD računalništva, ki bo garant za prihodnje uspehe. Podobno kot v avtomobilski industriji proizvajalci prehajajo iz nafte na elektriko, v informatiki prehajamo iz prodaje sw licenc na prodajo oblačnih storitev. Svoje preoblikovanje smo zasnovali na petih stebrih in jo poimenovali K5: Kadri. Ključni Procesi, Kupci, KPI, Kultura. Že pri prvem področju Kadri smo dosegli nesluten uspeh, saj smo v zadnjih dveh zaporednih letih dosegli prvo mesto na tekmovanju za najboljšega zaposlovalca Slovenije med srednjimi podjetji ZLATA NIT.
https://www.youtube.com/watch?v=3cm_ZX0v2R8&t=93s

Slika 7: **Dvakrat na vrhu ZLATA NIT 2020 in 2021.** Zaposlovalec leta med srednje velikimi podjetji

REFERENCES:

[1] Previharimo Viharje https://www.linkedin.com/pulse/previharimo-viharje-tone-stanovnik-/

[2] BIM Building Information Modeling Cankarjev Dom svetovni gradbeni kongres (2019) https://www.youtube.com/watch?v=tVpz4k6jRpc

[3] SBC Tone Stanovnik Špica ustanovni član Slovenskega Kluba Podjetnikov: Čas je zlato ! (2021) https://www.linkedin.com/feed/update/urn:li:activity:6894643587922165760

[4] GZS Gravitacija podcast: Tone Stanovnik Špica Disruptivno Innoviranje (2021) https://gravitacija.gzs.si/gravitacija-36/

[5] MJU: Digital nomads welcome to Slovenija (2020) https://www.youtube.com/watch?v=HlNcDVBjqEE

[6] Finance Izvozni Fokus: Change Management (2020) https://youtu.be/Cr54Jpmj76E

[7] ADECCO: CEO pogled (2020) https://www.youtube.com/watch?v=r1xtSrge-Jk

[8] GZS Metamorfoza Špice long (2020) https://www.youtube.com/watch?v=aAWnvq86UVw&t=7s

[9] Corpo EXPORT https://www.youtube.com/watch?v=KdtPjY9i5YA

[10] Corpo Video SLO: https://www.youtube.com/watch?v=l5v6WkGKWYw

[11] Corpo Video ENG: https://www.youtube.com/watch?v=fphZurgcBL0

[12] Točka Preloma 2020: Produktivnost https://4d.rtvslo.si/arhiv/tocka-preloma/174717227

[13] Špica Microsoft Partner leta: Produktivnost 2019 Kristalka: https://www.youtube.com/watch?v=56nfB-8H9cE&feature=youtu.be

[14] FINANCE: Tovarna leta: https://youtu.be/9lPlv1LYW78

[15] INFOSEC Špica Time & Space Varnostni produkt leta 2019: https://www.youtube.com/watch?v=xVjBu8mnAiQ

[16] Informatika Narodu: http://videolectures.net/posvetRIN2017_stanovnik_informatika/

[17] Slovenski Forum Inovacij NG: https://www.youtube.com/watch?v=gQ-eQ5xdX_o&list=PLQswk7TgcYpPf1EPldgcZdq4ca6751scS&index=3

[18] RTV Prava ideja: http://4d.rtvslo.si/arhiv/prava-ideja/30529184

[19] SPIRIT Izvoznik leta2017: https://youtu.be/VSwF5F_f2wU?t=167

[20] Radio VAL202: http://4d.rtvslo.si/arhiv/poletje-za-podjetje/174288684

[21] Val202 Poslovne krvulje: Delo od doma https://val202.rtvslo.si/2019/02/poslovne-krivulje-132/

[22] Videolectures zbirka Tone Stanovnik http://videolectures.net/tone_stanovnik/

[23] GZS ZITex https://www.youtube.com/watch?v=vgEmPcaMHPQ

[24] GZS Vrh Gospodarstva GZS https://www.youtube.com/watch?v=t38s39JiiGg

[25] Slovenija 5.0 1,50 min https://www.youtube.com/watch?v=kP5D2VFXeUE

[26] GS1 Dec2016 https://www.youtube.com/watch?list=PLQswk7TgcYpPVd0kbQM7YwQ-kSq3pqK_R&v=P_WgCLiXY3w

[27] Adria Summit BG 2016 https://www.youtube.com/watch?v=bFDjCpEQbZU&list=PLQswk7TgcYpPVd0kbQM7YwQ-kSq3pqK_R&index=2

[28] Odmevi 11 Vrh Gospodarstva na bledu 2016 19:34 http://4d.rtvslo.si/arhiv/odmevi/174439505

Omrežne varnostne storitve, zasebnost in računalniško obvladovanja zaupanja – strnjena kronologija (Slovenija od učenke do mednarodne partnerice)*

Cyber-security Services, Privacy and Computational Trust Management – A Timelapse (Slovenia from a student to an international partner)

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POVZETEK

Pričujoč prispevek podaja kratko kronologijo pomembnejših dogodkov pri razvoju z Internetom povezanih tehnologij in raziskav v Sloveniji, kjer je bil avtor tvorno (so)udeležen. Za začetek je podan minimalen pregled vzpostavitve Interneta, ker je to pač logično izhodišče. Potem pa so prikazana podrobneje ostala raziskovalna področja, o katerih se ve manj, a smo na njih dosegli pomembne dosežke. Ta področja so povezana z, npr. lahkimi kripto-protokoli, ki so že anticipirali pojav interneta stvari (to je z računskimi viri omejenih naprav), potem je tu računalniško obvladovanje zaupanja, itd. Aplikacijsko pa omenimo dva zanimivejša projekta iz devetdesetih let prejšnjega stoletja, eden je kartica zdravstvenega zavarovanja ZZZS, drugi pa vzpostavitev informacijskega sistema Narodne galerije v Ljubljani, ki je že baziral na Internetu. Če pri samem vzpostavljanju Interneta res nismo naredili kakega posebnega znanstvenega preboja pa se je to pri ostalih omenjenih področjih gotovo zgodilo. A brez tega, da smo »splovili« Internet tudi ostalih področij verjetno ne bi bilo – to nam je dalo pomembno izhodišče in možnost, da smo ujeli vlak na tem področju ter se postavili z ramo ob rami z vodilnimi, včasih pa smo bili tudi prvi.

KLJUČNE BESEDE

kibernetska (informacijska) varnost, zasebnost, kripto-protokoli, računalniško obvladovanje zaupanja

ABSTRACT

This paper gives a short chronology of some major events in the development of Internet related technologies and research in Slovenia, where the author was actively involved. A brief overview of the establishment of the Internet is given because it is a logical starting point. Other research areas are presented next, where we also have achieved important results, which may be less known. These areas are, among others, lightweight crypto protocols, which have already anticipated the emergence of the Internet of Things and computing devices with restrained resources. Further, computational trust management area is presented. Besides, there are two interesting projects from the 1990s, the first one is the nation-wide introduction of the Health Insurance Card of ZZZS, and the other is the establishment of the National Gallery information system, which was already based on the Internet. The »establishment« of the Internet was not an important achievement as far as science is concerned, but a mere transfer of technology. Nevertheless, it gave us an important starting point to catch the leading developments in this and related areas and came shoulder to shoulder with the leaders - sometimes we were even the first.

KEYWORDS

cyber (information) security, crypto-protocols, privacy, computational trust management

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1 Mreža vseh mrež kot začetek

O tem, kako je Internet prišel v Slovenijo je bilo že dovolj napisanega, npr. v [1]. Bi pa bilo na mestu za dodati še določene podrobnosti glede posameznikov, ki niso bili izpostavljeni do sedaj, pa je njihov prispevek gotovo potrebno omeniti.

Torej na IJS na Odseku za digitalne komunikacije E6, ki ga je v začetku devetdesetih let prejšnjega stoletja vodil dr. Janez Korenini, se je znanje s področja računalniških komunikacij nabiralo predvsem v teamu, v katerem so bili dr. Borka Jerman Blažič, mag. Marko Bonač, mag. Avgust Jauk, dr. Marjeta Pučko, dr. Monika Kapus Kolar, mag. Iztok Tvrdy, mag. Jože Rugelj in avtor tega prispevka. »Tihi« in pomembni »zunanji« član je bil tudi takratni direktor dr. Tomaž Kalin. Znotraj IJS pa je potrebno omeniti še mag. Marka Martinca iz Računalniškega centra, ki je velikokrat pomagal s svojim sistemskim znanjem, ne samo v povezavi z Digitalovim omrežjem Decnet in operacijskim sistemom VMS, ampak tudi v povezavi s svetom operacijskega sistema Unix.

Omenjena skupina na IJS je bila verjetno najmočnejše jedro na tem področju v Sloveniji, posamezni pomembni igralci, ki so bili z njo v povezavi pa so še mag. Davor Šoštarič z IZUM-a v Mariboru in Darko Bulat iz zagrebškega SRCE-a, ki se je kasneje tudi preselil v Slovenijo.

Začetek Interneta pri nas sega v leto 1991, ko je dr. Jerman Blažičeva vzpostavila ustrezne stike, avtor pa je kot sistemski (in delno programerski) akter to povezavo realiziral in nato precej časa upravljal za akademski svet. V tem času celo v ZDA ni bilo dobro znano, kaj je Internet in kako se priklopiti nanj. Zato je založba Prentice Hall izdala knjigo, kjer so navedeni tudi »pionirji« vzpostavljanja interneta, med njimi mi [2].

Ne glede na vse povedano pa sama vzpostavitev te povezave ne pomeni kaj vidnejšega v znanstvenem pogledu – gre le za prenos tehnologije. A izkazala se je kot pomembna, saj je naši raziskovalni sferi tudi na tem in povezanih področjih omogočila pospešeno pridruževanje najboljšim. Sreča je bila še ta, da je omenjeno področje (digitalnih in računalniških komunikacij) imelo tudi jasno podporo s strani vodstva IJS, predvsem dr. Tomaža Kalina in dr. Vita Turka.

2 Začetek eksperimentov

Z današnjega gledišča so bila gornja udejstvovanja precej trivialna, a kot rečeno, tovrstnega znanja je bilo tudi po svetu takrat malo. V kolikor so avtorju pri sami vzpostavitvi Interneta lahko pomagali predvsem kolegi iz nizozemskega inštituta NIKHEF (M. Teerpstra in P. Berteema), pa pri eksperimentiranju z varnostnimi storitvami ni bilo več tako. Po zaslugi vodje Laboratorija za odprte sisteme in mreže E5 dr. Borke Jerman-Blažič (ki je zapustila odsek E6 in kamor je avtor šel z njo kot svojo delovno mentorico na IJS) smo pridobili potrebno strojno in programsko opremo, npr. ISODE paket z imenikom po standardu X.500, a ob pičli dokumentaciji.

Vedeti je treba še, da je bilo to obdobje, ko smo vso računalniško opremo, knjige itd. dobivali z dolgim zamikom samo preko podjetij, ki si imela potrjeno izvozno-uvozno dejavnost. Poleg tega je bil avtor »lokalni samotar«, kajti v Laboratoriju E5 je bil poleg vodje dolgo časa edini raziskovalni član. Nadalje, zgoraj omenjeni softver je bil pisan za drug tip operacijskega sistema Unix, kot smo ga imeli mi (SunOS). Pa še dobili smo ga na magnetnem traku, ki ga na IJS ni bilo moč prebrati. Tu so pomagali kolegi na Fakulteti za elektrotehniko in računalništvo UL v laboratoriju dr. Trontlja. Potem pa smo ga prek omrežja Decnet prenesli na Digitalov računalnik Cathy na IJS, kjer je tekel protokol FTP, ki pa je nativni protokol za prenos datotek v okolju Unix. Tako je omenjeni softver končno prišel na postajo Sun, prek katere je avtor že upravljal Internetno povezavo in sistem DNS.

Vendar je bilo pred eksperimenti s strukturami za upravljanje ključev zaradi imenika X.500 potrebnih kar nekaj dolgih tednov sistemskega dela ter programerskega prilagajanja aplikacije, pri čemer je izvorna koda (če spomin ne vara) obsegala še za današnji čas obsežnih cca. 40MB. S sistematičnim analiziranjem in modificiranem kode (pa tudi s poskušanjem in nekaj sreče) se je nabralo dovolj znanja, da je nekako sredi leta 1993 direktorij X.500 stekel. Manj težav je bilo s softverom, ki je omogočal certificiranje javnih ključev, a vseeno. [1]

S tem se je lahko začelo vsebinsko raziskovalno delo na tem področju. Po nekajmesečnem delu se je izkazalo, da programski gigant X.500 in pa struktura agencij za overjanje javnih ključev (AC) ne moreta funkcionirati na način, kot je bil predviden v standardih. Najprej so bili tu bolj operativni problemi, ko smo še v letu 1994 reševali zaplete pri »enostavnem« navzkrižnem certificiranju našega AC z nemškim oz. angleškim. Potem pa so bili tu še bolj vsebinski problemi, ki so vplivali ne le na funkcionalnost, ampak na operabilnost strukture nasploh. Npr. administrativne pravice določene AC so bile podrejene administrativnim pravicam entitete, ki je upravljala pripadajoč del imenskega prostora v X.500 – in ta lahko sploh ni bila AC. Takih problemov je bilo precej, tudi na uporabniški strani, npr. kako naj v globalnem imeniku X.500 uporabnik najde vse certifikate, ki tvorijo verigo certifikatov, ki bi omogočila preverjanje nekega certifikata v poljubni mreži AC-jev. Avtor je po identifikaciji in analizi slednjega problema zasnoval rešitev, za realizacijo prototipa pa gre zasluga novemu članu laboratorija dr. Tomažu Klobučarju. Rešitev je vzbudila zanimanje vodilne srenje na tem področju in rezultati so bili predstavljeni na simpoziju NDSS 94 (Network and Distributed Systems Security 94) v San Diegu [3], kjer so se zbrali mnogi poznani igralci na tem področju, npr. dr. Steve Kent (med drugim oče standardov za protokol IPSec). Na tem simpoziju so bili prvič tudi širše predstavljeni požarni zidovi (ang. firewalls), ki so danes standardni arzenal pri zaščiti računalniških omrežij.

Nadaljnja analiza certificiranja in dela z direktorijem X.500 je pokazala, da bi bilo potrebno »bolj trdo«, to je formalno spoprijemanje s problematiko. Avtor je tovrstni model napravil v formalnem jeziku Z (ta temelji na teoriji množic in predikatnem računu prvega reda). Ideja z jezikom Z se ni prijela, je pa imel zato večji odmev iz razvitega modela izhajajoč nabor procedur. In tako je kmalu sledil naslednji »veliki met« [4]. Administracija ameriškega predsednika Clintona je septembra leta 1995 prek svojih vladnih in zveznih služb (US Dept. of Commerce, National Institute of Standards and Technology, Federal Security Infrastructure Program Management Office) organizirala v mestu McLean, Virginia, delavnico zaprtega tipa, ki je služila kot orientacija vladi pri njenih odločitvah in usmeritvah na tem področju. Nanjo je bil povabljen tudi avtor tega prispevka, kjer je predstavil z naše strani raziskano problematiko ter možne rešitve. Med udeleženci so bili tudi dr. S. Micali z MIT (nosilec Goeddelove nagrade in Turingove nagrade), pa dr. W. Ford iz Bell Northern Research (Kanadčan, ena osrednjih oseb v tistem času, ko je bila Kanada tudi prva država, ki je v digitalno podpisala enega od mednarodnih sporazumov).

Poudariti velja, da je bil takrat OSI pristop še vedno v središču (kar je pomenilo tesno sklopljenost z imenikom X.500), kmalu za tem pa je zmagoviti pristop »vsilila« ameriška komercialna sfera, spodbujena z ustreznimi vladnimi ukrepi – to je nekompleksna struktura overiteljev in odmrtje globalnega imenika X.500 (ob odmrtju mnogih standardov OSI). Ta prehod je avtor prispevka zaznal dovolj zgodaj in se je že v letu 1996 usmeril na novo porajajoča se varnostna področja.

3 Kriptoprotokli z anticipacijo interneta stvari

Nov fokus so postali kriptografskimi protokoli, predvsem taki, ki temeljijo izključno na močnih enosmernih zgoščevalnih funkcijah (katerih eksistenca, teoretično gledano in skladno z njihovo formalno definicijo še vedno ni dokazana) – vse to s

[1] Prvo našo AC je avtor v letih 1993/94 integriral prek X.500 s prvo mednarodno infrastrukturo javnih ključev v projektu Password - https://cutt.ly/VXIr5wc.

poudarkom na čim manjši porabi. Verjetno je temu botrovalo predhodno ukvarjanje z mikrokontrolerji in delo z zbirnikom. Čim manjša poraba pa je permanenten inženirski izziv in to je ena rdečih niti na omenjenem področju.

Kmalu so sledile objave s tega področja, fokusirane na družine lahkih kriptoprotokolov, ki temeljijo na enosmernih zgoščevalnih funkcijah. Prva najpomembnejša je prišla leta 2013 v reviji IEEE Wireless Communications (kot zanimivost - revija je bila prva na treh področjih ISI WoS, kjer je indeksirana). Članek je bil s področja lahkih protokolov za zasebnost in varnost pri uporabi interneta stvari v medicini [5]. Podobna je tudi družina protokolov HFBA [6], idr.

Dodaten mejnik je tudi objava znanstvene monografije s področja informacijske varnosti pri ugledni založbi Springer [7] – pred tem je monografijo pri tej založbi od Slovencev leta 1956 objavil le dr. Milan Vidmar (a tu bi bilo potrebno opraviti še dodatna preverjanja).

V ozadju pa je ves čas na tihem čakala problematika zaupanja, ki zaradi težke formalne opredelitve in tretmaja sprva ni bila primerna za inženirski oz. večdisciplinarni pristop, saj tega znanja takrat nismo imeli dovolj.

4 Računalniško obvladovanje zaupanja

Že od prvih poskusov zagotavljanja varnosti v Internetu se je leta prepletala s pojmom zaupanja, npr. da v povezavi s certifikatom, kjer imamo podpis s strani agencije za preverjanje pristnosti (overjanja) javnih ključev, da je to npr. sinonim za zaupanje. Tudi to, da če je kaka storitev »varna«, se je kar enačilo s tem, da je inherentno prisotno zaupanje vanjo. Za podkrepitev trditve – eden prvih pomembnih standardov s področja varnosti računalniških sistemov se je imenoval Trusted Computer Systems Evaluation Criteria!

A zaupanje je izmuzljiv fenomen. Zaradi ukvarjanja z varnostjo in zasebnostjo ter konceptualnimi nejasnostmi v zvezi s tem je področje zaupanja pritegnilo zanimanje in prve izpostavljene dileme ter kontroverznosti v zvezi s tem so bile podane na vabljenem predavanju avtorja na elitni nemški univerzi Ludwig Maximillian Universiataet v Muenchnu februarja 2002, kjer je bil gostujoči raziskovalec [8].

Kmalu so sledile temeljne raziskave za računalniško obvladovanje zaupanja, ki so vključevala tudi več-disciplinarna znanja. Najprej je bil razvit formalizem, ki je bil po svoji naravi polgrupa. Kar je delovalo spodbudno, saj bi lahko uporabili obsežno obstoječe znanje s področja abstraktne algebre. A je nadaljnje delo pokazalo, da ta struktura ni ustrezno reflektirala fenomena zaupanja. In sledila je nova struktura, ki je iz zgodovinskih razlogov imela kratek čas ime Kvalitativna algebra, potem pa je prišlo ustreznejše poimenovanje - Kvalitativna dinamika (KD, angl. Qualitative Assessment Dynamics, QAD). KD predstavlja antropocentrični model zaupanja. V tem modelu so operandi kvalitativne vrednosti vzete z ordinalne lestvice ocen, ki se najpogosteje uporabljajo v medsebojni komunikaciji pri opredeljevanju zaupanja, operatorji pa reflektirajo »možgansko procesiranje« pri nastajanju ocen zaupanja posameznih entitet v odnosu do drugih entitet. Prvi, čeprav še precej elementarni članek na to temo, je bil objavljen leta 2003 v SCI reviji Mathematical and Computer Modelling [9], prva bolj poglobljena formalna obravnava pa v [10].

Zanimivo je, da smo ob tem delu nehote delno pristali na področju umetne inteligence, čeprav tja nismo bili niti usmerjeni, niti se ne štejemo med tovrstne eksperte. Da se je to zgodilo je razlog ta, da je Kvalitativna dinamika primerna za simulacije z umetnimi agenti. In na tej točki je doktorand dr. David Jelenc dobil preblisk in napravil pomemben korak naprej [11].

Do leta 2010 je že obstajala množica metod za računalniško obvladovanje zaupanja, ki so se raztezale od Dempster-Shafferjeve Teorije evidence pa do metod na osnovi teorije iger. Kako sedaj vedeti, kaj je objektivno boljše od drugega? In dr. Jelenc je dobil pravi preblisk - zasnoval je simulacijsko agentno okolje, kjer smo lahko obstoječe metode »prevedli na skupni imenovalec« ter jih v kontroliranem okolju in pod kontroliranimi pogoji evalvirali. Delo je bilo objavljeno v reviji Knowledge-based systems (mimogrede, revija je bila prva v svoji – edini - kategoriji revij indeksiranih po ISI WoS).

Na tem mestu velja omeniti tudi dosežke drugih mlajših sodelavcev na področju obvladovanja zaupanja, na katere je avtor tudi ponosen, to je doktorandov dr. Damjana Kovača in dr. Eve Zupančič (s področja varnosti pa doktorandov dr. Jerneja Kosa, dr. Aleksa Huča in dr. Andreja Dorovoljca).

In končno, tudi s področja računalniškega obvladovanja zaupanja je leta 2018 sledila še ena znanstvena monografija pri ugledni založbi Springer [12].

5 Praktični rezultati za družbo

Do sedaj omenjeno delo je vodilo tudi do praktičnih implementacij v slovenskem okolju. Seveda pa gre večji del tega na račun npr. preostalih sodelavcev IJS.

Če začnemo s akademsko mrežo ARNES – pri njenem zagonu je potrebno izpostaviti vlogo mag. Marka Bonača in mag. Avgusta Jauka, znotraj ARNES-a pa je bil zagnan center za intervencije ob incidentih SI-CERT, ki ga je prevzel mag. Gorazd. Nadalje omenimo še dr. Aleša Dobnikarja, ki je vodil projekt SIgovCA in SIgenCA na Centru vlade za informatiko.

Neposredno je bil, med drugim, avtor udeležen tudi pri uvajanju kartice zdravstvenega zavarovanja ZZZS. Celoten projekt je vodil mag. Marjan Sušelj z ZZZS, gonilna sila projekta. V povezavi z IJS in Odsekom E6, ki ga je vodil dr. G. Kandus je prišlo do sodelovanja pri varnostnih vidikih same kartice (to je bila domena dr. R. Novaka) in pri varnostni arhitekturi pripadajočega omrežja na opremi, ki jo je dobavil Siemens (to pa je bilo v domeni avtorja prispevka). Omenjeni projekt je šel v produkcijo leta 1998 in je bil, po dostopnih podatkih, prvi tovrstni uspešni projekt na nacionalni ravni v svetu [13]. Ta projekt »imamo« v uporabi še sedaj, posodobljen in pripravljen za migracijo na novo osebno izkaznico.

Od praktičnih rezultatov, o katerih se do sedaj skoraj ni govorilo, omenimo še razvoj z Internetom integriranega informacijskega sistema Narodne galerije v Ljubljani v sredini devetdesetih let prejšnjega stoletja. Takrat je galerijo vodil dr. Andrej Smrekar, doktorand ugledne univerze Harvard, kjer je bil v stiku z Internetom ter imel na tem področju ustrezno vizijo. Tako so se stvari pokrile v pravem času in – Narodna galerija v Ljubljani je bila tehnološko na področju IT kmalu pred uglednimi tovrstnimi institucijami v svetu.

Lahko bi nadaljevali še z vzpostavitvijo infrastrukture za komercialno ponudbo interneta podjetja Quantum d.o.o. (drugi ponudnik interneta pri nas, prvo je bilo podjetje NIL), ko

Telekom še ni imel sestrskega podjetja Siol, pa kakim projektom v bančnem sektorju… So pa tu še sodelovanja z nekaterimi pomembnimi mednarodnimi organizacijami, ki jih zaradi osebnih razlogov ne bi navajal.

6 Še nekaj glasbenih paberkov

Študij glasbe je bila ena od resnejših opcij, ki se tudi po spletu naključij pač ni realizirala. Je pa glasba bila ves čas prisotna tekom osnovne kariere na področju računalništva in informatike, saj je avtor tega prispevka občasno produciral in komponiral glasbo za npr. oddaje, ki jih je potem realizirala RTV Slovenija (primer je serija filmov o Pajkcu Ajkcu, ki je služila izobraževanju najmlajših na področju restavratorstva).

Nadalje, inspiriran s psevdo-znanstvenim pristopom pesnika J.W. Goetheja in njegovo Teorijo barv je želel z osnovnim naborom semantično smiselnih preslikav povezati vizualno domeno z avdio domeno – gre torej proces za sonifikacije, ki je za razliko od obratne preslikave (vizualizacije glasbe), skorajda nepokrit. In razvil je ustrezen nabor »semantično ekvivalentnih« preslikav na fizikalnem nivoju, fiziološkem nivoju ter čisto kreativnem nivoju. Na osnovi tega je demonstriral, kako se skladno s temi principi sonificira določeno sliko in rezultat je še kar zanimiv – sodi nekako na področje minimalistične elektronske ambientalne glasbe. Celotno delo je objavljeno v reviji Digital creativity, ki visoko kotira v umetniški srenji [14].

7 Namesto zaključka

Na koncu bi dodal nekaj generalnih misli, ki se nanašajo na našo znanstveno srenjo in so prisotne v ozadju gornje kronologije. Ekonomska moč države in njen mednarodni rating sta še kako pomembna tudi za plasma in možnost prodora znanstvenih odkritij. Iz lastne izkušnje izhaja, da je nekaj povsem drugega, če npr. kak dopis pride z elektronskega naslova denis.trcek@stanford.edu (avtor je bil leta 2015 gostujoči profesor na Stanfordu) kot pa z elektronskega naslova denis.trcek@poddomena.si. To je javno potrdil tudi kak drug raziskovalec, ki se je vrnil po doktoratu na elitni tuji univerzi - na tihem pa je to splošno poznana »skrivnost«. Posledično je opaznost naše znanosti manjša, tudi ko imamo dobre rezultate.

Slovenska znanost je del blagovne znamke Slovenija, od katere v tem pogledu v glavnem še prejema (po zaslugi npr. naših športnikov), četudi vedno več prispeva. In mora imeti možnost vedno več prispevati tako, da je opažena (ob tem pa služi tudi skupnosti). Da pa bi prispevek slovenske znanosti rastel, je verjetno največja nevarnost ta, da se naša znanost kakorkoli zapre. Npr., da manjša skupina odloča, kaj je znanost in v kolikem obsegu kaj financirati – četudi so to kredibilni posamezniki in to počno z dobrimi nameni je dejstvo, da je moč lokalnosti »neobvladljivo kvarna«.

SICRIS ni čudežen, vendar omogoča vrednotenje znanstvenega dela prek spektra faktorjev. Naredil je precej reda in transparentnosti – in slovensko znanost potisnil iz dokajšnje anonimnosti, kjer je bila. Avtor sam je mnenja, da je tudi njemu to precej omogočilo prosperiteto, vključno z ugledno Fulbrightovo štipendijo – in to možnosti bi rad zagotovil še mlajšim kolegom.

Zunanje vrednotenje, ki se začne z objavami v uglednih mednarodnih revijah, je pomembno izhodišče. Ker se porajajo v zadnjem času pri nas precej drugačne pobude bi veljalo razmisliti, da SICRIS obdržimo kot ogrodje, ki npr. do 80% ovrednoti relevantnost in kakovost raziskav, ostalo pa bi bil »fine tuning«, ki lahko ostane lokalne narave. In ena ključnih oseb pri uveljavljanju kvantitativnega (pretežno eksternega) vrednotenja je bil dr. Franci Demšar s sodelavci, ki so tudi izšli z IJS.

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REFERENCE

[1] Udovč Lea, 2021. Gverilska akcija, romantika in zaupanje – tako je internet prišel v Slovenijo, 27. Nov 2021, https://n1info.si/poglobljeno/30-obletnica-tako-je-internet-prisel-v-slovenijo/.

[2] April Marine, 1993. *International Sri, Internet--Getting Started* (Sri Internet Information Series), ISBN-10: 0133279332, Prentice Hall.

[3] Denis Trček, Tomaž Klobučar, Borka Jerman Blažič, Franc Bračun, 1994. CA-browsing system: a supporting application for global security services. *Proceedings: Symposium on Network and Distributed System Security*, San Diego, str. 123-128.

[4] Denis Trček, Borka Jerman-Blažič, 1995. Certification infrastructure reference procedures. V: BURR, William E. (ur.). *Public Key Infrastructure Invitational Workshop*, Septermer 28, 1995 MITRE Corporation McLean, NIST.

[5] Denis Trček, Andrej Brodnik, 2013. Hard and soft security provisioning for computationally weak pervasive computing systems in e-health. *IEEE wireless communications*, IEEE, ISSN 1536-1284, vol. 20, no. 4, pp. 8.

[6] Trček Denis, 2005. MAC based lightweight protocols for strong authentication and key exchange. *Journal of information science and engineering*, ISSN 1016-2364, 2005, vol. 21, str. 1-13.

[7] Trček Denis, 2006. *Managing information systems security and privacy*. Berlin; Heidelberg, Springer, cop. 2006. XIII, 235 str., ISBN 3-540-28103-7. ISBN 978-3-540-28103-0.

[8] Trček Denis, 2002. *Computer networks security - a holistic perspective*, invited talk. München: Ludwig Maximilians Universität, Institut für Informatik, 8 Jan. 2002.

[9] Trček Denis, 2009. A formal apparatus for modeling trust in computing environments. *Mathematical and computer modelling*, Elsevier, ISSN 0895-7177. [Print ed.], Jan. 2009, vol. 49, no. 1/2, str. 226-233, ilustr., doi: 10.1016/j.mcm.2008.05.005.

[10] Trček Denis, 2014. Computational trust management, QAD, and its applications. *Informatica*, ISSN 0868-4952, vol. 25, no. 1, str. 139-154, https://doi.org/10.15388/Informatica.2014.08.

[11] Jelenc David, Hermoso Ramón, Sabater-Mir Jordi, Trček Denis, 2013. Decision making matters: a better way to evaluate trust models. *Knowledge-based systems*, Elsevier, ISSN 0950-7051. vol. 52, str. 147-164. http://dx.doi.org/10.1016/j.knosys.2013.07.016.

[12] Trček Denis, 2018. *Trust and reputation management systems: an e-business perspective*, SpringerBriefs in information systems, Springer, cop. 2018. Ilustr. ISBN 978-3-319-62374-0. ISBN 3-319-62374-5. https://link.springer.com/book/10.1007/978-3-319-62374-0.

[13] Trček Denis, Novak Roman, Kandus Gorazd, Sušelj Marjan, 2001. Slovene smart card and IP based health-care information system infrastructure. *International journal of medical informatics*, ISSN 1386-5056, vol. 61, str. 33-44.

[14] Trček Denis 2021. Cruxes for visual domain sonification in digital arts. *Digital creativity*, vol. 32, no. 4, str. 293-30, Taylor & Francis.

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V prispevku so opisani dosežki avtorja.

1 ŽIVLJENJEPIS

Žiga Turk (1962) je redni profesor na Fakulteti za gradbeništvo in geodezijo Univerze v Ljubljani, prodekan za področje kakovosti in razvoja ter vodja programske skupine eGradbeništvo. Je univerzitetni diplomirani inženir gradbeništva, magister računalništva in informatike ter doktor tehniških znanosti. Vse naslove je dobil na Univerzi v Ljubljani. Poleg akademskih ima nekaj političnih izkušenj. Dvakrat je bil minister v Vladi Republike Slovenije. Več.
Starejše generacije se ga spominjajo kot enega izmed pionirjev osebnega računalništva pri nas.

1983 napiše prve programe za ZX Spectrum, ki zakrožijo po tedanji Jugoslaviji. Med temi je progam, ki je urejevalnik besedila Tasword razširil z jugoslovanskimi črkami ćčšđž in Loader-Saver-Dekder za izdelavo varnostnih kopij programov.
1984 se pridruži računalniški redakciji Radia Študent.

1984 za računalniško kaseto s programi napiše naslovno igro Kontrabant (skupaj z Matevžem Kmetom) in še nekaj drugih programov.
1984 skupaj s Cirilom Kraševcem predlagata ustanovitev revije za mikroračunalništvo. Časopisna hiša Delo ustanovi revijo Moj mikro. Prav številka je izšla septembra 1984. Vsebinsko sta revijo prva štiri leta urejala Turk in Kraševec. V tem času je Turk za Moj mikro napisal okrog 120 poljudnih člankov.

1984 razširi urejevalnik pustolovskih iger Quill z grafiko. Urejevalnik je uporabljen za igro Kontrabant 2, ki izide pri založbi Xenon. Napišeta jo skupaj z Matevžem Kmetom.
1985 z Matevžem Kmetom napiše igro Eurorun.
1986 z Barbaro in Igorjem Bizjakom napišejo igro Bajke in povesti o Gorjancih.

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1986 napiše in pri Zvezi organizacij za tehnično kulturo izda knjigo Programski jezi C.
1986 pod mentorstvom J. Duhovnika diplomira na FAGG z diplomskim delom »Geometrijsko modeliranje – mejni model«.
1986 se zaposli kot mladi raziskovalec na FAGG.
1989 pod mentorstvom S. Divjaka magistrira na FERI z nalogo »Razredi objektov za modeliranje v gradbeništvu«.

1991 napiše in pri Zvezi organizacij za tehnično kulturo izda knjigo Uvod v objektno orientirano programiranje in programski jezik C++.
1992 pod mentorstvom J. Duhovnika doktorira z nalogo »Okolje za računalniško projektiranje gradbenih konstrukcij”.
1993 postavi enega prvih spletnih strežnikov v Sloveniji.

1994 izdela internetni iskalnik po prosti programski opremi “Virtual Shareware Library”, ki v svetu takrat postane glavno orodje za ta namen.
1996 je med ustanovnimi uredniki mednarodne znanstvene revije “Electronic Journal of Information Technology in Construction” (ITCON), ki od začetka izhaja na internetu in je ena prvih v prostem dostopu.

1997 izdela orodje WODA za izdelovanje spletnih storitev, ki imajo osnovo v zbirki podatkov. Orodje je osnova za številne storitve na spletu tistega časa. Orodje da kasneje v javno rabo in se še vedno uporablja.
2001 postane ustanovni predstojnik Katedre za gradbeno informatiko na FGG.
2004 je na FGG izvoljen za rednega profesorja.

Njegova znanstvena pot je povezana z gradbeno informatiko, kjer je okrog njega nastala v svetu uveljavljena raziskovalna skupina. Rezultati so razvidni iz biografij in bibliografij v sistemu COBISS.

LITERATURA

[1] Wikipedija https://sl.wikipedia.org/wiki/%C5%BDiga_Turk
[2] Domača stran https://www.zturk.com/p/ziga-turk.html
[3] Vsi članki naSiol.net https://siol.net/avtorji/ziga-turk-512/

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