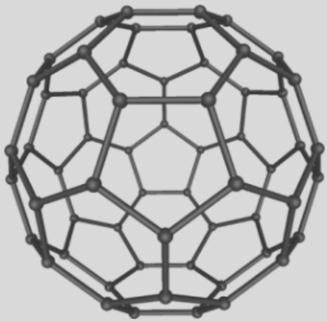
Proceedings of XXXIV. DidMatTech 2021 Conference

New Methods and Technologies in Education, Research and Practice

Eötvös Loránd University (ELTE)
Faculty of Informatics



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Introduction

The proceedings book XXXIV. DIDMATTECH 2021 consists of selected contributions from the conference with the same name which took place on September 2-3 2021 at the Faculty of Informatics of Eötvös Loránd University in Budapest. The publication covers several basic current research fields, the results of which were presented in eight sections of the conference. The purpose of these scientific contributions of notable authors – scientists and specialists from Czech, Hungarian, Polish, Slovakian universities – is to present the latest results, ideas and innovations from various fields of science and research. The main emphasis is being placed on the scientific disciplines of materials and technologies, including education, information and communication technologies.
The proceedings could be recommended primarily for teachers, who are teaching subjects focused on the fields of informatics, information and technologies, and who are possibly using modern didactic digital technologies and ICT in education. It could be also useful for research workers in the above mentioned fields, and also for PhD, postgraduate and gifted students, who can find in it not just interesting information, but also many inspirations for their research and pedagogical activities.

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Contents

A COMPARISON OF PROBLEM-BASED LEARNING AND STRONGLY GUIDED INSTRUCTION IN COMPUTER PROGRAMMING EDUCATION

László NIKHÁZY, HU

Abstract: The effectiveness of various discovery learning methods in public education is a much debated topic [1, 2]. Kirschner and colleagues [1] suggest that teaching through many worked examples is more efficient than minimally guided instructional methods. The aim of this study was to compare the former, strongly guided instruction with a form of problem-based learning in computer programming university education. The measurements included the enjoyment of classes, improvement of knowledge, and engagement in extra tasks besides the students' actual performance at regular tests. The same topics were taught in two parallel groups using the two different teaching methods for one semester. The students' performance in the tests at the end of the semester were similar, but the other measurements show some interesting differences, especially regarding the learning experience.

Keywords: computer programming education, discovery learning, strongly guided instruction, comparative study.

1 Introduction

In the second half of the 20th century, various forms of discovery learning (DL) gained very much attention in multiple scientific fields both at university and school-level education. A great amount of research has been conducted regarding the benefits and drawbacks of different types of DL, such as inquiry-based learning (IBL), problem-based learning (PBL), guided discovery learning (GDL), among others. The profound critical article of Kirschner et al. [1] brought forth an intriguing scientific dispute with comprehensive answers from the other side [2]. As a person, who loved learning with the IBL method of Pósa's mathematics camps [3,4] and gained very positive teaching experience applying these concepts in computer science talent education [5], I miss an aspect from the papers mentioned above: the students' enjoyment of classes.

Kirschner and colleagues suggest that a strongly guided teaching method demonstrating many worked examples is more efficient than the various DL principles. But the efficiency is expressed in terms of the students' performance, while their engagement should be an equally significant feature because it is not only important how much they learn, but also how much more they want to study later about the subject. The long-term effects are hard to measure, but the engagement can be determined with short surveys and evaluations on non-mandatory tasks. In this paper, the results of such a research in university education are presented.

2 Methods and materials

2.1 The course

The same teacher taught two parallel programming practice groups using different approaches for one semester, which was the first semester of their university studies. The subject, called Programming Lecture and Practice, is the introduction to programming fundamentals for computer science BSc students at the Eötvös Loránd University. The curriculum is built around solving first simple and later more complex problems using basic algorithmic patterns, like minimum/maximum selection, counting, searching, filtering, sequence calculations and combinations of these [6]. It involves learning the basic elements of a programming language (which is C++ currently), while the students also need to create formal specifications to real-world example problems and express solution algorithms with structograms (Nassi-Shneidermann diagrams [7]). The lectures mainly present the theoretical background using the formal specifications and the algorithms shown on structograms. On the other hand, the practice classes focus on solving tasks with C++ programs to provide a further base for the theories by having some hands-on experience. The detailed curriculum can be seen on the website of the course [8]. Because of the COVID-19 pandemic, all the lessons had to be held online. Attendance was mandatory for the online video conferences of the weekly 135-minute practice classes.

2.2 The two groups

The students of the two practice groups visited the same lectures, wrote the same tests, got the assignments in the same system, and the materials and tasks of the practice classes were almost the same. The only difference was the method of teaching. In the first group, I tried to give minimal guidance to the students and always make them face the problems on their own first, providing them with enough time to think and help when necessary. Hence, they are called the problem-based learning group (PBLG) in this article, although the teaching method differs from the general approach, which is called problem-based learning in science education [9] since the tasks for the students are not open-ended and are relatively short. Here the students build up their knowledge through a series of problems designed by the teacher. In the second group, the strongly guided group (SGG), I tried to demonstrate as many example tasks as possible to show how to solve a wide variety of problems that can appear in tests.

The critical difference in the education of the two groups is that in the SGG, the teacher tries to transmit his knowledge and best practices into the head of the students, while in the PBLG, the core knowledge is built by the students in their head, and the teacher has the responsibility of scaffolding, adjusting and organizing it. The students in the two groups were similar in terms of intelligence and previous knowledge. When they enter the university, the most talented persons are selected to a separate study group, and the rest are divided into two halves based on a threshold in their entry points and then assigned randomly to groups. The two groups of this study were chosen from the below-threshold half of the students, so they presumably had less programming experience. At the beginning of the semester, the students were asked to fill out a form about their prior education and expertise in programming. The answers did not differ significantly between the two groups.

2.3 Assessments and surveys

The students were assessed with several tests and home assignments listed below at the middle and end of the semester.

- Coding test (CT): a 45-minute test about implementing an algorithm in C++ given a structogram and a corresponding specification in the middle of the semester.
- Algorithm test (AT): a 45-minute test towards the end of the semester, where the task is to give an algorithm on paper to a task specified with a short text and formal definitions.
- Coding exam (CE): at the end of the semester, the students had to solve a complex task with multiple subtasks in 150 minutes, which was evaluated automatically using input-output matching by an online judge giving immediate full feedback.
- Algorithm exam (AE): at the end of the semester, the students got four tasks with short text descriptions, and they had to give formal specifications and solution algorithms to them on paper in 90 minutes.

11 Example of a note “under the line” – near the page footer – a footnote.

12 Another example of such a note.

- Home assignments (HA): throughout the semester, the students had to write and submit programs as homework for four simple tasks given 3-weekly in an online judge.
- Home project (HP): the students had to submit a program with documentation for a complex task at the end of the semester.
- Extra tasks (ET): every week, I gave a more challenging task as non-mandatory homework for the students in the Codeforces system [10]. Students could earn only plus points with these tasks. Their results in these indicate their motivation and engagement in the programming studies.

The main research interest was the students' enjoyment of classes. It was measured by a simple short feedback question with a 1-5 numeric answer after each lesson. Furthermore, there was a question about their perception of development on the same feedback form. Precisely, the document contained the following questions:

- How much did you learn/improve in today's class on a scale from 1 to 5? (1 – nothing, 5 – a lot)
- How much did you enjoy today's class on a scale from 1 to 5? (1 – I was bored, 5 – I enjoyed it very much)

3 Data analysis

3.1 Assessment results

There were 20 students in the PBLG and 17 students in the SGG. The results of the assessments in the two groups are visualized below in figure 1 using box plots; the PBLG is in blue (left side), the SGG is in orange (right side). The scores of the students were calculated as percentages at each test. The middle line of a box plot marks the median result of the group, the box above and below extends to the first and third quartiles, and the thin lines stretch out to the minimum and maximum.

Outliers are visualized as dots. These correspond to students who gave up the course inside the semester and did not take the given test or just partly took it. There is a sad fact worth noting: in the SGG, the number of such students increased gradually during the semester, up to 4 of them not taking the final coding exam. It is a strong sign of loss of motivation, but not necessarily about this course. Some of the students quit university soon after starting because they realize that computer science is not for them. Another factor was the quarantine and the fully online education, which could cause psychic difficulties.

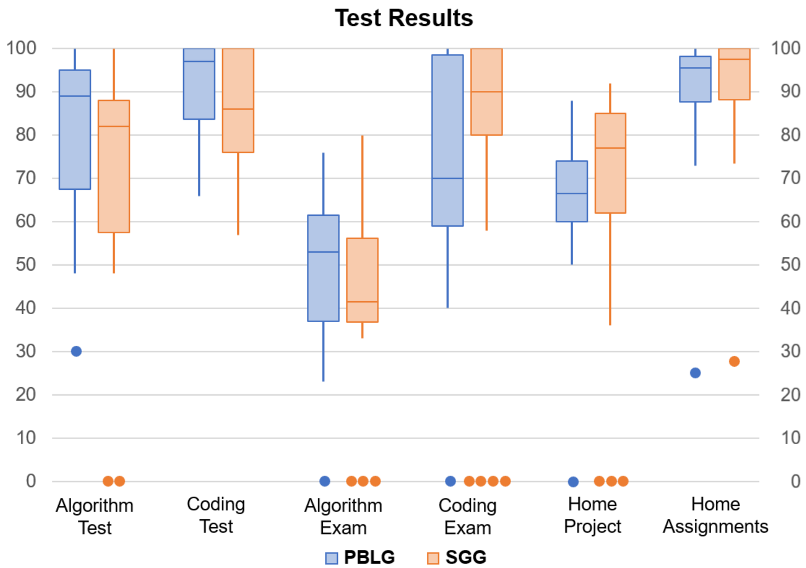

Figure 1: Box plots of the test results in the two groups

As visible above, the two groups performed similarly in the assessments. The mid-term coding and algorithm tests and the semester-end algorithm exam went a bit better for the PBLG. However, in the coding exam, the SGG students did much better and slightly better in the home assignments and the home project. To determine whether these differences are significant, p-values were calculated using two-sample t-tests, and they are shown in the table below, along with the averages of the two groups in different tests. We can see that the difference in the CE is significant ($p < 0.05$), and the other differences are not significant, although the PBLG produced slightly better results in the other tests (AT, CT and AE), while the SGG was a bit better in homework (HP and HA). What might be the reason for the SGG doing significantly better in the coding exam? Probably the greater variety of example problems and solutions shown was helpful when the students had to face the complex coding task. However, an additional, prosaic reason might play a role in this. Namely, the students get one combined mark for all the tests combined. Since the CE is the last test, they know how many points they need for their desired mark and might finish the test as soon as they get enough points in the online judge system. Thus, if students collect more points on earlier tests, they need less at the last one.

Table 1: Test result averages and p-values

	AT	CT	AE	CE	HP	HA
PBLG avg	81.316	91.900	51.053	75.009	67.605	91.421
SGG avg	74.600	86.529	47.357	86.769	72.571	92.391
p-value	0.135	0.089	0.239	**0.049**	0.144	0.384

A great indicator of student motivation is the number of solutions to extra tasks. These were non-mandatory, more challenging tasks where students could collect a tiny amount of extra points. So, the reward in points was not proportional to the invested time, but it was also an opportunity for students to try their best and test the limits of their knowledge. Surprisingly to me, the results were almost identical in the two groups, as shown in figure 2 below. The heights of the bars correspond to the percentage of students submitting correct solutions. There is a clear trend of decreasing number of solutions in both groups starting from the middle of the semester. However, it is probably not because of the loss of motivation, but because the students have very little free time in the second half of the semester because of the many tests. Another factor is the increasing difficulty of the tasks. It would be interesting to measure which is the decisive factor – we could give out easy exercises throughout the whole semester to test it. In the SGG, the last extra task received much more solutions, which can be attributed to the reason mentioned above: they needed more points at the end of the semester.

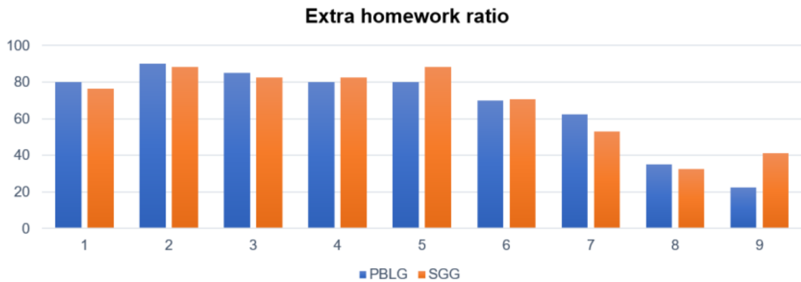

Figure 2: The ratio of students doing extra homework after classes3.2 Feedbacks

The short feedback forms at the end of each class are of great interest in this study. Each student was asked to give a 1-5 rating of how much they enjoyed the practice and improved (according to their feeling). On the charts below, the heights of the columns are the group averages of the feedbacks for each lesson, while the line segments of the top show the calculated standard deviations. There were two occasions when the SGG group did not have a class due to holidays, in those cases, there were practice lessons in the PBLG group.

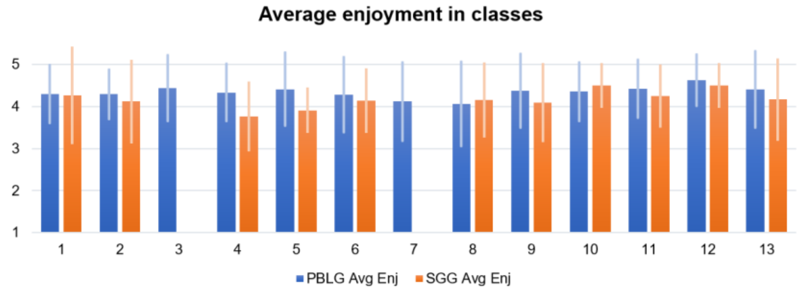

Figure 3: Average and standard deviation of enjoyment feedback in classes

The enjoyment ratings are positive in general, as can be seen above in figure 3. The average of the enjoyment values is higher in the PBLG on 9 occasions and lower on 2 occasions than in the SGG, but there is a significant difference only two times, in the 4th and 5th lesson (mid-semester). At this point of the semester, the worst feedback results occurred in the SGG and the best feedback results in the PBLG. It is a point when the students already know the elements of the programming language, and the basic patterns of algorithms (counting, search, minimum/maximum selection) are introduced. The measurements show that here it means a lot to the students to let them try working on their own first. If the examples are demonstrated, the topic might not seem attractive at all because it looks easy. On the other hand, these tasks are on the level where the students can find a little challenge and gain success, and in this case, it is much favourable not to tell them the solutions first.

Another interesting observation is that the enjoyment levels change similarly across classes in both groups (excluding the previously mentioned two occasions). For example, the 12th lesson was excellently rated in both groups, which was about sorting algorithms, a more advanced topic. So, the subject of the class affects the enjoyment values similarly in both teaching methods.

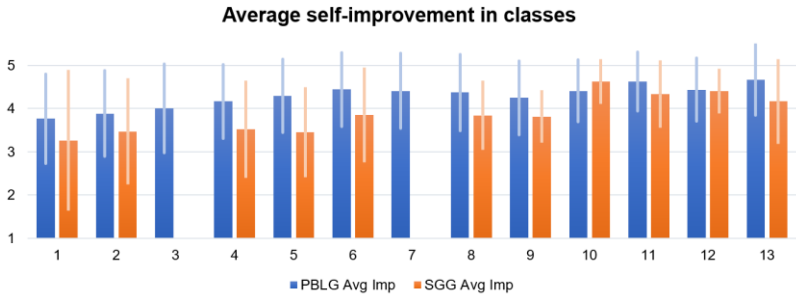

Figure 4: Average and standard deviation of self-improvement feedback in classes

Figure 4 above shows the averages improvement values – how much was the development of the students' knowledge and skills felt by themselves. In the last four classes, the results of the two groups are close to each other. This is because, in these lessons, more complex topics and tasks were discussed. However, in all the previous occasions (1-9), the improvement values are much higher in the PBLG group than in the SGG group. This is an exciting finding. We can interpret it by saying that if the topic is simple enough, the students feel that they improve more by working out the solutions on their own rather than listening to many different solutions. There can be two explanations. Firstly, it is possible that they really improve more. Secondly, it might be that the group listening to the solutions does not realize the difficulties lying in the tasks because it looks straightforward when demonstrated; thus, they think they learn nothing new. Most probably, both explanations are true at the same time. Nevertheless, this outcome was unexpected in this measurement.

4 Conclusions

In this paper, a short, small-scale study was presented where the effects of teaching with minimal guidance learning based on problem-solving and strongly guided method with demonstrating many worked examples were inspected. I taught two programming practice groups for one semester with the different techniques (PBLG and SGG). The performance at most tests was similar in the two groups. However, a significant difference was observed at the final coding test; the SGG had better results, which can be explained by the students having seen a wider variety of tasks and solutions. However, it is worth noting that four students gave up the subject in the SGG, while only one in the PBLG, which is an influencing factor. In other tests, the PBLG students did a bit better, but not significantly.

The focus of this study was on the students' experience during classes as felt by themselves. The measured difference in enjoyment was not as big as expected; there were only some classes where the problem-based learning was definitely more entertaining: when some simple algorithmic patterns were applied for the first time. However, the students' feeling of improvement was significantly better in the first half of the semester in the PBLG. So, it seems beneficial to let students try to solve problems even if the underlying knowledge has not been explained previously, provided that it is easily accessible to them. It is a surprising result that students felt that they learned more when they had the option to try themselves than when they were told the solution to multiple other examples.

There are some important limitations. The most desirable measurement would be the long-term effects of the two teaching methods. How much difference does it bring in motivation to engage in the field of programming? Does it change the way how a person approaches a problem in her professional career? Unfortunately, these are nearly impossible to measure since there are so many influencing factors in addition to what we introduce. Furthermore, in the current measurements, we cannot disclose the effects of other university subjects that might influence how the students develop during the semester. Still, it would be interesting to conduct a similar study with different groups or in another field.

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SPREADSHEET AS AN ALGORITHM VISUALIZATION TOOL

Gábor TÖRLEY, Péter BERNÁT, HU

Abstract: This paper first presents the definition of algorithm visualization (AV) and its potential in increasing students' engagement in the learning process according to Bloom's taxonomy. Then it demonstrates in detail that not only can spreadsheet develop and support computational and algorithmic thinking, but it can also be used as an AV tool. Authors give examples as well on how learners can reach increasing levels of engagement using spreadsheet as an AV tool.

Keywords: spreadsheet, algorithm visualization, computational thinking, algorithmic thinking, programming

1 Introduction

Among the aims of the Hungarian primary and secondary education, the development of students' cognitive skills and the improvement of their thinking have received more and more attention. Real life creates real problems that is why conscious thinking is needed in order to find a quick and efficient answer for everyday problems. Acquiring the ability of computational and algorithmic thinking also provides help in reaching this goal.

Educational programming can take a decisive role in improving the students' cognitive skills by teaching basic algorithms; however, based on past experiences – abroad included [6, 7] –, it is rather complicated to learn and teach algorithms.

One of the strengths of AV can be involving more sensory organs in learning. Kátai et al [8, 10] confirmed that if a teaching method impacts on different sensory organs, it can effectively support the teaching and learning of algorithms. Furthermore, AV tools can be used to develop algorithmic thinking not only in computer science students. [9]

2 Literature review

Algorithm visualization (AV) is a subclass of software visualization, and it handles the illustration of high level mechanisms of computer algorithms, usually in order to help students understand better how algorithms work. [3]

Naps et al expanded [1] the conclusions of Hundhausen et al [3] i.e. a student who is actively engaged with the visualization technology has consistently outperformed learners who passively view visualizations. A taxonomy was defined which determines the level and type of the students' activity. Six levels were stated:

1. No viewing: in this case AV is not used at all.
2. Viewing: students only look at the execution and the steps of AV.
3. Responding: students are presented with questions during the visualization.
4. Changing: students can alter data or make other changes during the visualization.
5. Constructing: students construct the algorithm's visualization themselves.
6. Presenting: students explain the algorithm using visualization and ask for feedback and discussion.

This taxonomy relates to Bloom's hierarchy [11], which is possibly one of the best known and most widely used models of human cognitive processes. A revised version of the taxonomy was published in 2001 (Figure 1.) [2].

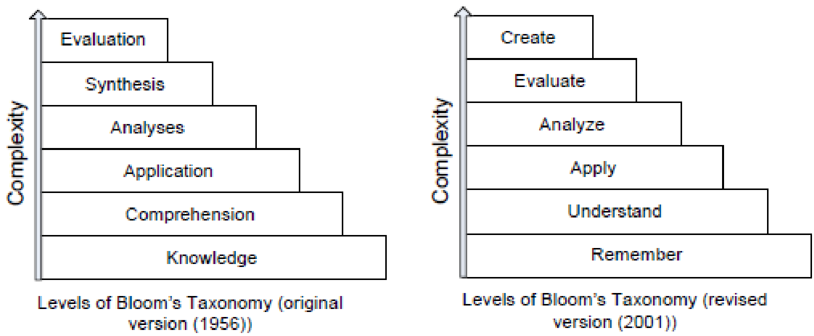

Figure 1: Bloom's Taxonomy, Original and Revised [2, 11]

Learning taxonomies can help description and categorization in cognitive, affective, and other dimensions, in which an individual operates as part of the learning process. In other words, learning taxonomies help us to "understand about understanding". [12]

The new Hungarian Curriculum Framework 2020 [13] adopts an approach according to which spreadsheet is a new topic in the field of "Developing problem-solving skills". Unfortunately, we must note that the new coursebook for spreadsheeting (Grade 9) does not follow this concept. The old tool-centered method is presented instead.

The spreadsheet teaching field includes basic programming concepts [14] like data types, operations, variables, and functions. Tort also suggests adding procedures, scopes of variables, data tables, sorting, etc. because a spreadsheet can be considered as a program and building a spreadsheet is partly programming. If we use a model of a spreadsheet explicitly, then we can help learners in the process of abstraction, which is a very important part of programming.

According to Szalayné [4], a table or a spreadsheet can be considered as a program with data and pre-defined algorithms. Although students can see a table or a spreadsheet on their screens, they need to understand the "program", which consists of their solutions implemented by functions.

Csernoch and Bíró claim [5] that a spreadsheet software can be used as a problem-solving tool. Their method, called Sprego, "is a deep approach metacognitive problem-solving environment, which has borrowed and combined proven methods from high level programming languages. The three milestones of Sprego are

- using as few and as simple general-purpose functions as possible,
- building multilevel formulas,
- building array formulas." ([5] p. 27)

This method can develop students' computational thinking and algorithmic skills. Teaching spreadsheet has an important role in ICT education because students learn several aspects of computer science and develop skills connected to this field, for example, handling data structures, database management, programming principles, logical and computational thinking, and algorithmic skills. Sprego also promotes schema construction through authentic problem-solving and algorithm construction [15].

3 AV in Spreadsheet

Our study connects these two fields above: AV supports demonstration, spreadsheet develops algorithmic thinking. Spreadsheet can visualize the input, the output and the state of the output variable at each step of the algorithm. This means that spreadsheet can show the whole state space (i.e., input, output, and local variables). A spreadsheet software is available for every student, and since this topic is included in the curriculum, students can have the required knowledge. We will show that great programming knowledge is not required in order to create an interactive environment in spreadsheet and by creating the visualization, the student will use algorithmic thinking.

Basic algorithms can be demonstrated in three different levels in spreadsheet:

1. with the appropriate built-in functions, students can become familiar with the concept of programming theorems;
2. using spreadsheet as an algorithm visualization tool, students can understand how programming theorems work;
3. most programming theorems can be implemented using array formulas based on the postconditions of their specifications.

In our paper, we will focus on level 2.

4 Programming theorems and the Counting algorithm

During programming, using algorithm patterns can give general and basic solutions to recurring problems, such as, how many elements have a given attribute in a data sequence, or which is the greatest (or smallest) element of that. In Hungarian programming education, algorithm patterns which relate to one or more data sequences are called "Programming theorems". [16] We will use this term in our paper. Most of modern programming languages include solutions for these problems as built-in functions but we feel strongly that students must understand and create the appropriate basic algorithms by themselves.

According to the new coursebooks based on the new curriculum [13], students learn the concept of programming theorems at Grade 10. Our introductory programming courses at Eötvös Loránd University are also based on the programming theorems. That is why we suggest using our AV examples, presented below, at secondary school (from Grade 10) and at university for students who are familiar with the basic concepts of programming (such as variables and control structures) and can also read pseudo code.

We have chosen the Counting programming theorem as an example. We will demonstrate two kinds of AV of this algorithm: a basic one and an advanced one. Our sample task is the following. At a ski resort, we measured the snow depth in centimeters on some consecutive days. Let us determine the number of days on which the measured value was greater than 5. We will store data (numbers) in a sequence. The algorithm follows the everyday method with which we count objects with a specific attribute. We ask a yes/no question (Does the current object have the specific attribute?) for each object, and if the answer is yes, then we write a mark on a paper, and finally, we count the marks. (Or we can also keep the current count in mind after each yes/no question). Accordingly, the algorithm of the programming theorem uses one auxiliary variable whose initial value is 0 and the algorithm checks all the elements of the data sequence from the beginning to the end and if the current element has the given attribute, then the auxiliary variable is incremented by one. After traversing the whole sequence, the final result can be found in the auxiliary variable.

```
Counting(N, Array, Count)
Begin
  Count := 0
  For i:=1 to N do
    If Array[i]>5 then Count := Count + 1
  End For
End.
```

It is very simple to create the Basic AV in spreadsheet. It will demonstrate the main steps of the programming theorem as a still picture. In order to create the Advanced AV, advanced spreadsheet skills (complex (nested) formulas, conditional formatting, lookup functions) will be necessary. It will demonstrate all the basic steps of the algorithm as an animation, that is why it can support creating the code and novice students can have a more understandable and more spectacular tool.

5 Basic AV

A sequence with 10 integer elements is given on the worksheet (B3:B12), indices are added to the elements (A3:A12) (Figure 2). Our task is to count the numbers that are greater than 5. By copying a formula, let us demonstrate the current value of the above-mentioned auxiliary variable after examining each element of the sequence. (D3:D12)!

	A	B	C	D	E
1	i	X[i]		Count	
2				0	initial value
3	1	3		0	=IF(B3>5;D2+1;D2)
4	2	7		1	=IF(B4>5;D3+1;D3)
5	3	5		1	=IF(B5>5;D4+1;D4)
6	4	6		2	=IF(B6>5;D5+1;D5)
7	5	4		2	=IF(B7>5;D6+1;D6)
8	6	8		3	=IF(B8>5;D7+1;D7)
9	7	9		4	=IF(B9>5;D8+1;D8)
10	8	8		5	=IF(B10>5;D9+1;D9)
11	9	1		5	=IF(B11>5;D10+1;D10)
12	10	4		5	=IF(B12>5;D11+1;D11)

Figure 2: Basic algorithm visualization for the counting programming theorem

A copyable formula needs to be created, which should be based on the previous element of the sequence. Before the first element, we use the initial value of 0. Then, this value (Count) should be incremented every time when the current value (X[i]) has the given attribute. The appropriate formula can be seen in column E.

This solution corresponds to the algorithm of the programming theorem in details: value 0 in cell D2 can be comparable to the initialization of the auxiliary variable, copying the relative reference of the formula refers to the traverse of the sequence and IF function refers to the branch (if conditional) in the loop.

With this Basic AV created in spreadsheet, students can reach all the levels of the earlier mentioned Engagement Taxonomy [1].

5.1 Viewing

The values of the auxiliary variable can be seen for every step of the algorithm (at the same time). If we copy the formula line by line we can see the change of this variable as an animation and we can control its speed easily.

5.2 Responding

Teacher can ask questions in written form about the value of the auxiliary variable. For example, what will the value of variable Count be at specified step of the algorithm? At which step of the algorithm change the variable Count to a specified value? etc.

5.3 Changing

Thanks to the spreadsheet as a developing environment, the elements of the sequence can be modified easily. In order to change the given attribute, it is enough to modify the logical condition in the formula. We can motivate the modification by asking questions. For example, let us modify the sequence in order to get a specified value in variable Count at the end of the algorithm. Of course, questions can refer to modifying the given attribute as well.

5.4 Constructing

We have chosen spreadsheet as a developing environment because students know this tool consequently they can create their own AV in that, with or without support of the teacher. It is a great advantage that for creating the "Basic AV" needs similar (and not more complicated) concepts to those that we would use at programming.

5.5 Presenting

The well-known environment and the few and easy tools which are needed for the visualization support the presentation of the algorithm. Students can copy the above-mentioned formula (column E on Figure 1) as a demonstration. Moreover, they can create the formula during the presentation and can explain the required steps. Of course, they can change the sequence, its size or the given attribute during presentation and can ask questions in order to engage their audience.

6 Advanced AV

Although advanced spreadsheet skills (complex (nested) formulas, conditional formatting, and lookup functions) are required to create the algorithm visualization described below, it provides additional features compared to the basic version (Basic AV).

A ten-element sequence of positive integers is given on the worksheet (D4:M4), each element of which is numbered (D5:M5) (Figure 3). The task is the same as earlier, let us find the number of elements greater than 5. Let us create an animation that demonstrates the operation of the required algorithm and can be played step by step clicking on a spin button (G11:G12)!

During the animation,

1. a black arrow should point to the current element of the number sequence (D3: M3);
2. the background color of the current element should be gray when selected, yellow when tested, and then green or red depending on whether it had the attribute in question (and it should turn back to white when selecting the next element) (D4: M4);
3. the current value of the auxiliary variable should continuously be visible!

Then, let us display the pseudo code or the program code of the programming theorem next to the animation area, and highlight the currently executed instruction with the background color that the current element has in the animation!

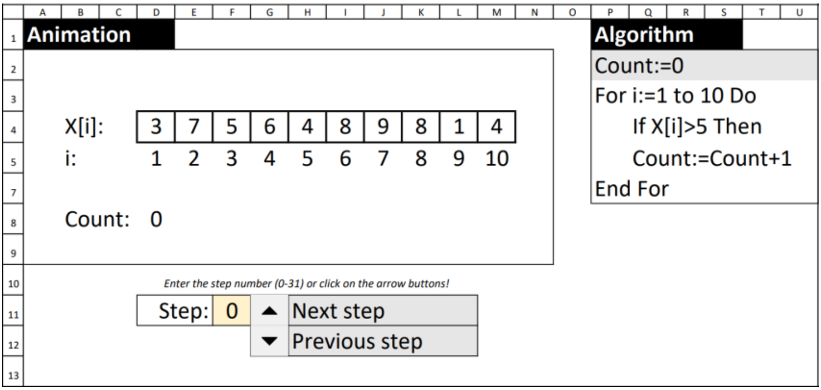

Figure 3: Advanced algorithm visualization for the counting programming theorem

In the implementation, the current step number is stored in cell F11, which value goes from 0 to 31 with the spin button. The step numbers were chosen arbitrarily as follows.

In step 0 the auxiliary variable is set to 0. In step 1, the first element of the number sequence is selected (and gets a black arrow and a gray background color).

In step 2 the element is tested (and gets a yellow background color), and in step 3 the decision is made (green or red background color), and if the answer is yes to the yes/no question, the auxiliary variable is increased by one. In step 4, we move on to the second element, and so on (Figure 4).

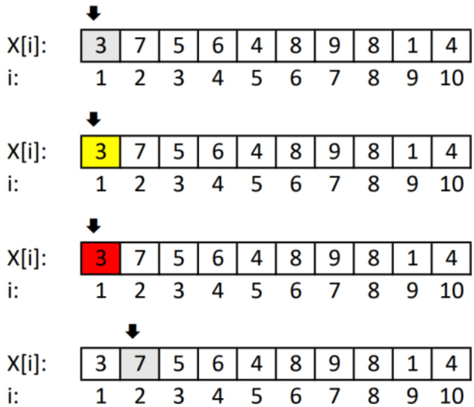

Figure 4: Animation in step 1, 2, 3, and 4

Thus, in step 30, the last element is the current one, and the solution of the original problem can be read from the auxiliary variable (D8). In the very last step (step 31), traversing of the number sequence terminates (the black arrow and the green or red background color disappear).

Conditional formatting was used in the animation, as well as in the pseudo code to highlight the currently performed instruction.

In each cell of range D3:M3, there is an arrow symbol with white font color, from which the only one that points to the current element of the number sequence is displayed in black by the help of conditional formatting. The index number of the current element of the number sequence can be easily calculated from the current step number of the animation.

The background color of range D4:M4 (in which the number sequence is located) is conditionally formatted depending on the current step number of the animation, and the value and the index number of the current element of the number sequence.

Each line of the pseudo code in range P2:U7 is formatted by a separate conditional formatting rule, which depends on the current step number of the animation and whether the tested element has the specified attribute (greater than 5).

Finally, the current value of the auxiliary variable is determined in D8. To this, in a hidden row (row 6) under each element we calculate its temporary value based on the elements so far and the specified attribute just like we did with the basic AV earlier. Then, in D8, we select the proper value from the hidden row according to the current step number of the animation.

Regarding how each level of the Engagement Taxonomy can be accomplished using the algorithm visualization in question, we can say the following.

6.1 Viewing

At the beginning, the pseudo code or the actual program code can be hidden to direct the attention to the animation. We believe that this animation demonstrates the operation of the algorithm in a clearer and more detailed way than the basic visualization. The animation can be viewed at any pace, which can be dictated by the teacher during the presentation and then by the students as they solve tasks. If necessary, they can also jump back to the previous step. During coding, the pseudo code or the program code can be displayed, allowing students to see the algorithm visualization and the algorithm itself at the same time. Because the currently executed step is highlighted in both the animation and the program code, it is easy to determine the relationship between each step of the animation and each instruction in the code.

6.2 Responding

Similar to the first visualization, teacher can ask questions verbally or in writing about how the algorithm works. The question can be about the value of the auxiliary variable, or the animation itself: for example, where the black arrow will be (move) in the next step, and which element will get a background color (and what color).

6.3 Changing

The elements of the input sequence can be easily changed in this visualization as well, but the examined attribute must be modified in several formulas, making it more cumbersome. Otherwise, changes can be motivated with the same questions that we have already outlined in the section on our basic algorithm visualization.

6.4 Constructing

The creation of this algorithm visualization requires advanced spreadsheet knowledge and a longer time (much longer than comprehending the programming theorem in question and writing the proper program code), that is why we recommend this visualization primarily to use and not to create in the class.

6.5 Presenting

At the same time, not only the teacher but also the students can use this visualization very well to present the programming theorem, taking advantage of the already mentioned possibilities of the visualization.

7 Conclusion and future work

In our paper, we have showed the benefits of spreadsheet and AV in order to develop algorithmic thinking, and we linked these two fields together.

We have introduced two types of AV in spreadsheet: an easier one e.g., Basic AV and an advanced one e.g., Advanced AV. With both AV, students can reach all the levels of the Engagement Taxonomy, but there are some differences between them.

Basic AV is very simple. Basic spreadsheet and programming knowledge is enough to use and understand it. Using this kind of visualization, it is easy to understand the current state of the algorithm (at a specific step). It is easy to change and create new visualization as well. That is why we recommend this type of AV for students who have basic knowledge of spreadsheet and programming.

Advanced AV is a better tool for viewing and presenting an algorithm. Its creation and modification (except changing the values of the sequence) needs advanced spreadsheet skills. We recommend this type of AV if the animation and the "output" of the animation is important for the students and the teacher.

We plan to do an empirical study and try out Basic and Advanced AV in our course Programming fundamentals at Eötvös Loránd University. Our students have course on spreadsheet parallel, so we may see how these two fields (programming and spreadsheet) can have impact on each other and how this teaching method can develop students' algorithmic skills.

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MATHEMATICS AND PROGRAMMING IN TEACHING NUMBER THEORY

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Abstract: Programming and mathematics are closely linked, as both have a strong role in problem-solving thinking and in using different algorithms. There are many skills that are relevant to both mathematics and programming. Given the interdependence of the subjects, it is worth looking at the topics that are covered in both programming and mathematics lessons in terms of sequencing. In this article, the topic of number theory is examined from the perspectives of the sequencing and content. Number theory is relatively important at the beginning of teaching programming and programming competitions also tend to frequently include tasks based on number theory.

In this article, we examine which concepts of number theory are discussed in mathematical textbooks and the curriculum in different grades. We show examples of related algorithmic and programming tasks as well. In this way, we show which programming tasks related to number theory can be set for different age groups without any explanation of the mathematical background. By solving these tasks, students are able to focus on the algorithmic and programming aspect to be learned rather than on understanding the mathematical content.

Keywords: number theory, teaching programming, teaching mathematics, programming tasks, beginner programming

1 Introduction

Programming and mathematics are closely linked, as both have a strong role in problem-solving thinking and in using different algorithms. There are many skills that are relevant to both mathematics and programming. There are some that can be learned in either subject, but there are also some that are more easily learned in mathematics (e.g. prime factorization, taking roots) and vice versa, there are some that are easier to visualize and teach in computer science (e.g. concepts related to graphs).

Given the interdependence of the subjects, it is worth looking at the topics that are covered in both programming and mathematics lessons in terms of sequencing. In this article, the topic of number theory is examined from the perspectives of the sequencing and content. Number theory is relatively important at the beginning of teaching programming for multiple reasons, the first of which is its reliability in the teaching of loop types. It can also be used to set a wide range of easy-to-think-through tasks that are easy to illustrate using elementary tools. In addition, programming competitions tend to frequently include tasks based on number theory. Regardless of whether we are talking about tasks performed on a computer or without one [1, 2].

2 Mathematical algorithms in teaching programming

In teaching programming, after the print and read instructions, the most common tasks are related to the number type and more specifically to integer variables. The reason for this is that (most of) the operations that can be performed with integers are already familiar to students from everyday life and from mathematics lessons. However, they do not meet in other subjects what operations can be performed with, for example, text-type values. They are only used to alphabetise words in Hungarian lessons. Or, if they have already been taught spreadsheets in computer science lessons, and within that text functions, they already have some idea of operations that can be performed on texts (e.g. concatenation, cutting, searching). However, from the point of view of teaching programming, it would be inadvisable to start with tasks that contain operations on texts, because it would require functions and an array (text as an array of characters) to interpret operations.

For these reasons, the (integer) number problems are the easiest way for students to learn the basic concepts of programming, especially the different types of loops. Many programming textbooks (courses) also start with mathematical problems, because many problems do not require the use of arrays.

Of course, the learning and teaching process of mainly geometry-based development environments and programming languages (e.g. Logo, Scratch, Micro:bit) are different. There, instead of using numbers, arrays and text variables, the focus is on motion and displacement.

Number-related tasks can be easily linked to mathematical questions and mathematical algorithms. These tasks can also be used to show students why programming knowledge and algorithmic skills are useful to them.

For example, they can create a program that

- determines that a triangle can be constructed from the data based on three lengths of the sides;
- calculate average, factorial or compound interest instead of them;
- round to a given positional notation; or
- convert a number to another number system.

Students also meet with these problems in maths lessons, so they are familiar with the related solution methods and rules. It helps them to focus on learning new programming skills. They can also use the program to check their own calculations and to calculate quickly with larger numerical values, even for tasks where just using a calculator would not be enough.

These experiences will help students to think more easily about more complex mathematical algorithms (e.g. geometric problems, graph problems). In this way, they can be able to learn about different problem solving and programming strategies (e.g. decomposition into sub-problems, bottom-up or top-down construction, solving a similar problem), storage data, efficiency. In the case of more complex tasks and algorithms, the difference in time between calculations on paper and on the computer, and the possibility of eliminating errors in calculations, becomes even more significant.

3 Mathematical algorithms in programming competitions

One of the top levels of teaching programming is programming competitions. In programming competitions there are rarely mathematical exercises in themselves. It is more common to apply mathematical algorithms in practical tasks. When a mathematical problem is set in a competition, the mathematical knowledge which must be used to solve the problem is most often explained in the problem text. For example, as in the following competition task for 11-12th graders:

> **Divisibility by 37 (OKTV 2020-2021. Round 2, Task 1)** [3]
> Divisibility by 37 can be tested by taking the number from the first digit to the penultimate digit of the dividend and subtracting 11 times the last digit. If this number is divisible by 37, then the original number is divisible by 37 as well.
> E.g. 32227 → 3222−(11·7)=3145 → 314−(11·5)=259.
> 259 is divisible by 37, therefore 32227 is also divisible by 37. The iteration stops when the resulting number would be less than or equal to zero. Write a program that decides if a given number can be divided by 37.

This means that competitors do not need to know every algorithm and mathematical concept by name to solve the problem. There are some tasks where a well-known algorithm can be bypassed, however, using and applying it can lead to a much faster and more efficient solution.

For large international competitions, there are rules that specify which mathematical skills can be used in the programming competition task. For example, the IOI syllabus [4] specifies which topics and algorithms can be included in the tasks

- without explanation,
- with explanation only, or
- where knowledge of the algorithm is essential for the solution, or
- if it can be used for the solution, where knowledge of the algorithm is an advantage.

This list makes easier to define which algorithms and mathematical skills need to be learned for a successful competition.

There are also programming competitions with a mathematical theme, such as the Izsák Imre Gyula Complex Science Competition. In these competitions, of course, participants are expected to have a wider range of mathematical skills.

4 Number theory in maths lessons and programming

As mentioned earlier, at the beginning of the programming course, the focus is on tasks related to numbers, especially integers. The main part of the tasks related to integers is related also to number theory. The advantage of number theory is that it contains a lot of simple problems that are easily understood by everyone. But it is also true that it is easy to meet with questions that are impossible to answer (e.g. twin prime) or difficult (e.g. What is the next prime number after the currently known largest?). However, the latter is a question that is being answered with the help of computers.

Many problems in number theory can be set as programming problems whose algorithms are easily understandable to novice programmers and which produce relatively short programs with few lines and elements. From a teaching point of view, it is good that these problems are easily understandable and easily explainable. In most of these problems, the algorithm can be demonstrated with concrete, small numbers, and it can be thought through and tested step by step. The completed program can be run also with large numbers, which would be difficult to calculate without a computer (with many possibilities of errors).

The tasks related to number theory may be familiar to students from maths lessons, where they may also meet with these problems (e.g. prime number, finding divisors). However, it is important to consider when and at which grade level students will learn the mathematical concepts and rules that are required to solve programming tasks. It is not advisable if the mathematical content and the programming knowledge are also new for them.

Another advantage from a teaching point of view is that there are many exercises in number theory that can be made into another with minor modifications, so they can be built on each other. In a single lesson students can solve several related programming tasks, for example related to divisibility, or they can create several versions of one task which are more and more efficient algorithms. We give a few examples of how to build tasks on each other.

The efficiency of programs in terms of memory requirements and runtime for short tasks would be negligible. But it is important that novice programmers meet with efficiency questions early in the learning process. One reason for this is to understand later, when programs with higher memory requirements are used, what is it all about, and to be familiar with efficiency issues. On the other hand, it is easier to visualise what is happening, which steps and operations can be omitted from the less efficient version of the task solution in order to achieve more efficient solutions. A good example of this is the way to find a divisor of a number with a special property (e.g. smallest different from 1) or all its divisors.

In the following, we will examine the main concepts of number theory in relation to the current (2020) NAT mathematics framework [5, 6, 7, 8], to see at different grades which concepts are known and at which level. In this way, we can see which programming tasks can be assigned to the different grades related to number theory.

4.1 Divisor, quotient, remainder

Students learn about the concepts of divisors, quotients and remainders in primary school. First by experience (e.g. grouping objects by 4 in grades 1-2), then by learning division by hand (grades 3-4).

In this way, after 3-4th grade, it is already possible (from the point of view of mathematical content) to carry out programming tasks such as division by remainder without using the division operation, by repeated subtraction. (But from the point of view of algorithm skills, this is a task for a bit older age group.)

```
In: Divident, Divisor
Quotient:=0
Remainder:=Divident
While Remainder ≥ Divisor
   Remainder:=Remainder-Divisor
   Quotient:=Quotient+1
End of while
```

In this task, students can use the method that they have already learnt in mathematics lessons, so this task can be used to introduce the while loop (pre-test).

Listing the divisors of a number is studied in maths in grades 5-6. In this age group, the listing of the divisors of a number is done without prime factorization, using systematic trial and error and with the use of pairs of divisors. They are already familiar with division by a remainder and the division remainder, so they can be also introduced to the modulo programming operation. At this age group, from a mathematical content point of view, we can set a programming task that expects

- listing the divisors of a number;
- determining a distinguished divisor of a number (e.g. largest, smallest) or
- the number of divisors of a given number.

It is not expected from students to give a loop condition that is efficient from a programming point of view, that searches for possible divisors only up to the half or root of the number.

These tasks can be built on each other well, and with minor modifications we can make one from the other. They are also suitable for teaching or practising the while loop and can be used to introduce the for loop.

> Find the *smallest divisor* of a natural number (greater than 1) which is different from 1.

```
In: N
i:=2
While i∤N
   i:=i+1
End of while
```

We should now think of `i∤N` as `N mod i ≠ 0`, because this idea is practically the same as what we do in maths class: *we try all possible divisors until we find one where the remainder of the division is 0*. Since each number is a divisor of itself, `i∤N` condition is correct, there will never be an endless loop.

> Find a positive natural number (greater than 1) *smallest divisor* which is not different from 1 (`Sd`) *and the largest divisor* (`Ld`) which is different from itself.

```
In: N
i:=2
While i∤N
   i:=i+1
End of while
Sd:=i
Ld:=N/Sd
```

Here, the problem can be solved by using the fact that the greatest and smallest divisors are a pair of divisors. In this way, the largest divisor can be calculated by knowing the smallest divisor, because `Sd·Ld=N`. By using this, we get a shorter algorithm with fewer steps than by starting an other loop from `N-1` to try the progressively smaller possible divisors, to find `Ld`. We should talk about this with the students. On the other hand, the use of pairs of divisors is well related to the next task.

> List *all divisors* of a number!

```
In: N
i:=1
While i≤N
   If i|N then Out: i
   i:=i+1
End of while
```

For loop can be used instead of while loop, which can be taught using this task.

```
In: N
For i=1 to N
   If i|N then Out: i
End of for
```

If the task doesn't require writing out the divisors in a row, then we can talk about efficiency. We can use pairs of divisors, which means that if `i` is a divisor of `N`, then `N/i` is also a divisor.

```
In: N
For i=1 to i<root(N)
   If i|N then Out: i, N/i
End of for
If root(N)|N then Out: i
```

As we mentioned it earlier, the idea of searching up to `root(N)` is not an expected idea from grades 5-6 students. But they already know that they can stop searching for divisors with pairs of divisors when the two numbers in the pair are the same or when the next divisor to be tested is larger than the pairs of divisors tested earlier. With this idea we can bypass the use and explanation of the root and we can create an efficient algorithm which is suitable for the age group.

```
In: N
i:=1
While i<N/i
   If i|N then Out: i, N/i
   i:=i+1
End of while
If i=N/i then Out: i
```

In this algorithm, we used the fact that the "second" element of the pair of divisors cannot be smaller than the "first" element of the pair of divisors.

4.2 Prime numbers, prime factorization

In one of the 6th grade mathematics textbooks [9] based on the 2020 NAT, it is stated that if a number has two divisors, it is called prime, but in the other [10] it is not mentioned. According to the 2020 curriculum, the concepts of prime and composite number are learned in grades 7-8. The same is true for the sieve of Eratosthenes and the prime factorization of numbers. It is likely that these concepts will be included in the 7th grade textbooks, but they have not been published at the time of writing.

In mathematics textbooks [11, 12] based on the previous curriculum, the prime factorization of numbers was already included in the 6th grade mathematics textbook. (Although [12] lists it as additional content).

Accordingly, in the new NAT groups, programming tasks related to prime numbers cannot be given before grade 7, only if we explain the concept before that. If we think of the exercise of deciding whether a given number is a prime number or not, it will be enough to rephrase the programming task. For example: *Is it true for the given number that it has two divisors?*

As a programming task, the prime property can be examined as a continuation of the tasks related to finding the divisors. If the smallest divisor of a number which is different from 1 is the number itself, then the number is prime.

```
In: N
i:=2
While i∤N
   i:=i+1
End of while
IsPrime:=i=N
```

Of course, it can be done more efficiently if the divisors are searched up to `root(N)` instead of `N`, or up to `i≤N/i` without using a root, as in the previous example.

However, in the case of prime factorization, it is more difficult to avoid the mathematical content if we want to program it before grade 7. The task can be explained by the age-appropriate mathematical knowledge: *we need a multiplication whose value is equal to the given number and each of the factors has two divisors*. But this would focus the pupils' attention on understanding this, rather than on constructing the correct algorithm. They would also have more difficulty than usual in testing the program they are preparing, since they have no routine in recognising prime numbers and checking prime factorization.

When programming a prime factorization, it is useful to proceed differently from the method used in mathematics class. We can use the knowledge that the smallest divisor of a number which is different from 1, has no divisor different from 1 and from itself, so that the smallest divisor of a number is also a prime divisor.

Find *all prime divisors* of a natural number which is greater than 1 by printing.

```
In: N
i:=2
While i≤N
   If i|N then Out: i
               While i|N
                     N:=N/i
               End of while
   End of if
   i:=i+1
End of while
```

When we created the algorithm, we took advantage of the fact that the smallest divisor is prime. *(If it is not a prime, then the number would have a divisor less than its smallest divisor (different from 1), which also divides the smallest divisor that we have found.)* If we divide by it as much as we can, the next smallest divisor will be prime again. So, we find all prime divisors of the number in increasing order.

From this algorithm, with a bit of calculation, the prime factorization can be constructed. This requires that, after we have found a prime divisor, we count how many times we divide by it.

```
In: N
i:=2
While i≤N
   If i|N then db:=0
               While i|N
                     N:=N/i
                     db:=db+1
               End of while
               Out: i, db
   End of if
   i:=i+1
End of while
```

It is necessary that students be familiar with prime factorization and confident in recognising prime numbers up to at least 50 by the time they use this knowledge in programming tasks. The idea used in the algorithm above goes a bit beyond what is taught in maths class about prime factorization, and needs to be understood in depth. For this reason, we do not recommend to assign programming tasks related to prime factorization before grade 7, and in grade 7 only in interested groups after the topic has been practiced in mathematics lessons.

4.3 Greatest common divisor, multiple, least common multiple

In maths lessons, pupils in grades 5-6 study about the greatest common divisor and the least common multiple of two numbers. In this grade these problems are solved by listing the divisors and multiples.

Students learn in mathematics in grades 7-8 how to find the greatest common divisor and least common multiple using prime factorization.

This is actually not a problem from a programming point of view because, when we are looking for the greatest common divisor of two numbers, the primal factorization method is not the best way to make a program which is easy to program and is efficient. When we make this program, we should follow a similar method to that used in mathematics in grades 5-6. We should systematically start to try the divisors of one of the numbers (in terms of efficiency, the smaller one) in descending order until we find one that is also a divisor of the other number.

This task can be easily linked to the previously mentioned tasks related to divisors and can be assigned after them.

Find the greatest common divisor of two positive natural numbers.

```
In: A, B
If A<B then i:=A
       else i:=B
While i∤A or i∤B
   i:=i-1
End of while
Out: i
```

After students learn about the prime factorization method in mathematics class, they usually have difficulties to remember the possibility of systematic trial and error. It is useful to talk with them about this. The use of prime factorization is faster if we can quickly decide whether a number is prime or not, and also whether it is a divisor of the number in question. To make it easy for the computer to decide all this, we need to "give" a list of prime numbers to the computer, which is already in our heads (for small numbers).

The notion of relative primes is only specifically mentioned in the part of the curriculum for grades 7-8 of the six-grade secondary school [7]. Nevertheless, we think that this concept can be used in programming exercises after explanation, when students are already familiar with the meaning of the greatest common divisor. Such as:

- Decide for two given numbers whether they are relative primes or not.
- Find the largest number that is a relative prime to the given number (natural number greater than 2) and that is at least 2 less than the given number. *(Neighbouring numbers are relative primes. And 1 is good for any number, so there will definitely be a number which is good.)*

Determining the greatest common divisor using the Euclidean algorithm is not part of the mathematics curriculum. So unfortunately only a small percentage of students will learn this algorithm in mathematics class. Nevertheless, it is a well visualizable algorithm that is interesting to learn from a programming point of view, so we think it is useful to show it to students from grades 7-8. Students will not fully understand the mathematical reasoning behind the algorithm without learning about divisibility properties (according to the 2020 curriculum, they will learn about it in grades 11-12). By showing examples, and checking the results of the examples using methods that they know to determine the greatest common divisor, we can show them that the Euclidean algorithm works and it is able to determine the greatest common divisor of numbers.

It is interesting to note that the easier but slower algorithm, which can be used instead of the Euclidean algorithm, relies on the fact that the common divisors of two numbers are also the divisors of their difference. However, this also requires knowledge of this divisibility property.

```
While A≠B
   If A>B then A:=A-B
          else B:=B-A
End of while
Gcd:=A
```

In the 10th grade digital culture textbook prepared for the 2020 NAT [13], there is a much simpler exercise relating to the divisibility of two numbers, which uses no loop, only a selection:

> [13] **page 48 task 7:**
> Ask two integers from the user and then determine if the smaller is a divisor of the larger (so, if the quotient is an integer).

```
In: A, B
If A≥B then divident:=A
            divisor:=B
       else divident:=B
            divisor:=A
End of if
IsDivisable:=divident mod divisor=0
```

4.4 Divisibility rules

Pupils already use divisibility by 10, 100 and 1000 in maths lessons in grades 3-4. In this age group, they do not formulate a specific rule yet, they just observe the shift to the right or left in the table of positional notations.

The list of divisibility rules is extended in the 5th and 6th grades. Students observe and apply the rules of divisibility relating to the end of numbers (2, 5, 10, 4, 25, 100) and the sum of digits (3, 9). At that stage, they are only learning the rule of divisibility by 6 of complex divisibility rules. However, in the mathematics textbooks, the rules for divisibility by 12 and 15 [9] and by 20 [10] are also used in exercises.

The divisibility rules are not mentioned in the part of the 2020 curriculum for grades 7-8 in the topic of number theory. The textbooks for these grades have not yet been produced, so it is not clear what other complex divisibility rules (apart from the rule of divisibility by 6) will be expected for this grade.

(In the 2012 curriculum for grades 7-8 [14], the topic of number theory contains the expression divisibility rules, but does not list exactly which rules are required. In one of the mathematics textbooks for grade 6 [11], complex divisibility rules include divisibility by 6 and 24 with their concrete rule, and there are also exercises with divisibility by 12 and 15. In another series of textbooks, in the volume for 7th graders [15], divisibility by 6, 12 and 24 appears as a rule, and in the exercises, divisibility by 15 and 18 also appears.)

The question of complex divisibility rules in grades 7-8 is very important in the 2020 curriculum because for grades 9-10, number theory is not included in the curriculum at all. Hence, number theory does not appear as a separate lesson or topic in the 9th and 10th grade textbooks [16, 17] based on NAT 2020. In a few exercises, the knowledge of number theory is only mentioned. For example, some divisibility rules appear in set theory [16] or logic problems [17]. Therefore, after grade 8, students will continue to learn about number theory in grades 11-12. In the section of the curriculum for 11-12th graders, knowledge of divisibility rules is mentioned as a requirement, but it is not listed exactly which numbers it means.

For these reasons, it is not clear from grade 7 on which grade levels which divisibility rules are required to be studied when teaching programming in computer science and which ones need to be explained. It is probably best to set the tasks with a description of the rule and a short example. In tasks related to less frequently used divisibility rules, this happens even in programming competitions, as we have shown in an example earlier.

Applying the rule to a concrete example also helps to guess and implement the correct algorithm. For this reason, it is useful to recall the rule and demonstrate its usage. Besides, we have to think about the fact that if students may theoretically know the divisibility rule that is needed, there may still be students in the group who do not remember it or do not remember correctly.

One of the biggest difficulties for students when they are programming divisibility rules is that most of the divisibility rules work with single digits of a number, not with the whole number. For this reason, there are three ways to go.

One of them is to use mathematical operations to determine the digits in each positional notation. This may require the use of powers of 10 and, depending on the group, mathematical operations may require a longer explanation.

Another way is to treat the number not as a number, but as a text. One disadvantage of this is that it requires to secede from integers and the operations that can be performed on integers. We have to switch to text-type variables and operations on texts, which is more remote for students than operations on numbers. Another disadvantage is that, depending on the programming language and the environment, the number has to be converted into text and then the text which contains the digit has to be converted back into a number to make it possible to perform operations on numbers.

The third way is to store the numbers as array elements, one digit by one, which of course also requires operations to be written.

Because of the mentioned programming difficulties, we do not propose to assign tasks related to divisibility rules to beginners who are just getting acquainted with the programming language. Unless they have a very good mathematical sense and have no difficulty in calculating digits using mathematical operations.

4.5 Properties of divisibility, counting with remainders

Calculating with division remainders is already introduced in primary school. At this level, students are only experimentally studying about division remainders. E.g. playing with money, dividing into parts.

In grades 5-6, pupils are already grouping numbers according to their remainder.In addition, in two 6th grade mathematics textbooks [9, 10], it is stated in an example that the division remainder of a sum is equal to the sum of the remainders of its members, or that remainder.

However, learning about the properties of divisibility and calculating with division remainders has been moved to grades 11-12 in the 2020 curriculum. In the textbooks [18, 19] prepared for the 2012 curriculum, these were still 9th grade topics. Thus, according to the new curriculum, pupils will learn much later about the properties of the divisibility of sum, difference, multiplication and power, and will also learn much later about the tasks related to this knowledge in mathematics lessons. E.g.:

[18] page 79 task 3:
Prove that 3 is a divisor of $1516^{40} + 202^{50} + 400^{60}$.

With this topic, the understanding of the mathematical content of Euclidean algorithm is also delayed. Also delayed is, for example, the possibility of programming the problem *How many zeros does a factorial of 100 end in?*
In the 10th grade digital culture textbook prepared for the 2020 curriculum [13], we found one task that can be mentioned as a task related to remainders, but it is only tangentially related to this, because we do not have to perform an operation on the remainder, we only have to define it.

> [13] **page 50 task 4:**
> Write out the numbers between one and one hundred which are divisible by three.
> (...)
> d. Modify the program to use the numbers given by the user instead of one and one hundred.
> e. Rewrite the program so that the user can say a number instead of three.

4.6 Conversion between numeral systems

Pupils start to learn about numeral systems which have different bases from 10 in a playful way in grades 5-6. The curriculum suggests shopping with dump: *"Shopping with dump, e.g. buying products priced with numbers in the decimal system in the virtual shop using token money in denominations of 1, 3, 9, 27, ..., using as few coins as possible."*

In grades 7-8, pupils also have to write the local values of the different numeral systems after they have learned raising to powers. (In the 2012 framework curriculum and in the mathematics textbooks [18, 19] based on it, this was also a grade 9 topic.)

Converting from 10-based numeral system to a different numeral system is easy to make algorithms for, and the process itself can be illustrated with an example. Thus, students can implement a program that converts a number from based-10 numeral system to an other numeral system in grades 7-8. However, the mathematical reasoning behind the algorithm is more complex, so it is better to introduce it to students in mathematics lessons. In a computer science lesson, it is enough to accept that the method shown in the example is suitable for converting a number from 10-based numeral system to an other numeral system. Students who have good mathematical skills and are interested in mathematics may also understand some of the mathematical background of the algorithm based on their previous mathematical knowledge.

However, if we want the students to be already aware of the mathematical explanation of the algorithm when they program the task, we should wait until the 11th-12th grades under the 2020 curriculum.

The conversion from another numeral system to a 10-based numeral system is a more complex process than the opposite. It also requires the digit-by-digit form of the number and powers of the base number of the numeral system. The digit-by-digit generation of the number can be done in the same way as we described above for the divisibility rules for the sum of digits. We can use a text variable, appropriate mathematical operations or an array. If you choose to produce digits by mathematical operations, you should be carefully explaining them. The number (e.g. 3445_6) is not in the 10-based numeral system (6-based in the example), but it is still treated as a 10-based number when we perform the operations to get the digits. For this reason, this solution is only recommended for more experienced groups with a good mathematical sense, or with careful and appropriate explanation.

It is interesting to note that, despite the foregoing, converting between number systems, which is familiar from everyday life, may be a programming task much earlier. For example, to convert time (hours, minutes, seconds) to seconds and back, we use 60-based numeral system. The conversion only requires the calculation of quotient and remainder. And if we add days to the time, the 24-based and 60-based numeral systems are mixed. Pupils do not think of these as numeral systems, but as concepts and units of measurement they know from everyday life, so they are not confused by the mathematical content.

There are also conversion exercises between different units of measurement and currencies in the 10th grade digital culture textbook prepared for the 2020 curriculum. For example, from litres to "akó" (Hungarian unit of measurement):

> [13] **page 57 task 1:**
> Write a procedure that converts the given volume in litres to "akó" and writes the result to the screen.

Or between penny and pound:

> [13] **page 74 task 8:**
> We keep a list of how much money the waiter has put in his wallet in the last hour in London. When he took money out of his wallet, it was marked with a negative number. Our waiter is clumsy and sloppy, so he never gets a tip. `[3, 8, 10, 19.35, -6, 5.1, 9, 20]`
> (...)
> b. If his wallet is empty at the beginning of the hour, how much is in it at the end of the hour?
> (...)
> g. If he had 8 pounds 23 pence in his wallet at the beginning of the hour, how much money was in it at the end of the hour?

If the payments are not stored in decimal form in this task, but the pence and the pound are stored separately, the conversion can be more significant. Similarly, it also can be more significant if we choose currencies that do not differ by a power of 10.

4.7 Amicable, perfect, ... numbers

Amicable numbers, perfect numbers, happy numbers, absolute primes and similar numbers with special properties are not included in the curriculum of primary and secondary school. The curriculum suggests the topic of amicable and perfect numbers as a short presentation for pupils in grades 11-12, but does not specify them as obligatory topics.

Students can meet with these numbers with special properties in extra-curricular maths activities and competitions. In maths competitions, the texts of the tasks not only give the name of these numbers, but also explain their special property. Hence, pupils do not need to know these concepts in competitions by name. It is enough to interpret the properties described in the texts of the tasks.

An interesting aspect of the relationship between number theory and programming is that in programming, these tasks related to numbers with special properties are more frequently given to students and groups who already know the basic programming routines. More complex tasks, tasks which require more programming instructions and tasks which are given in competitions are often related to these number theory concepts. Since pupils are not familiar with these sets of numbers in their mathematics studies, the programming tasks also have to explain in their texts what properties these numbers have.

5 More complex programming tasks related to number theory

Of course, we can also make more complex programming tasks related to number theory than previously mentioned. And these more complex tasks do not need to substantially exceed the mathematics curriculum of the topic of number theory. Here are some examples of our own number-theory related tasks that require more complex algorithms. Because of the complexity of the algorithms required to solve them, these would be given in groups at secondary school, where the relevant mathematical and algorithmic knowledge is already available.

For example, the following task can be set in connection with divisibility rules:

> Make a program that gives all the prime divisors between 2 and 40 of a very large natural number.

The "very large" number mentioned in the text of the task cannot be stored as a number type, so we cannot perform the remainder division operation on it, so it must be stored as text (or as an array of digits). In addition to the text type operations, a new feature is the need for more divisibility rules beside what the students have already know from mathematics. We can leave to students the search for these more complex division rules on the Internet.

To solve the next task, you don't even need that much extra mathematical knowledge. It introduces a new concept, but it only requires the knowledge already learned in grades 7-8. This new concept (discrete semiprime) can be omitted from the task.

> Create an algorithm to decide if a number is a discrete semiprime. Discrete semiprimes are positive integers that are multiples of two prime numbers and not a square number.
>
> e.g.: 33 is a discrete semiprime because $3 \cdot 11$
> 2021 is a discrete semiprime because it is $43 \cdot 47$
> 25 is a semiprime because it is $5 \cdot 5$, but not a discrete semiprime because it is 5^2

```
In: N
j:=2
While j≤root(N) and j∤N
   j:=j+1
End of while
IsDiscreteSemiprime:=j<root(N) and IsPrime(N/j)
```

To solve the task, we utilized the fact that the smallest divisor of a number which is different from 1 is prime, and we used the previously mentioned is prime algorithm, which decides for a given number whether that number is prime or not.

The problem can also be simplified and performed with semi-primes. And it can be extended further by using the concept of a brilliant number.

> Create an algorithm to decide whether a number is a brilliant number.
> Brilliant numbers are half-primes where the two prime factors have the same number of digits.
> e.g.: based on the examples in the previous exercise, 33 is not a brilliant number, but 2021 is

```
...
IsBrilliantNumber:= IsDiscreteSemiprime and
                    Length(j)=Length(N/j)
```

Here, comparing the lengths of numbers can cause some difficulties, depending on the programming language and on the knowledge of type conversions and operations on strings that students are familiar with.

Like this task, the next task, which is related to highly complex numbers, does not require any new mathematical knowledge.

> A highly composite number is a positive integer with more divisors than any smaller positive integer has.
> Create a program that lists up to N the highly complex numbers.

However, the algorithm requires more steps and more attention from the students than if they only had to determine the numbers of divisors of a number.

There are many sets of numbers like these, where a property related to divisibility, the number of divisors, prime factors distinguishes the numbers in the set from other numbers. These properties are usually easy to formulate and understand, so it is easy to create a program that recognizes the numbers with these properties. Some of these special number sets were mentioned by name in the previous subsection.

6 Number theory in programming competitions

The competitions for primary and secondary school students, the programming category of the Nemes Tihamér International Computer Science Competition (NT) and the National Secondary School Competition (OKTV), both feature several problems related to number theory. We will now focus on the tasks that have to be solved on the computer and actually programmed.

According to László Nikházy's collection ([2], table in reference 3), we can get a comprehensive overview of the knowledge which is required to solve the tasks of these two competitions. The collection shows for each task which algorithmic strategy, data structure, algorithm and mathematical concepts are required to solve them. It is indicated for each task if the knowledge is required.

There are 6 columns in all that are based on the topic of number theory. The summary scores for these are shown in **Table 1**. In each cell, the number of tasks related to that knowledge is shown. A task may require more than one knowledge of number theory, so the numbers do not necessarily mean as many different tasks. They analysed a total of 51 tasks from both the 5-8 and 9-10 grades, and 80 tasks from the 11-12 grades.

	NT cat. 1 grades 5-8	NT cat. 2 grades 9-10	OKTV grades 11-12
algorithm related to number theory (greatest common divisor, is prime, etc.)	4	0	0
operations with remainders	11	2	2
prime numbers	0	0	0
prime factorization	0	0	0
greatest common divisor, least common multiple	4	0	0,5
numeral systems, unit of measurement conversions	10	2	0
total number of tasks analysed	51	51	80

Table 1: Extract from László Nikházy's summary table [2]

Although the number of tasks analysed was different for different age groups, it is still clear that the prevalence of number theory in competition tasks is decreasing. For the older age groups, there are only a few tasks related to number theory. One reason for this is that simple, easy to visualize and solve number theory problems are being replaced by more complex problems which require more complex data structures and algorithms (e.g. problems connected to graphs, graph algorithms).

In grades 5-8, many of the competition tasks are related to operations with remainders and conversions between numeral systems and units of measurement. For example:

2018-2019. Round 2 Task 1: Dates [20]
For a date in a year, we can define what week of the year it falls on, what day of the week it falls on, and within that time, how many hours, how many minutes, how many seconds it was. Create a program that gives the distance between two dates and a new date that is the same distance from the later date as the later date is from the earlier date.
The two lines of the standard input contain the two times. Each of them can be written with 5 numbers (`1≤Week≤25, 1≤Day≤7, 0≤Hour≤23, 0≤Minutes≤59, 0≤Seconds≤59`).
The first line of the standard output should contain the distance between the two times, and the second line should contain a new time, which is the same distance from the later time as the later time is from the earlier time!

As it is a competition task, the task text includes the format of the input and also specifies the format of the output.

Pupils in this age group are already familiar with the units of time and count with them routinely. They also got a little extra help in the description of the input for the change of measurements. They may find it a little confusing why the maximum number of `Week` is 25, but it does not disturb them when they are constructing the algorithm, and they may realize that it is to make sure they avoid counting with years when they calculate the new date.

The tasks have to be a bit more complex than those for grades 5-8 in Round 3. One of these tasks in Round 3 requires students to calculate and use the greatest common divisor:

2017-2018. Round 3 Task 1: Castle [20]
Castles have different numbers of rectangular rooms of different sizes. When renovating a castle, the aim is to have the same square tiles in each room within a castle. Create a program that calculates the largest possible tile size for each castle.
The first line of the standard input is the number of castles ($1 \le K \le 10$). The first line of each of the next K blocks contains the number of rooms of a castle ($1 \le T_i \le 10$), followed by T_i lines of the width and length of each room ($1 \le S_{i,j}, H_{i,j} \le 1000000000$).
In line K of the standard output, the maximum size of a square tile to be used in a castle must be printed!

In maths lessons, students solve a lot of similar real-life tasks to practise how to calculate the greatest common divisor. Hence, it is probably easy for them to find that the first thing they have to do is to find the greatest common divisor of the widths and lengths of the rooms. (They can also use the example in the exercise to check that the method they have found out works).

When solving the task, students should also pay attention to the fact that the greatest common divisor should be found per castle and not per room or for all rooms of all castles, but this is also clearly shown in the example.

In grades 9-10, one of the tasks related to numeral systems and remainders is:

2015-2016. Round 2 Task 1: Earthquakes [20]
In Bergengocia, the exact time of earthquakes was recorded for a 31-day month.
Create a program that gives the longest period without an earthquake and the minimum period between two earthquakes.
The first line of the standard input is the number of earthquakes ($2 \le N \le 1000$). The next row N contains the time of each earthquake, in ascending order: ($1 \le Day_i \le 31$, $0 \le Hour_i \le 23$, $0 \le Minute_i \le 59$, $0 \le Second_i \le 59$).
In the first line of the standard output, you have to write the length of the longest earthquake-free period, and in the second line, the minimum of the periods between two earthquakes! The format of both lines should be the same as the format of the input time!

In this exercise, the conversion of units is only a small part of the task, and is essential for solving the rest of the exercise.

One of the tasks in grades 11-12 is related to operations with remainders:

> **2014-2015. Round 3 Task 2: Ranking** [21]
> Pupils in a class are numbered according to their names. We want to rearrange the students in such a way that no one is immediately after the next (i.e. next in line) in the roster.
> Create a program that shows how many ways this can be done. The single row of the standard input has the value `N` (`1≤N≤30`). In the single line of the standard output, write the number of ways in which the reordering can be done! As this can be a very large number, the value must be given as `MOD 1 000 000 000`!

It is also true for this task that operations on remainders are not sufficient to solve the problem. To solve this problem successfully, a good deal of combinatorial knowledge is also required.

7 Conclusion

The topic of number theory can be well connected to the teaching of programming structures, because the tasks are easy to understand and well demonstrated. However, when we assign the tasks, we have to pay attention to the mathematical knowledge of the age group for which the tasks are aimed. For grades studying according to the 2020 curriculum, this will require more attention, as the 2012 curriculum 9th grade number theory topic has been transferred to grades 11-12.

More complex programming tasks, which eventuate longer algorithms, would often require more mathematical knowledge from students than is contained in the secondary school curriculum. Some of this extra knowledge can be avoided by rewording (e.g. the property of a brilliant number can be used to describe the task instead of the notion of brilliant number), while others should be avoided or require additional explanation by the teacher because of the mathematical content (e.g. rule of divisibility by 19, tasks related to properties of divisibility).

Number theory is more important in programming competitions for younger age groups than for older ones. However, the knowledge required to solve the tasks, which goes beyond the compulsory mathematics curriculum, is explained in the text of the programming tasks, thus helping to focus on programming knowledge rather than mathematics.

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ARTIFICIAL INTELLIGENCE ALGORITHMS WITH VISUALIZATION

Imre BENDE, HU

Abstract: Nowadays we are speaking more and more about artificial intelligence (AI). While in the past it was only a theory, now we have enough knowledge and computing power to create and use basic AI in everyday life. Therefore, it is important to teach its basic functions at school, so students get familiar with the way they work. In this article we would like to demonstrate how we can introduce these algorithms to pupils with visualizations including backtrack, A*, minimax, evolutionary algorithm.

Keywords: programming, algorithm, algorithm visualization, artificial intelligence.

1 Introduction

"Algorithm animation is the visualization of the behavior of an algorithm." [2] Therefore it is not only a simple video or animation, as it is more complex and has more fundamental points. In order to find the most convenient way to use, we will concentrate on how the animation should represent the current step, how and what data should appear and how we can track the progression of the algorithm.

The algorithm itself appears in every visualization, which can be a pseudocode (that is what we use) or an exact implementation in a programming language as well. Every main changing mechanism is a breakpoint, where we can check our progression, our achievements, our current position and what is left to do (while the current position in the code is highlighted as already introduced in the first animations as well [1]). This part of the visualization helps to make a connection between the animation and understanding, learn then later reproduce the algorithm to another task.

Another part of the visualizations is the interactivity. Based on Myller's extended taxonomy [6] and research presented in [3], [5] the interactive functions like controlling the visualization and question about the algorithm's next step could help the understanding of the functionality. That is why we will present methods, helping pupils to connect with these (beside the multiple-choice quiz question, controlling the steps and the changing of the speed of the visualization). Few of them even introduce gamification elements, which not necessarily makes the education process more effective (as shown in [10]), but is definitely making it more interactive, and for some of the students more enjoyable. [7] article introduces multiple requirements besides the already mentioned ones: rewind capability, interactive prediction. Unfortunately, the input change with these algorithms is not possible, because most of them already have predefined inputs, or fixed game platform. The application also should be "reliably reaching a large target audience" [7], that is why we chose an online platform, so everybody with Internet connection and a simple web browser can reach it (the code was also written in JavaScript, so the pupils can check the source code as well). [4] also mentions features that make the system more attractive to use, which was in mind at the time the visualizations were created: "easy installation", "platform independence" (it is a HTML+JS application, so no further installation required), "internationalization" (the application is easily translatable with only a notepad, no development environment required)," interactive prediction support" (previously mentioned) [4].

In this paper we will first introduce the algorithms and their pseudocodes, then observe in depth how they can be displayed in the form of a visualization. The goal of this article is not only to introduce how we can visualize these algorithms, but also to demonstrate how we can present more complex algorithms without using, understanding unnecessary knowledge of any programming language's grammar.

2 Heuristic search algorithms

"Strategies that use such considerations are called informed search strategies or heuristic search strategies" [9]. Many algorithms could be a part of this section, but our priority is the backtrack and A* algorithm. While we focus on the often-mentioned algorithms in the topic, it is worth a few words that these games, tasks can be solved with simple, static codes too. It could be a great introduction for each visualization to try to think and solve these problems with the already owned knowledge. This way the students can find strategies, schemes and patterns that could facilitate understanding the later examined algorithms.

2.1 Backtrack algorithm

"Backtracking is a systematic way to run through all the possible configurations of a search space." [9] (algorithm shown in Figure 1)

```
Backtrack-DFS(a, k)
  if a = (a₁, a₂, ..., aₖ) is a solution, report it.
  else
    k = k + 1
    construct Sₖ, the set of candidates for position k of a
    while Sₖ ≠ Ø do
      aₖ = an element in Sₖ
      Sₖ = Sₖ – {aₖ}
      Backtrack-DFS(a, k)
```

Figure 1: Backtrack algorithm [9] ("a" is a given partial solution, by adding another element at the end we test whether it is a solution or not)

The most common introduction task for backtrack algorithm is the **eight queens puzzle**[1].

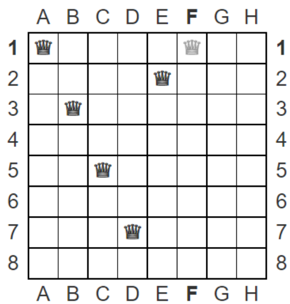

Figure 2: Backtrack algorithm visualization: Eight queens puzzle with already placed queens and the currently investigated newly added queen

- The visualization is the chessboard with the already placed queens (whether it will be their final position or not, so it shows only the actual state). (Figure 2)
- The currently investigated coordinate is highlighted with a transparent queen and additional marking on the file letter and the rank number.

[1] The goal is to put down eight queens on a chess table, while none of them threatens each other.

- With these, every main data, variable is appearing, therefore it is not necessary to show them in a separate block.
- The visualization gives opportunity to place the queens on our own as well, while showing if they are on a "good" position, or one of them threatens another.

2.2 A* algorithm

"A* heuristic is an elaboration on the branch-and-bound search, where at each iteration we expanded the best (cheapest) partial solution that we have found so far. The idea is to use a lower bound on the cost of all possible partial solution extensions that is stronger than just the cost of the current partial tour." [9] (algorithm shown in Figure 3)

```
A* algorithm()
  make an openlist containing only the starting node
  make an empty closed list
  while (the destination node has not been reached):
    consider the node with the lowest f score in the open list
    if (this node is our destination node):
      we are finished
    if not:
      put the current node in the closed list and look at all
of its neighbors
      for (each neighbor of the current node):
        if (neighbor has lower g value than current and is in
the closed list):
          replace the neighbor with the new, lower, g value
          current node is now the neighbor's parent
        else if (current g value is lower and this neighbor is
in the open list):
          replace the neighbor with the new, lower, g value
          change the neighbor's parent to our current node
        else if this neighbor is not in both lists:
          add it to the open list and set its g
```

Figure 3: A* algorithm[2]

Probably one of the most common example tasks for A* algorithm is a pathfinding in a **labyrinth**. We have the description of the labyrinth (where we are allowed to go in each position), a starting point and a goal.

[2] Based on the pseudocode displayed here: https://brilliant.org/wiki/a-star-search/

With the A* algorithm we can get a suboptimal solution to get to the target.

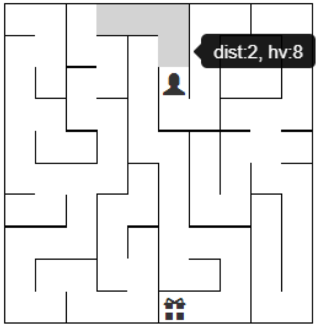

Figure 4: A* algorithm visualization: Labyrinth with data display

In this case the visualization's main part is the labyrinth itself. It should contain where we are now (current observed vertex), where we were (observed vertexes which are not the target point) and where the goal is. The heuristic is based on how far we are from the goal. As we see in Figure 4, we represented:

- The current vertex with a figure (where we are now in the current step),
- the observed vertexes with grey background (where we were already),
- and the goal with a gift.

At this point we see a normal labyrinth representation, while using a pathfinding algorithm. The Depth First Search (DFS), the Breadth First Search (BFS) and the Dijkstra algorithm can be visualized with the same components. At some point (with visualization), we can even compare these, so we can see what the difference between them is, which one is faster/more effective in specific situations.
Normally, we would list the observed vertexes in a priority queue, which contains the vertexes with their name, and would show the distance from start and the heuristic value (sorted by the sum of this two value). In this case the vertexes do not have names, and there are too many of them to show them at the same time. That is why the data should be showed in the "game platform" as well (as we can see in Figure 3). While we hover on a space in the labyrinth, we can see the distance from the start (if the algorithm already calculated it) and the heuristic value. That

is how we will know where the algorithm stands now, and how it chooses which will be the next observed vertex.
“The **8-puzzle** consists of a 3x3 board with eight numbered tiles and a blank space. A tile adjacent to the blank space can slide into the space.” [8] The object is to get a sorted list with the numbers. It has other variants (for example: it has more numbers, or the number replaced by small images, which in the right places can show a bigger picture), but the algorithm and the visualization could work on them as well, it is only matter of computing time and number of the steps of the algorithm. The heuristic this time is how many tiles are in the good positions.

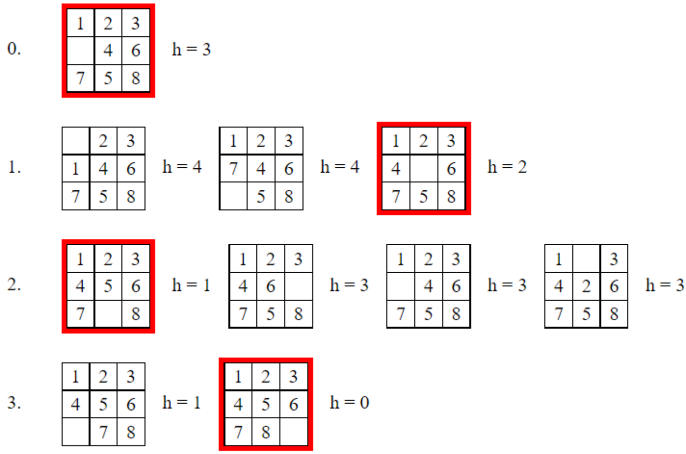

Figure 5: Data visualization for A*: Possible moves in current 8-puzzle game, the best option with heuristic is highlighted

While with the labyrinth the key was a detailed representation of the labyrinth, with a sliding game/8-game it would be different. The main goal is to show the possible moves and how far we are from the goal (sorted numbers) at the same time, while following the algorithm’s path. In this case:

- As mentioned before the most important part is the data visualization. That is why the game’s current state does not have to be too big.
- There are maximum four possible moves in each position, so we can build a graph with these states for a few levels while it is still clear and understandable. We can make it bigger with expanding only the solution’s vertexes. With this the data visualization will not be too wide, and we can display more levels of the algorithm (Figure 5).

Both the labyrinth and the 8-puzzle visualizations are playable, so the pupils can try out the games on their own, while thinking about the used algorithm, or try to find other possible ways to complete the task.

3 Minimax algorithm

The minimax algorithm "returns the operator that corresponding to the best possible move, that is, the move that leads to the outcome with the best utility, under the assumption that the opponent plays to minimize utility". [8] (algorithm shown in Figure 6)

```
function MINIMAX-DECISION (game) returns an operator
  for each op in OPERATORS[game] do
    VALUE[op] — MINIMAX-VALUE(APPLY(op, game), game)
  end
  return the op with the highest VALUE[op]
```

```
function MINlMAX-VALUE(state, game) returns a utility value
  if TERMINAL-TEST[game](state) then
    return UTILITY[game](state)
  else if MAX is to move in state then
    return the highest MINIMAX-VALUE of SUCCESSORS(state)
  else
    return the lowest MINIMAX-VALUE of SUCCESSORS(state)
```

Figure 6: Minimax algorithm [8]

To showcase this algorithm, we need a two-player game, besides it cannot be a game with long gametime (which means too many rounds/possible moves), because then the algorithm would need too many resources, and it would take too much time to calculate the next move. Therefore, we chose a 3x3 **tic-tac-toe**[3] game for a visualization. The maximum level of the decision tree is 9, so it is still manageable by an average computer (that schools have).

[3] The rules are simple: each player marks an empty space with a sign (O/X), who succeeds in placing three in diagonal, horizontal or vertical wins.

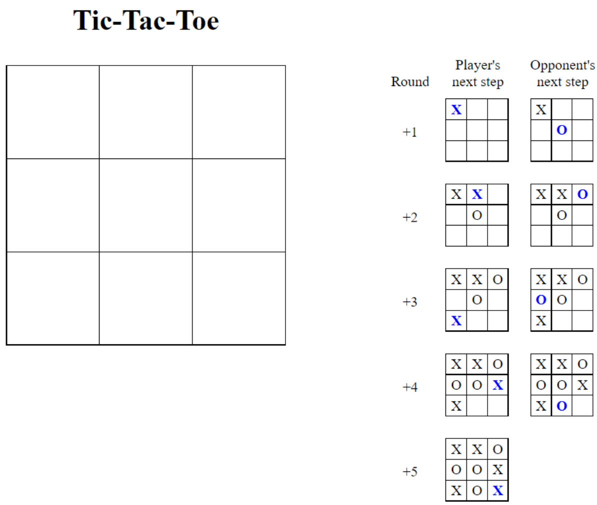

Figure 7: Tic-Tac-Toe visualization with the optimal decisions for each round/player

The main points for the visualization (Figure 7):

- Obviously, we show the 3x3 grid current state with the symbols (O, X) in the visualization.
- The key here is how we can show the decision tree. With every future rounds it becomes bigger and bigger, which cannot be displayed in one screen (1st level has 9 moves, 2nd level has 56 moves, 3rd level has 392 moves, etc.). That is why we only show the "best"/optimal (min/max) moves in a queue, just like as it has shown in Figure 7.
- Each element (row) shows a round with each player's optimal move in the field (the mark is highlighted). Therefore, we can see what we should choose and what will be the opponent's next optimal step (if they follow the algorithm's way).

After checking the visualization, it could also be a useful exercise to find out a simple, static algorithm (strategy) for winning the game (or in this case at least draw because of the length of the game/possibilities). We could even compare the outcome of the game and the running time of the algorithms. The new algorithm would probably have better statistics (much faster answer, lower memory usage), but the minimax algorithm gives a universal solution for 2-player games.

This could only work if we have the option to play the game (which is implemented in this case). With this version we can play the game completely on our own (we put down both signs), and we can play against a built-in AI. The second one can help understand the functionality of the algorithm/enemy, while on the other hand it can help the “player” to make, then implement their own method to beat the computer.

4 Evolutionary algorithm

Evolutionary algorithm “starts with a set of one or more individuals and applies selection and reproduction operators to "evolve” an individual that is successful, as measured by a fitness function”. [9] (algorithm shown in Figure 8)

```
function GENETIC-ALGORITHM (population, FITNESS-FN) returns an
individual
  inputs: population, a set of individuals
    FITNESS-FN, a function that measures the fitness of an
individual
  repeat
    parents ← SELECTION (population, FITNESS-FN) population
    population ← REPRODUCTION (parents)
  until some individual is fit enough
  return the best individual in population, according to
FITNESS-FN
```

Figure 8: Evolutionary algorithm [8]

With this algorithm the result will be a bit different. While with the other algorithms the goal was to show how it proceeds, and what is happening in each step, with evolutionary algorithm the one step of the method will be a generation. Therefore the “visualization” will be similar to a simulation. The simplest way to show the algorithm’s work is setting up a starting point and a finish point in a canvas, while the goal is to reach the second one from the first one. In this case the points/population’s members are evaluated by how close they are to the finish point.

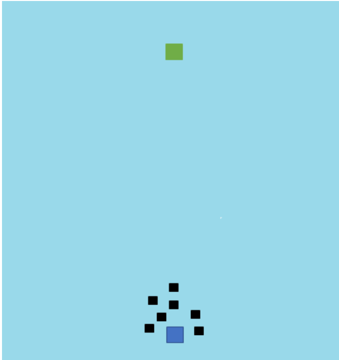

Figure 9: Visualization for evolutionary algorithm (blue is the starting point, green is the finish point and the black one are the current generation's population)

The first variant is when the user can set the number of population and the generation (as inputs). At this point we can see how far the best individuals can reach in the current generation.

The second variation works with the data more deeply (basically it is more concentrated on the data visualization, helping understand algorithm's process). The visualization (Figure 9) for the current step/generation should contain:

- Previous generations' best individual's moveset.
- Current population's moveset (mostly the number of population and the moveset's size is large, but with a sorted list based on the fitness function we can check all the individuals' moves).
- In the previously mentioned list, the "best" individual(s) is highlighted, so we can see its moveset, and what will be the ancestor(s) of the next generation.

4 Conclusion

As we saw a simple animation is not necessarily enough, the key is the connection between the representation, the data, and the algorithm itself - while the visualization highlights main events, that could be explained with descriptions in an "image" or showing the used data structure for the current state. With this we can give the pupils comprehensive image about the algorithm and its operation in a specific situation with a particular case or task. The mentioned methods can easily be converted to another more complex algorithms' visualizations – unlike the usually mentioned basic array algorithms –, for example dynamic programming, greedy algorithm, etc. Thanks to these, we can make the programming education more colourful and enjoyable for every student regardless of whether they have previous knowledge of coding or programming or not, while showing interesting worlds and exciting problems.

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AZ ALGORITMIZÁLÁS, KÓDOLÁS ÉS ROBOTIKA TÉMAKÖR MEGJELENÉSE A DIGITÁLIS KULTÚRA TANTÁRGYBAN, AZ ÁLTALÁNOS ISKOLA FELSŐ TAGOZATÁN

Andor ABONYI-TÓTH, HU

Absztrakt: Magyarországon az új Nemzeti Alaptanterv (NAT2020) a 2020/21-es tanévben lépett életbe felmenő rendszerben az 1., 5. és 9. évfolyamokon. Az informatika tantárgyat a tartalmában és módszertanában is megújult digitális kultúra tantárgy váltotta fel, amelyben fontos szerepet kap a robotika, kódolás és algoritmizálás témaköre. Az új tankönyvekben a diákok (többek között) megismerkednek a robotika alapjaival, blokkprogramozási környezeteket használva szimulálják a robotok működését, betekintést nyernek a micro:bitek programozásába, (saját tervezésű) játékokat fejlesztenek, valamint valós, oktatási robotok segítségével oldanak meg különböző feladatokat, illetve problémákat. Cikkemben áttekintem az új tankönyvek (tervezett) tematikáját, és azt, hogy az új alaptanterv milyen kihívások elé állítja az intézményeket, a pedagógusokat, valamint a tankönyvszerzőket.

Keywords: digitális kultúra, algoritmizálás, kódolás, robotika.

APPEARANCE OF ALGORITHMISATION, CODING AND ROBOTICS IN THE SUBJECT OF DIGITAL CULTURE IN THE HIGHER GRADES OF THE PRIMARY SCHOOL

Abstract: In Hungary, the new National Core Curriculum (Nat2020) was introduced in the 2020/21 academic year in grades 1, 5 and 9, in a phasing-out system. The subject of informatics has been replaced by the subject of digital culture, which is renewed in its content and methodology. The topics of robotics, coding and algorithmics play an important role in the new subject. In the new textbooks, the students learn, among other things, the basics of robotics, use of block programming environments to simulate the robot operation, and the basics of micro:bit programming. Students also learn how to develop self-designed games, and how to solve real-world tasks using various educational robots. In this article, I present the (planned) contents of the new textbooks and the challenges that the new core curriculum poses to institutions, educators, and textbook authors.

Keywords: digital culture, algorithmization, coding, robotics

1 A digitális kultúra tantárgy megjelenése az új Nemzeti alaptantervben

Az új Nemzeti alaptanterv (Nat2020) magyarországi bevezetésére a 2020/21-es tanévben került sor, felmenő rendszerben az általános iskola első és ötödik, valamint a középiskola kilencedik évfolyamain.

Az informatika tantárgy mind tartalmában, mind elnevezésében megújult, immáron **digitális kultúra** néven jelenik meg az alaptantervben. *„A digitális kultúra tantárgy olyan kompetenciák megszerzését teszi lehetővé, amelyek a mindennapi életben nélkülözhetetlenek, és elősegítik az információs társadalom változásaihoz történő folyamatos alkalmazkodást. (…) A tantárgy olyan naprakész ismeretek átadását és olyan készségek kialakítását teszi lehetővé, amelyek biztos alapot kínálnak a tanuló számára az információs társadalomba való sikeres beilleszkedéshez.”* – olvashatjuk a Nat2020 [1] szövegében.

Az alaptantervben foglaltak szerint [1] a tantárgy legalapvetőbb célja, hogy *„a tanuló:*

1. *megszerezze a digitális írástudás, a problémamegoldás és az információs technológia – mint a tantárgy három fő témakörének – ismereteit;*
2. *felkészüljön a digitális kompetenciák széles körű alkalmazására úgy, hogy arra a más tudásterületekhez tartozó tananyagok feldolgozásakor már építeni tudjon;*
3. *rendszerezni tudja a digitális eszközök más forrásokból származó tudáselemeit;*
4. *ismerje a digitális eszközök használatával járó veszélyek kezelését, az ellenük való védekezést;*
5. *fejlessze tudatos felhasználói attitűdjét mind az egyén, mind a közösség, mind a társadalom szintjén;*
6. *megtanulja a problémák digitális eszközökkel való megoldásának módjait, beleértve egy adott probléma megoldásához szükséges algoritmusok értelmezését, kiválasztását, módosítását, illetve létrehozását.”*

A digitális kultúra tantárgy az általános iskola 3. osztályától a középiskola 11. osztályáig folyamatosan jelen van a tantervben.

Arról, hogy hogy az alsó tagozatos tanulók digitális kompetenciáinak fejlesztésével kapcsolatban milyen fő fókuszpontokat tartalmaz az új Nat, Lénárd András publikációjában részletesen olvashatunk [2].

Érdemes azonban rövid, táblázatos formában áttekintenünk, hogy az alsó, illetve felső tagozaton milyen témakörök, mekkora óraszámban jelennek meg az érvényben lévő kerettantervek alapján.

Témakör neve	**Javasolt óraszám 3-4. évfolyam**
A digitális világ körülöttünk	6
A digitális eszközök használata	14
Alkotás digitális eszközökkel	18
Információszerzés az e-Világban	8
Védekezés a digitális világ veszélyei ellen	6
A robotika és a kódolás alapjai	16
Összes óraszám:	68

1. Táblázat: A tantárgy témakörei a 3-4. évfolyamon

Témakör neve	**Javasolt óraszám**	
	5-6. évfolyam	**7-8. évfolyam**
Algoritmizálás és blokkprogramozás	14	15
Online kommunikáció	5	4
Robotika	11	8
Szövegszerkesztés	12	8
Bemutatókészítés	8	6
Multimédiás elemek készítése	8	6
Táblázatkezelés	-	12
Az információs társadalom (e-Világ)	6	5
A digitális eszközök használata	4	4
Összes óraszám:	68	68

2. Táblázat: A tantárgy témakörei az 5-6., valamint 7-8. évfolyamokon

Elmondható, hogy a digitális kultúra tantárgyban megjelenő témakörök három fő témacsoportba tartoznak. Ezek a következők:

1. Digitális írástudás (internetes kommunikáció, szöveges, táblázatos, multimédiás dokumentumok készítése)
2. Problémamegoldás (táblázatkezelés, algoritmus készítés, programozás, adatmodellezés, adatbáziskezelés)
3. Információs technológiák (robotika, webes és mobiltechnológiák)

Van olyan témakör is – az informatikai eszközök használata – , amely integráltan is megjelenik az egyes témakörökben [2].

2 Az új Nat bevezetésének kihívásai

Mivel az új alaptanterv a 1., 5., valamint 9. évfolyamokon felmenő rendszerben került bevezetésre, a 2022/23-as tanév végéig lesznek olyan évfolyamok, akik még a korábbi alaptanterv és kerettanterv szerint tanulnak, míg mások már az új kerettantervekhez kidolgozott tankönyvek és feladatgyűjtemények alapján haladhatnak.

Ezért a **tankönyszerzőknek** figyelembe kellett venniük azt a tényt, hogy a diákoknak esetleg még nincs meg az az előismeretük, amelyet az új Nat megfogalmaz az adott évfolyamra vonatkozóan. Jó példa erre a robotika és kódolás témakör, amely az új Nat szerint már az általános iskola alsó tagozatán (3-4. évfolyam) bevezetésre kerül, ezen ismeretekre viszont az 5. évfolyam számára készült tankönyvben még évekig nem lehet építeni. Ezért az 5. évfolyamnak szóló tankönyv jelenleg olyan bevezető ismereteket és foglalkozásokat tartalmaz, amelyek később az alsós évfolyamnak szóló tankönyvekben kapnak helyet. A fenti okokból a tankönyveket az átmeneti időszakra végére, a 2023/24-es tanévig kis mértékben módosítaniuk kell a szerzőknek, annak érdekében, hogy a témakörök egymásra épülése a tantervben megfogalmazott célokkal összhangban lehessenek.

A **pedagógusok** számára kihívást jelent, hogy a tantervben megjelenő témakörök egy részével (pl. robotika) képzésük során még nem találkozhattak. Ezért rendkívül fontos, hogy a tanárképző intézmények és más oktatási szervezetek olyan tanártovábbképzési programokat indítsanak, amelyek elvégzésével a tanárok magabiztosan és hatékonyan tudják az új ismereteket az oktatásban felhasználni, akár tantárgyak közötti együttműködés keretében is. Az ELTE Informatika Karán például több olyan képzési programot is kidolgoztunk, amely a micro:bitek oktatásban való felhasználását mutatják be, eltérő célközönségre hangolva. Ezek a következők:

- Micro:bitek használata informatikaórákon (informatika tanárok számára)
- Bevezetés a robotikába micro:bitek felhasználásával
- Micro:bitek felhasználása a reál tantárgyakban

A 2020-ban kezdődő pandémia miatt azonban ezen jelenléti képzéseket nem tudtuk elindítani, bízunk abban, hogy a 2021/22-es tanévben már számos tanár kolléga részt tud venni a képzéseken. De a képzéseken felül számos olyan szabadon elérhető, önállóan feldolgozható jegyzetet biztosítunk a pedagógusok rendelkezésére[4], amely a robotika, illetve programozás témakörével foglalkozik.

A **pedagógusok és oktatási intézmények** számára az is kihívást jelent, hogy az oktatáshoz szükséges hardvereszközökből melyeket és milyen forrásból szerezzenek be. Oktatási célú robotokból rendkívül nagy a választék a piacon, ezért a választás nem mindig egyszerű. Nagyon fontos, hogy mindig olyan eszközöket használjunk, amelyek az adott korosztályok számára ideálisak. A választásban segítenek a gyártók által megfogalmazott ajánlások, a tanárkollégák tapasztalatai, vagy akár a kapcsolódó szakirodalom. Több olyan gyártó is van, aki a termékpalettájával képes lefedni a teljes közoktatás spektrumát, a különböző korosztályok számára kifejlesztett robotok, robotjárművek egyre komplexebbek és több feladat megoldására alkalmasak, de a programozásukhoz használható felület ugyanaz, vagy nagyon hasonló, így a diákoknak nem kell feltétlenül újabb és újabb környezetekkel megismerkedniük.

Az is előfordulhat, hogy az oktatási intézményben nem állnak rendelkezésre kellő számban az oktatási célú robotok ahhoz, hogy a diákok hatékonyan dolgozhassanak egyéni vagy akár csoportmunkában. Ebben az esetben sokat segíthet, ha a robot viselkedését szimulálni is lehet, így az adott probléma megoldására kifejlesztett algoritmust és kódot a robot nélkül is ki lehet próbálni, tökéletesíteni lehet, majd a végső stádiumban a gyakorlatban is ki lehet próbálni. Ilyen környezet lehet például egy robotjármű esetén a https://vr.vex.com/ címen elérhető VEXcode VR környezet is. A szimulátorok használata akkor is előnyös lehet, ha a diákok otthon, önállóan próbálnak egy adott problémát megoldani, majd azt ki szeretnék próbálni az intézményben elérhető, valós robotokkal [3].

[4] Jegyzetek, digitális tananyagok (ELTE IK), https://www.inf.elte.hu/etananyagok?m=397

Az új Nat bevezetése a **tanárképző intézmények** számára is tartogat kihívásokat. Szükség lehet az egyes tantárgyak tematikáinak felülvizsgálatára, illetve új (kötelező, vagy szabadon elvégezhető) kurzusok kidolgozására és elindítására. Például az informatika tanárok képzési programjában sokkal nagyobb hangsúlyt kell fektetni a robotika témakör megjelenésére, mint korábban.

2 Az algoritmizálás, kódolás, robotika témakör megjelenése a tankönyvekben

Az 1. táblázatban is láthatjuk, hogy a robotika és kódolás alapjai témakör már az általános alsó tagozatának **3-4. évfolyamán** megjelenik, fő célja pedig az algoritmikus gondolkodás fejlesztése. Kezdetben a diákok még robotok nélkül, különböző eszközök, vagy akár saját testük segítségével végeznek olyan tevékenységeket (pl. útvonalbejárás), amelyek később a robotok irányításának alapját jelentik. A diákok egyszerű algoritmusokat hajtanak végre, azokat módosítják, illetve elemzik. Később folyamatokat modelleznek, szimulálnak, természetesen játékosan, az életkori sajátosságok figyelembevételével. A tanultakat természetesen valós robotok (pl. padlórobotok) használatával is kipróbálhatják, így azonnal visszacsatolást kapnak az általuk megalkotott algoritmus és kód helyességéről [2]. A 3. évfolyamnak szóló tankönyv várhatóan 2021 végén válik elérhetővé.

A következőkben az általános iskola felső tagozatának szóló tankönyvek, algoritmizálás, kódolás, robotika témakörének tartalmát kívánom összefoglalni, amelynek kidolgozásában magam is részt vettem.

Az **5. évfolyamnak** szóló tankönyvben [4] a robotika témakör bevezetéseként először a diákokkal közösen összegyűjtjük, hogy milyen előismereteik vannak a robotokról, az általuk ismert robotok milyen tevékenységeket tudnak elvégezni, majd ezen tevékenységek alapján hogyan lehet csoportosítani a robotokat. Ez a tevékenység jó alkalom arra, hogy beszéljünk a robotok különböző generációiról, az érzékelők nélkül működő első generációs robotokról, az érzékelőkkel ellátott második generációs robotokról és az igazán fejlett, szabályszerűségek megállapítására, gépi tanulásra képes harmadik generációs robotokról. Természetesen – az átmeneti időszak elteltével – ez a témakör már a 3-4. évfolyamnak szóló tankönyvekben fog megjelenni, itt már csak ismétlő jellegű tevékenységekben fog előkerülni.

A robotok tevékenységeit szimulálni is fogjuk a diákokkal. Ennek részeként először vezérelni fogjuk a szimulált (vagy valódi) robotot, amelyhez egyszerű utasításokat fogunk kiadni. Ehhez először megtervezzük a robot tevékenységeit, mondatszerű leírással megfogalmazzuk a feladat megoldásának algoritmusát. Az algoritmusokkal való ismerkedésnél a diákoknak hétköznapi tevékenységekhez kapcsolódó algoritmusokat is meg kell fogalmazniuk, illetve az egyes algoritmusokat el is játszhatják.

Ezek után megismerkedünk egy blokkprogramozási környezet használatával, a blokkok jelentésével, a paraméter fogalmával, a program végrehajtási módjával. Kezdetben a billentyűzet segítségével vezéreljük a szimulált robotot, amelynek alakját akár a diákok is megrajzolhatják, vagy megváltoztathatják. A feladat például lehet az, hogy egy labirintusból kivezessük a robotot. Mindezt akár a Scratch környezetben is megvalósíthatjuk, de megvan a lehetőség más, alternatív környezetek használatára is. A tankönyvben több, alternatív blokkprogramozási környezetből származó példa is helyet kapott, bemutatva azt, hogy egy adott probléma megoldására többféle környezet is használhatunk.

A billentyűzettel történő vezérlés után megmutatjuk, hogy a szereplőnket hogyan irányíthatjuk utasítások segítségével, és hogyan oldhatjuk meg, hogy látszódjon, hogy milyen útvonalat járt be a robot. A labirintus helyett itt már olyan problémák kerülnek előtérbe, amelynél a feladatot ismétlődő tevékenységekkel lehet megoldani, amelynek kapcsán a diákok megismerkednek a ciklus fogalmával és használatával.

Ezt követően olyan problémákat mutatunk be, amelyeknél szükség van arra, hogy a robotunk érzékelje a környezetét, például azt, hogy van-e előtte valamilyen akadály, vagy sem. Ez a feladat is megoldható szimulált környezetben, például a Scratch blokkprogramozási környezet színérzékelőjének használatával, de a valódi, kézzelfogható robotok segítségével is, amelyek használata motiválóbb lehet a korosztály számára.

A tankönyvekben kiemelt szerepet kapott a micro:bit egylapkás számítógép, tekintettel arra, hogy nagyon sokrétű tevékenységeket támogat, és olcsón beszerezhető eszközről van szó. A diákok ennek kapcsán megismerkednek a makecode[5] blokkprogramozási felülettel, egyszerű animációkat készítenek, illetve a gyakorlatban is felhasználják az érzékelőkben (pl. gyorsulásmérő) rejlő lehetőségeket. A projektek megvalósítása során megtanulják a változók, elágazások használatát, egyszerű játékokat készítenek, illetve saját ötleteiket is megvalósíthatják egyéni, illetve csoportmunkában.

[5] https://makecode.microbit.org/

A **6. évfolyamos** könyvben [5] a diákok még mélyebben megismerkednek a micro:bitek által nyújtott lehetőségekkel. A diákok az eszköz LED kijelzőjére rajzolnak a pontok koordinátáit felhasználva, valós folyamatokat szimulálnak, algoritmusokat játszanak el, illetve megismerkednek az összetett feltételek és logikai műveletek használatával. A tanultak alapján a diákok már komplexebb játékokat készíthetnek, saját ötleteik alapján.

Ezt követően a diákok megismerkednek valódi robotok programozásával, melynek része az adott készlet és a programozási lehetőségek megismerése. A tankönyvben példaképpen a LEGO Mindstorms EV3 készlet kerül bemutatásra, illetve a micro:bitre épülő készletekről és azok programozásáról is szó esik. A különböző projektet kapcsán a diákok megismerkednek a motorok használatával, a fékezés és kanyarodás lehetőségeivel. A záró projekt keretében olyan programot kell elkészíteniük csoportmunkában, amely lehetővé teszi, hogy egy előre nem ismert pályán minél gyorsabban végigvezessék a járművet.

A **7. és 8. évfolyamnak** szóló tankönyv jelenleg még fejlesztés alatt áll, megjelenésük 2021 végén, illetve 2022 közepén várható. A tervezett tematika szerint a diákok tovább mélyítik tudásukat a micro:bitek programozásával kapcsolatban; a projektek megoldása során megismerkednek a ciklusváltozó fogalmával és használatával és az egymásba ágyazott ciklusokkal. A micro:bitek közti kommunikációs lehetőségek felfedezése és kipróbálása után olyan projekteket készítenek, amelyekben az egyik micro:bit érzékelője által mért adat egy másik micro:bit számára kerül átküldésre, például grafikonon történő megjelenítés céljából. Ezen tevékenységek után a diákok képesek lesznek arra, hogy saját ötleteik alapján akár többfelhasználós játékokat készítsenek.

A robotika területén a vonalkövetési algoritmusok megismerése, kipróbálása és továbbfejlesztése újabb és újabb problémák megoldását teszi lehetővé. A diákok munkájuk során tetszőleges (az intézményben rendelkezésre álló) készletet használhatnak.

Ebben az életkorban még nagyobb teret kapnak a projekt jellegű feladatok, melyek során a diákoknak valós problémákat kell modellezniük, megoldaniuk a megismert eszközök segítségével.

A kidolgozott tankönyvek mellett a diákok és tanárok munkáját segíti egy feladatgyűjtemény is, amely a Nemzeti Köznevelési Portálon[6] kerül publikálásra 2021 végén.

[6] https://www.nkp.hu/

Összefoglalás

Cikkünkben bemutattuk a digitális kultúra tantárgy céljait, témaköreit és részletesebb betekintést adtunk az algoritmizálás, kódolás, robotika témakör tartalmáról, amely újdonságként jelent meg a fejlesztési területekhez kapcsolódóan. Bemutattuk azt is, hogy a Nat 2020 bevezetése milyen kihívásokat tartogat a pedagógusok, oktatási intézmények, tanárképző intézmények, illetve a tankönyvek szerzői számára, és hogy ezen kihívásoknak hogyan lehet megfelelni.

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PREPARING MICROBIT TASKS USING BLUETOOTH FOR IT EDUCATION

István SZERZŐ, HU

Abstract: Nowadays there are more and more opportunities to use IT tools for edu-cation. There are a lot of appliances available in schools which are capable of providing a feeling of high success without any previous learning. A simple little tool like microbit for example: according to my experiences we can highlight a part like radio/bluetooth connection and we can build educational unit for students from small bits based upon one another even in public education. In this article I would like to introduce this with the help of microbit and I am also going to show some playful classroom task knowhows.

Keywords: IT knowledge, playful programming, microbit, bluetooth, passing IT knowledge.

1 Introduction

First, thanks to the revolution of digital appliances there are plenty of newer and newer technologies which we can use. Our lifestyle is infiltrating into education. One of the tailenders in progressing is IT education where teachers have to update their knowledge constantly because of quick change Nowadays students claim the variety of the latest technologies in use. [1] Here we must deal with integrating mobile based tools into the fields of IT education. Plenty of opportunities have appeared for the latter years and they show the power of technology supported teaching & learning. [2]

Gaining theoretical knowledge which are provided by information technology competences – creating models is a kind of mechanism where you can solve everyday tasks or even more difficult ones and get immediate success. During modelling we prepare general descriptions which help to understand the process with their ordinary language. Preparing a model is an abstraction skill which provides an exact description with the help of one or several IT notions. We use phrases related to information technology in these descriptions with the help of the mother tongue sentences. We prepare solutions for imaginary or real-life tasks, problems. [3]

We can use such problem-solving approach in this current situation in which we can build IT knowledge around mobile technologies. In my report I use teaching in practice primarily combined with the right theoretical training. First, I present a problem, then we are searching for solutions. I am going to introduce 4 parts where I show playful IT tasks based upon connections among appliances.

2 Method

Providing different opportunities, we can prepare spectacular tasks for IT students. When youngsters see the chosen rather playful tasks, they can formulate solutions immediately. I rather wonder what ideas students can give from their surroundings when they see the half ready descriptions shown to them. According to my experiences most students are very talented in completing and colouring unfinished, embryonic thoughts.

This kind of induction works by gradualism where the exercise is rather built upon exercises available and explainable in our environment. Setting the IT task partly only I expect that students use their imagination in completing the exercise. So that they can give birth to complete solutions. In most cases we do not need to intervene during the solution processing. Here is the following aim of those specs, in this way there is not just one possible solution, so that students can use their imagination and creativity to make several alternative approaches. [4]

2.1 Shaping IT tasks

Step by step starting with simpler exercises I only prepared the frame of the tasks which students could enrich with their own knowledge. Certainly, later I extended the tasks' steps gradually to enable students to complete the tasks successfully.

- First, I listed a few words, so that I provided the frame of the solutions
- I expected their very own solutions from the children.
- In the beginning I had the following strategy: I presented the following words only - game, micro:bit, two appliances, Bluetooth.
- Therefore, my directions contain the minimum but the most important parts.
- I intervene exclusively in those cases when solutions do not lead in the direction planned by myself.
- There are several approaches in each given task.

- Although we need to let only those solutions further which reach the final goal, the others must be discussed repeatedly after smaller additions.
- The method mentioned above proves for me that a planned goal has plenty of similar ways to achieve.

2.2 Appliance to use

I experienced that micro:bit can be used well for that method in any age groups. The chosen appliance is small sized but possesses a lot of sensors. Its digital display is 5X5 with LED base. Its processor provides the following information needed for the user: text or shape which can be displayed with the given matrix. Different programming languages could be used for its programming in online area. [5] It gives a lot of help at the beginning if there are sample programmes available for students, those programmes can process plenty of events on sensors. [6]

3 Communicative games

I would like to highlight that radio communication itself is the basic task but there are other supplements which occur sometimes that come into question. If the task needs it, a complex solution can be formed during game planning & design.

I found tasks only for Bluetooth communication channel which can occur in students' everyday life.

Like in data communication the tasks have been made for 4 levels:

- one to one
- one to many
- many to one
- many to many

3.1 One to one

I Before I gave the detailed task, I gave a few additions:

- On the first level, formulate a game for only two people.
- The process of the game should be as simple as possible, so there should be quite a few steps.
- Try to eliminate the solutions offered by the computer.

The result should be readable on the device display. Task can be created only, where only two devices are connected and they perform equal tasks. Out of the pair games, there were quite a few options that made the selection difficult. It was important however, that on a device with a fairly limited display, communication with the user was still clear. This is where the “stone-paper-scissors” game came up as the simplest game.

3.1.1 Method

Modules created:

As a starting state - on start - two information had to be stored, so we entered two variables, one stored its own selected value, and the second collected the number of hits.

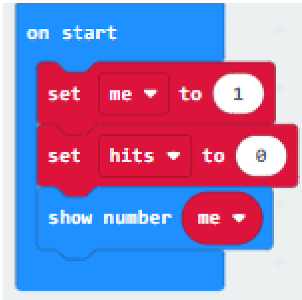

Figure 1: “on start” method

Select your own choice by pressing button A. For simplicity, in the first part, each step has been replaced by integers. Thus, by pressing the key, the integers [1, 2, 3] appear in a circular way on the display.

$$1 \rightarrow 2 \rightarrow 3 \rightarrow 1 \rightarrow \cdots$$

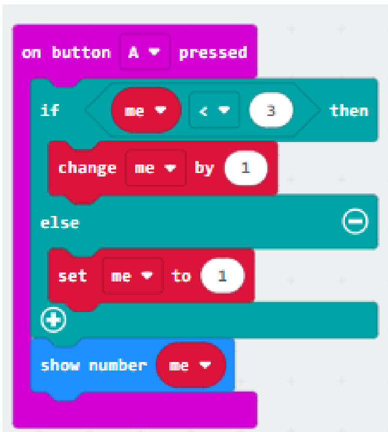

Figure 2: “on button **A** pressed” method

Use the B button to display the number of hits.

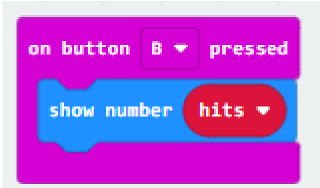

Figure 3: "on button **B** pressed" method

Pressing buttons A + B on this module starts sending the radio signal to the other device.

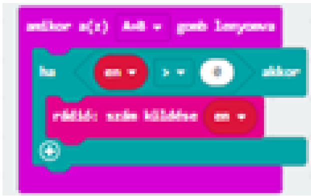

Figure 4: "on button **A+B** pressed" method

In the case of on radio received, when the data of both values - own and the opponent - are available, the evaluation can start. For each of our own hits, we increase the number of hits.

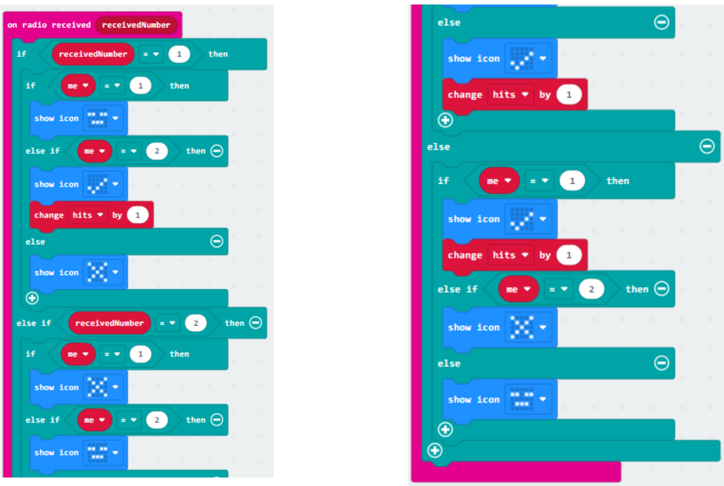

Figure 5: "on radio received" method

3.2 One to many

Further enhancing the first task – allowing on one side to use multiple devices. From one sending location, the signal arrives at several receiving devices and the received task can be completed. Therefore, a solution had to be made, that several devices perform the task in the same way. Here, it is no longer enough to create just one program, as different tasks arise in the sending and receiving parts. The simplest game with a Christmas decoration became the most appropriate idea.

Christmas Decoration

When sending, it is enough to create the solution for only one device, but on the other side, the program can be used in several places. Changing the lineup, I added the option to run the host program on more than two devices.

Server side

On start

The display shows the shape of the bell and creates the game variable with a value of zero.

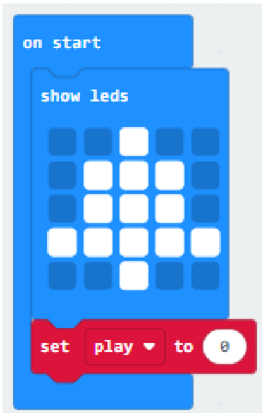

Figure 6: "on start" method

Since the process on the sending side needs to be started I chose the shake event in which by setting the game variable to one, we send the signal needed to start in the direction of the receiving part and we play a melody. At the end of the melody, we reset the variable content of the game to zero.

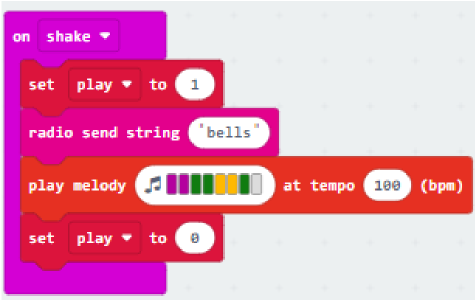

Figure 6: "on start" method

Made with a procedure itRings, the image of the small bell on the display is changing.

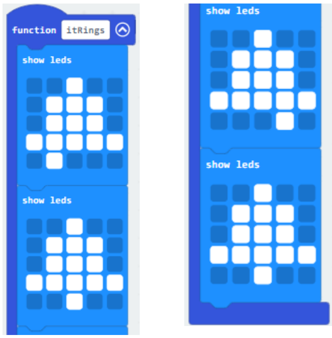

Figure 7: "itRings" method

Client side

At this point, instead of using the on shake procedure, the on radio received procedure has been used, which includes the itRings procedure to start four times when the event arrives.

Figure 8: "itRings" method

3.3 Many to one

From time to time, I may meet students who have already received some form of music education. With their help, we were able to create a game simulating a piano.

In this case, I divided the implementation into two parts again. The task itself contains sections that include multiple sending and one receiving unit. Even if we did not make a real piano that spans multiple octaves, we managed to incorporate an octave of sound for beauty and usability.

Client side

The client-side program contains the notes one by one. The first part contains the value of the radio group setting and the keys - using a program, of course - and can be used for several, in this case eight, devices. The soundList contains the basic octave characters.

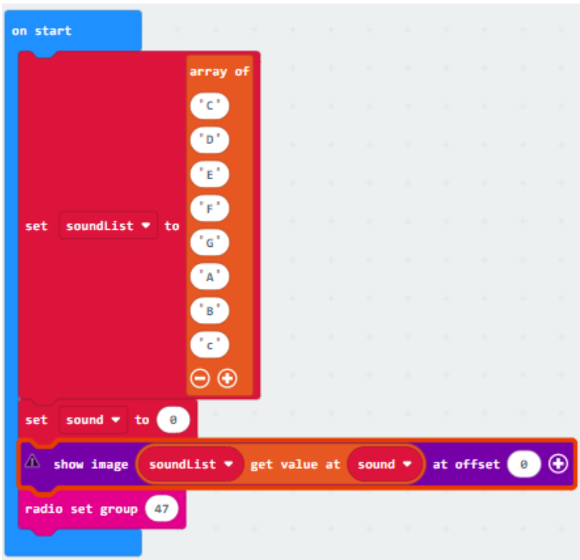

Figure 9: “on start” method

For simplicity, we used both buttons A and B to determine what note the given unit represented.

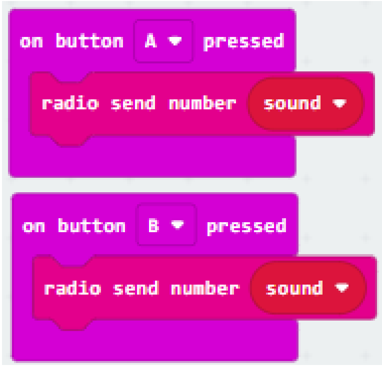

Figure 10: “on start” method

When sending, pressing the **A+B** keys simultaneously starts the set value of the selected soundList array.

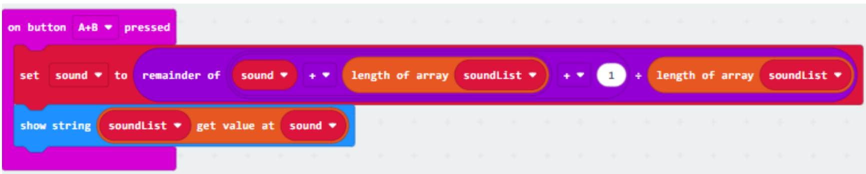

Figure 11: “on start” method

Server side

On start we set the radio group and simply use the number type values sent to the given radio channel from the list of predefined tones to the selected value and display the received numeric value for safety.

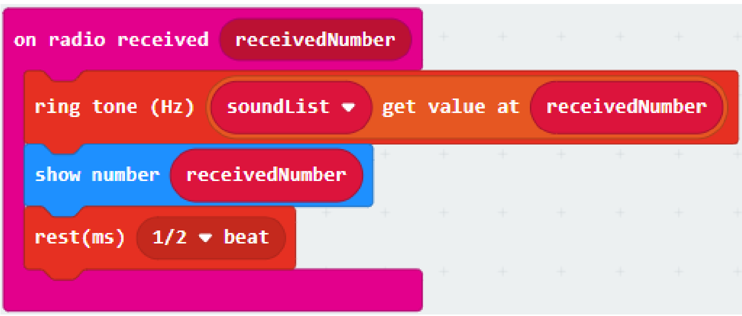

Figure 12: “on start” method

After that, it is enough to upload the sending program created in the first part to eight devices, to set the appropriate music tones. At the receiving part, connect the speaker connection to the serial ports also specified in the simulator.

3.4 Many to many

So far, there has been only one device in one direction, i.e. client-server, on one side. Now, we use more tools on both sides. It should not be imagined in the way that it consists of different servers and again different clients, rather we integrate the process into one machine. We can go in the direction of the first task when both directions were working together. It will be much easier for this little tool to have the dataset you want to share in one place.

For this, I created a more complex task where a lot of data is handled and yet can be interpreted at the elementary school level. At an early stage in school, appears the concept of an operating system. By reviving its schematic principle of operation, the game should be able to place participants in place of processes running in parallel. The dining philosophers problem known from E. W. Dijkstra is suitable for complex process descriptions, which are functionally available in many programming languages based on the solution, [7] but for me, it is a nice challenge to create on such a low-performance device.

This solution is available at:
https://github.com/szerzoistvan/diningphilosophers

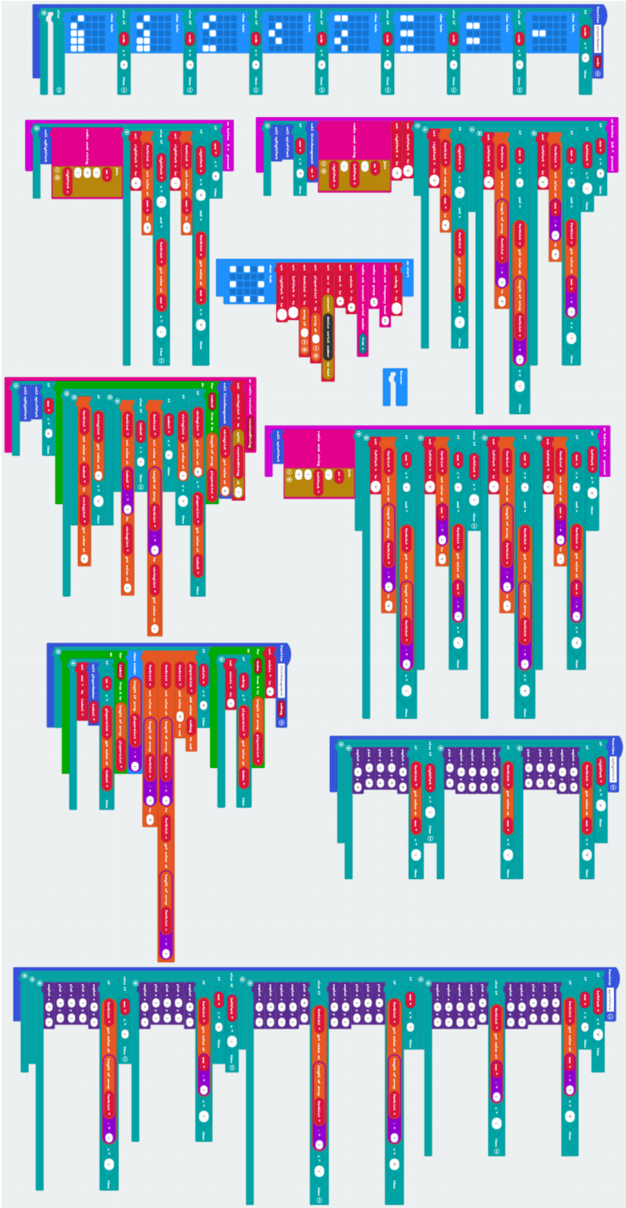

Figure 13: The DiningPhilosofers Micro:bit block program

Preparation: After setting the initial data, the display shows a so-called group placement. Using the events of all three buttons, the recognition of the group is started by pressing the **A+B** buttons. It is always the device in which initialization starts, that sends the group and for itself the connection to the group. This increases the content of the playerList. After that, the forkList is enriched to the same size. On devices that are turned on, the display shows the Arabic numeral of how many are connected. After a device sends out its request to join, it is already logged into the game and it displays its own group number in the bottom two lines of the screen with a Roman numeral. In the top two rows, from top to right, is the fork on the right, with three LEDs. Below the second row, the left fork gets three LEDs from the left again.

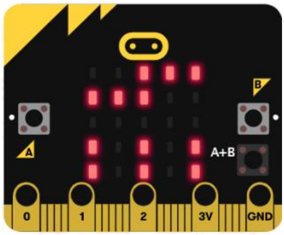

Figure 14: "on start" method

The Figure 14. contains the connection of the third device and the two unattached forks.

Continue game:

We can always use the forks with the help of our own button. If the fork on the right is picked up it will be moved to the center and if the fork on the left was picked up by my neighbor, only one LED from the lightning on the left will appear. (show Figure 15).

Figure 15: "on start" method

A fork picked up by a neighbor will become unusable on the other side and will not move as a result of the corresponding button. Once both buttons have been added at the same time, we can only replace them by pressing the A + B buttons together. The Figure 4. contains the recording of the two forks in the fourth device.

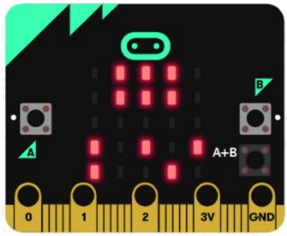

Figure 15: “on start” method

With this short, informal description, the students were able to work together to solve a simplified model of a basic operating system.

4 Experiences

For most of the last school year, when online education took place in high schools, the framework of the examples described were obtained in a high school system after school and during summer IT camps with groups of middle and elementary school students. I observed that the individual groups that received the information needed for the tasks using this hierarchical method had significantly better performance in finding solutions than the groups that were given the full task in advance. Based on this, it can be stated that fewer issues arose during implementation and the applications created were executed more accurately or in a shorter time. Based on the feedback from the students, they really liked that they could complete the task descriptions and unleash their creativity according to their own will.

In many solutions, the initial part of the task I gave them was also upgraded in their unique ways.

It can be said that in many cases I found their ideas supplemented with their uniqueness instructive even to me. Last but not least, the structure of the tasks also stimulated their completion and the motivation of the students. I did not meet a participant at all who wanted to stop the task and based on their feedback, they will apply for even more similar tasks.

I have observed over the last few years that in the school environment and in most of the examinations the students get the full task to work on. I found competitions where the goal was not exactly to make a final solution at once. Based on my decades of experience in the industry and looking at such competitions, solving a task often develops the final form of the program on the fly. The final marketable shape of a software product is always made under the control of the customer and the development of needs.

I was able to experiment my idea for the first time in learning groups - the first one was called MONDAY with eight people and the second was THURSDAY with seven people. The students in the two groups had roughly the same knowledge.

I gave the same tasks in the MONDAY group and the THURSDAY group. The difference was that in the MONDAY group I gave the same task step-by-step, unlike in the THURSDAY group, where they received it at once.

	Stone-paper-scissors	Christmas decoration	Piano	The dining philosophers
Failed	0	1	2	4
Excellent	8	7	6	4

Table 1: MONDAY group result

With

	Stone-paper-scissors	Christmas decoration	Piano	The dining philosophers
Failed	0	2	2	6
Excellent	7	5	5	1

Table 2: THURSDAY group result

It can be seen from the results of the two groups - although not with a big difference - but there is a difference.

This fact didn't convince me yet and I knew I was getting invited to a summer IT camp, therefore I tried the same steps with ten students in the course of a week. There were no difficulties in sorting the five students each. Rather, when giving the tasks, I had to be careful to enter the task gradually or at the same time. There was little time in the camp, so I could only fully evaluate the planning phase. I rather asked for the design in the form of drawings. I give the names of the groups based on the choice of the students. The first ELF: BIT where I used to assign the task in a hierarchical form. In the second, they were given the task at once, it was BEAR:BIT.

	Stone-paper-scissors	Christmas decoration	Piano	The dining philosophers
Failed	0	2	2	4
Excellent	5	3	3	1

Table 3: ELF:BIT group result

	Stone-paper-scissors	Christmas decoration	Piano	The dining philosophers
Failed	1	2	4	5
Excellent	4	3	1	0

Table 4: BEAR:BIT group result

I consider it important to continue the experiments in case of other tasks as well, where I prefer to focus on the planning, and leave the implementation to the students again.

In IT education, understanding the task and the importance of planning determine accurate and effective solutions.

5 Conclusion

It can be said that on this tiny device, even examining only the radio connection part, very nice tasks can be solved. Of course, in addition to the few tasks presented, many other solutions can provide a quick sense of success if we effectively provide a description of the task. These playful solutions can advance students through instructors to not only seek to learn the basics, but also to research and develop more sophisticated playful solutions themselves. This small device can also provide tremendous opportunities for newer generations born into computers.

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GENERATING AND STORING ARTIFICIAL SENSOR DATA

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Abstract: In this paper a relational database structure is introduced, which is suitable to receiving and storing general sensor data. The database structure incorporates the advantages of the structuring that is ensured by relational databases, but still demonstrates the flexibility that would be expected in sensor systems. The database gives the opportunity to define new sensors, sensor types, new measurements and measurement conditions, among other things. A data generation process is also presented, which is implemented in Python. It is able to simulate the operation of sensor systems, and it is suitable for generating sensor data – depending on the properly defined boundary conditions - for transferring the data into the database and for supporting the development of related mobile and desktop applications. The original sensor data are sometimes sensitive, for example the production and personal data in an industrial environment. In this case we usually have to use sample or artificial data under the application development process. Our data generator and database form a complex unit and it is capable of simulating the operation of a sensor environment from the data generation to the efficient data storage.

Keywords: sensor data, databases, data generator

1 Introduction

Nowadays, the sensors are immensely popular and important devices in the industry and in everyday life. We can find them used more and more often in different places and tasks. A sensor is a special device which measures signals from its environment and converts them into a format that a person or a machine can already process and interpret [1]. The sensors have a lot of advantages: we can buy them at a low price, and we can measure almost any value with it, for example the traditional temperature or different production data. For these reasons it is not surprising that, according to the challenges of Industry 4.0, an increasing number of companies and factories acquire and apply such devices to measure various data [2] in their production processes. It helps them to improve the product efficiency, to reduce the costs and to increase the profit. We can also mention the smart home and smart building systems, which also include and use a huge number of different sensors. With the help of special mobile or desktop applications we can control our smart home devices, even from the other side of the world.

Not only the sensors, but the applications which handle them, process and display sensor data, are really important in the industry and in all areas of our casual life. However, in many cases this data can be sensitive, for example the product and machine data in the industry, or the personal data of the workers. In the software development process, the person, or the organization who ordered the application must not transfer the sensitive data to the developers; only sample data, or the characteristic of data can be transmitted. In our article we introduce a complex system with two modules, where the first module is the data generator and the second one is a general database. The data generator generates artificial sensor data according to the given conditions (range, measurement frequency, measurement unit, accuracy, distribution, etc.). The second component, the database receives and stores these data. Our system allows us to quickly and easily create a test environment and test data - which are really similar to the original sensor data - for the development or testing of different applications.

One of the basic elements of the sensor data management process is their efficient, reliable and flexible storage in a database. Both relational and non-relational databases offer the opportunity for this function, with all their advantages and disadvantages. In terms of their popularity, the relational databases are much more acknowledged [3], than the non-relational form and they are capable of performing more complex queries. A huge number of companies usually use traditional relational databases, like Microsoft SQL server. The structure of a non-relational database is not fixed (unstructured), there are no relation schemas, connections, the form and structure of data can be easily modified [4]. Because of the aforementioned, we decided to use and create a flexible relational database structure with its structured background.

Our aims were, in one hand to define and create a relational database to store and handle sensor data from different environments, domains and include the possibility to define new sensors, sensor types, measurements and measurements conditions. On the other hand, the data generator was created in Python language. This application is capable of (1) generating artificial sensor data using the given parameters, for example the distribution, the range, the frequency, the timestamp of the data; and (2) of sending and storing the data to our database. According to the above mentioned expectations, our application – including two main modules – is suitable for supporting the development and testing processes of applications which handle sensor data, without the original, sensitive sensor data being transferred to the developers.

2 The application components

2.1 The database

During the design of the database our aim was to develop a universal, flexible relational database structure. There were four basic, defined requirements according to a sensor system: the database can be expanded with (1) new sensor types, (2) new sensors, (3) measurement types, (4) measurement conditions. Accordingly to the above mentioned expectations, a universal data base structure was developed and implemented, as illustrated in the first figure below.

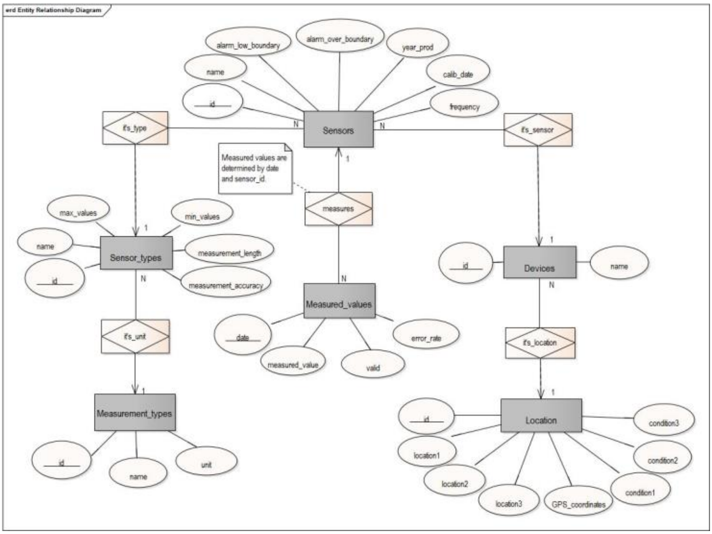

Figure 1: *Entity relationship diagram of our database*

Our database includes the next six tables (Figure 1.):

- **Sensor_types table**: general characterization of the different sensor types in which we can define real sensors to the different types. Each one of the sensor types are defined by a unique identifier (*id*) and each type has a practical name (*name*). *Max_values* and *min_values* are important attributes to define the possible minimum and maximum measured values by the given sensor type. The *measurement_length* and the *measurement_accuracy* are stored, the first one defines the length of one measurement and the second one defines the measurement precision of the actual sensor type (Figure 1., Sensor_types).

- **Sensors table**: it describes the parameters of a given sensor, which belongs to a certain type. Each one of the sensors are defined by a unique identifier (*id*) and each one has a practical name (*name*). There are two important parameters, the *alarm_low_boundary* and the *alarm_over_boundary*. These attributes define the lowest and the highest measured values which might be practically correct. The frequency defines the density of the measurement. Furthermore, the year of the production (*year_prod*) and the date of calibration (*calib_date*) are stored in this table (Figure 1., Sensors).
- **Measurement_types table**: this table describes the parameters of the measured data. All data has a unique identifier (*id*) and has a practical name (*name*). The name depends on the measured values, e.g. temperature (temp), pressure (pres) etc. The unit of the measured values is stored as well (*unit*) (Figure 1., Measurement_types).
- **Measured_values table**: it contains the measured sensor values. All measured values are defined by two attributes: the *date* and the *sensor.id*. The first one defines the exact time of the measurement and the latter defines the sensor from the sensor table, which measured the given value. The attribute *measured_value* stores the measured sensor values. The attribute *valid* is a binary parameter with only two values, 1 and 0. Value 1 shows that the measured value is correct, it is between the *sensors.alarm_low_boundary* and *sensors.alarm_over_boundary* values from Sensors table and the *error_rate* attribute is NULL. Value 0 shows that the measured value is incorrect, in this case the value of *error_rate*, is the value of signed distance of the measured value and the given boundary. The values of attributes *valid* and *error_rate* are created automatically by a trigger (Figure 1., Measured_values).
- **Devices table**: this table describes the parameters of the devices which contain the sensors. Each of the devices are defined by a unique identifier (*id*) and they have a practical name (*name*) (Figure 1., Devices table).
- **Location table**: it describes the parameters of the location of the devices and sensors. Each places and locations are defined by a

unique identifier (*id*) and they have a practical name (*name*). *Location1, location2* and *location3* attributes store the details of the location, e.g. the name of the company. The *GPS_coordinates* attribute contains the accurate location in GPS format. *Condition1, condition2* and *condition3* attributes provide the opportunity to store different information about the conditions of the location, e.g. if the sensor or the device is an indoor or outdoor gadget (Figure 1., Location table).

The next connections were defined between the tables:

- Each of the sensors have one and only one sensor type. In other words there are sensor families, with some well-defined general parameters, in which we can define a concrete sensor, which belongs to the given sensor family. This connection is a one-more relationship, because one sensor family can contain more sensors and one sensor always belongs to only one family (Figure 1., type).
- Each of the sensor types include the unit and the type of the measurement. It is a one-more relationship, because a given sensor type measures only one thing, but one measurement type can measure more than one sensor type (Figure 1., unit).
- The measured values are connected to the sensor which measured them. This is a one-more connection, because a measured value always belongs to only one given sensor, which measured it, but one sensor can measure more than one data type (Figure 1., measure).
- All sensors belong to a device, which contains the given sensor. This connection is a one-more relationship, because a device can contain a lot of sensors, but one sensor is always in one device (Figure 1., sensor's).
- It is important to store the conditions, e.g. where is the sensor. It is a one-more connection, because a given device is always in one place, but more than one devices can be in one place (Figure 1., location).

The efficient and automatized operation of the database is supported by the above mentioned trigger. It helps us to decide whether the actual measured value is correct or not (is it between the boundaries or not). According to this decision we store that the given value is valid or not (0 or 1). If the value is not valid then the trigger calculates the signed magnitude of the error as the difference of the measured value and the proper boundary.

The database and the connected elements were developed in MSSQL-Server Management Studio 18.6 version.

2.2 The data generator

The main task of the data generator module is to create artificial sensor data according to the parameters that are defined by the user. The generator forwards the data to the database, where it will be stored.

The data generator module was implemented in Python language and along with that we used a public Github project, the Mandrova. This project was developed by a Korean team, Mandrova means „make it" in English, but in relation to sensor domain it means „make sensor data" [5].

In the Mandrova project there are a lot of possibilities to create data with different distributions. In this current application we only used the normal distribution, but there is the opportunity to choose other distributions, as exponential, Poisson, etc..

It was really important to design a user-friendly application so that we can generate and store a large amount of the data in an easy way. To fulfil this expectation a special user interface was defined and developed. The user has to give or choose three main parameters on this interface to create the data: (1) choose a sensor from a list, which is queried from the table sensors, (2) the number of the created data records, (3) the timestamp, which defines the timestamp of the last created data. If the parameters are in correct form the data generator starts to create the data in the background. In our current software we used only simple normal distribution for the data generation. This distribution needs two values, the average and the standard deviation (sigma). The average value is the numerical mean of the alarm_low_boundray and alarm_upper_boundary values and the value of sigma was created according to the boundaries. We wanted to create the value of sigma in a simple way, as it is described in the first algorithm.

Algorithm 1.: the definition of value sigma using max_value, min_value, alarm_max_value and alarm_min_value variables

if $\max\_value - min\_value \leq 10$ **then**
    return 2
if $\max\_value - min\_value > 10$ **and** $max\_value - min\_value < 90$ **then**
    return 5
if $\max\_value - min\_value \geq 90$ **and** $alarm\_max\_value - alarm\_min\_value \leq 10$ **then**
    return 7
return 10

The data generator is connected directly to the MSSQL database to send and store the created data.

3 Testing results

After the design and the development of our application the testing period started. The database tables were filled in manually with some sensor types (temperature, humidity, pressure), sensors (hom1, hom2, viznyom1, etc.), devices (XX, YY, ZZ) and locations (hall-A, court-B). The table measured_values was filled in by our data generator after choosing the corresponding parameters on the user interface. There are currently six sensors in our table named sensors and 1700 values were created for each of these six sensors. This is shown in an example in Figure 2, where we chose sensor hom3, the time stamp is 2021. 04. 29 11:56:36 and we generated 1700 values.

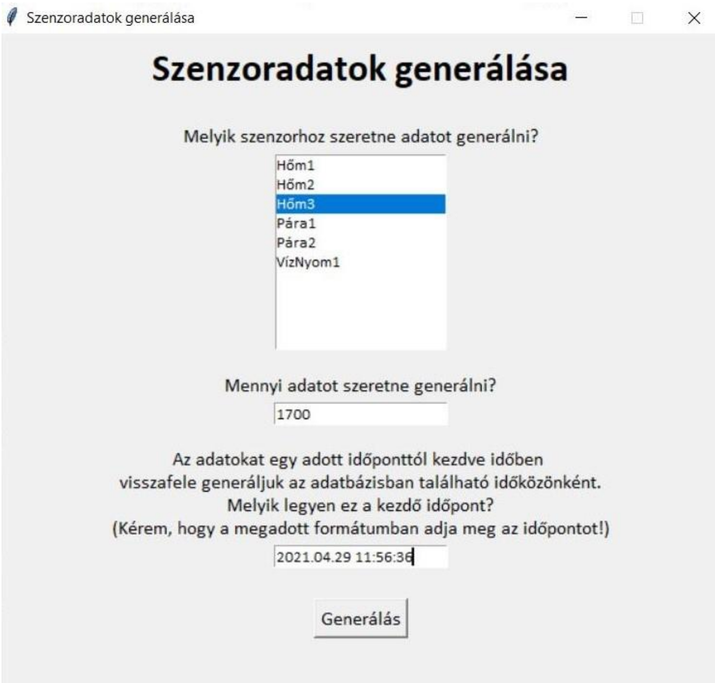

Figure 2: *test data generating (in Hungarian language)*

After a few seconds we got the sign that the system generated and stored the data according to the given parameters. The content of the table was checked manually and we can see a part of the generated data in the first table.

Table 1: *Table measured data, a short example*

time stamp	sensor_id	measured_value	valid	error_rate
2021-04-17 16:46:36.000	3	28.27	0	3.27
2021-04-17 16:56:36.000	3	21.31	1	0
…	…	…	…	…
2021-04-29 11:46:36.000	3	25.71	0	0.71
2021-04-29 11:56:36.000	3	22.21	1	0

After that, the attribute values of valid and error_rate were checked by selecting random rows from the columns including their data. The lower boundary of Hom 3 was 15 and the over boundary was 25, so the trigger generated the right valid and error_rate values in the table.

4 Conclusion

The sensors, the measured data and the related applications are becoming more and more relevant in our everyday life. The reliable development and testing of these applications are very important tasks. The original measured data are very sensitive sometimes, and the owner cannot give them to the developers. We provide a solution for this problem with a data generator and with the connected, universal database structure. In this article a flexible, structured SQL-based database is presented with the tables and the connections between them. Furthermore, a data generator is introduced, that generates random sensor data – under the right, user defined conditions – and transmits them into the MSSQL database. The stored data can be used for the applications in the development phase and for the testing.

Our complex system is suitable for storing data from any sensor environment (factories, smart homes, etc.), because there are tables to store the information about sensors, sensor types, measured data, location and many other conditions. A flexible database was designed, with the opportunity to store new circumstances and parameters. Thanks to the data generator application anyone can easily generate test data in a simple, user-friendly way. The generated data are useable for the development of the new applications, which use the sensor data, and for the testing phase.

The presented, two-component system includes a huge number of the steps to take the process further and development possibilities. The data generator uses only normal distribution in this version, but it is possible to implement other distributions too. In the case of database component, an SQL-based solution was chosen, but we can use NoSQL databases, or any other database forms too. The parametrization possibilities of the data generator can be expanded with the parameters, which are currently burned into the code. The user interface can be supplemented according to the above mentioned steps.

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USE OF FGPA IN HIGH-SPEED INDUSTRIAL NETWORK

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Abstract: Nowadays, the industrial systems are under a lot of cyberattacks. The defence is very difficult due to high-speed data traffic. Detecting and countering different attacks is also difficult. One of option is to use FPGAs.

Keywords: fpga, vhdl, it, ot, industrial network, iiot, spi, ethernet, tcp/ip, honeypot

1 Introduction

Nowadays industrial systems are being hit by more and more cyberattacks. These attacks, in addition to causing significant material damage, also do a lot of damage to the company's reputation. There are several options for protection and minimizing damage. However, they are expensive and even rudimentary. For example, the real-time data collection is very important so that the method and structure of an attack can be understood. This will be very important in the subsequent defence. But how do we collect data on a high-speed industrial network? Is it necessary to store all data? Another task to be accomplished is the post-encryption of protocols used in industrial networks for decades. If we use encryption in the communication of programmable devices, how to implement it in real time? Another way to defend against cyber-attacks could be to use a honeypot. Honeypots are not used in live systems, but we have broken this rule in our research by giving a new task to the industrial honeypot. During a cyber-attack, the purpose of this honeypot is to divert the attacker's attention. It can be seen, then, that protecting an industrial network, detecting an attack immediately or retrospectively is not an easy task. Our goal is to research and develop a target device that, in addition to defence, can also save network data that can be analysed to learn about the characteristics of a cyber-attack, even in real time during an attack. The use of high-speed FPGAs seems to be an obvious solution to these problems, but its use raises several questions. For computer networks and embedded systems, the ENC28J60 Ethernet-SPI converter is commonly used, but the SPI serial protocol significantly reduces the maximum data rate.

In this article, we focus on the implementation of the data acquisition sensor and its placement in the industrial network.

1.1 Problems in Industrial Network

The Ethernet used by today's industrial networks goes far beyond the functionality of standard Ethernet. Ethernet now covers the entire territory of companies, not just the office part. In the case of industrial networks, different communication protocols appear at the fieldbus level, which are connected to the already complex network [1]. The emergence of time-sensitive networking (TSN) in industrial networks brings to the fore the issue of priority. These problems are exacerbated by the growing use of IIoT (Industrial Internet of Things) devices. Today's industrial control equipment (PLCs) are becoming more powerful and processing more and more data. This requires ever-increasing data communication speeds, and our network is becoming increasingly complex. These devices now have more than one Ethernet port. With the help of these ports, they can communicate no longer only with field devices but also with, because due to the size of the equipment, we may need several control devices. In addition, they can write data to databases and display the status of the equipment on a WEB interface. As the cycle time of the equipment is getting shorter for faster production, the data delay, e.g., due to an unexpected attack, can cause serious operational problems [2].

1.2 Devices in our solutions

For the sake of a few sentences, we would like to present the tools that can be used to monitor the traffic of an industrial network, and other "business logic" can be implemented in their use. Such a "logic" to be implemented is the so-called honeypot, which able attracts the attacker's attention during a cyber-attack. However, it is also expected that, if there is no attack in progress the honeypot must be invisible to other participants in the network. This ensures that the data acquisition sensor does not interfere with manufacturing processes.

The ENC28J60 [3] target circuit converts Ethernet traffic to a stream that conforms to the "Serial Peripheral-to-Interface" (SPI) protocol [4]. This is important because not all FPGAs [5] can directly receive network traffic. The architecture of ENC28J60 can be seen in the Figure 1.

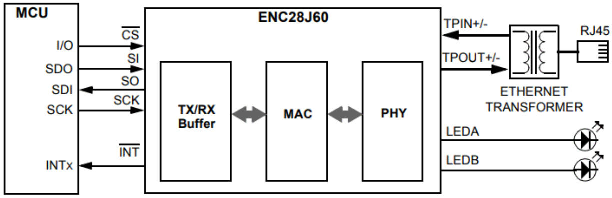

Figure 1: The scheme of ENC28J60 device [3]

The Field Programmable Gate Arrays (FPGA) is a programmable logic device in which various digital circuits can be implemented. The FPGA consists of CLBs, programmable interconnects, different RAM, and I/O blocks (Figure 2).

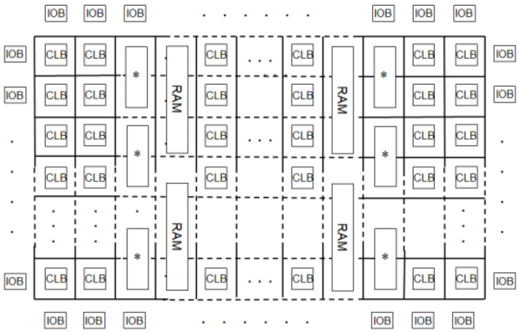

Figure 2: The scheme of FPGA

Different digital solutions can be implemented in the FPGA. Therefore, the architectures we designed are housed in this tool.

The ethernet frame arrives in the FPGA using the SPI protocol. First, we must distinguish the MAC address of the target and source devices in the frame. This is followed by the definition of the protocol, for which knowledge of EtherType is essential (Figure 3.).

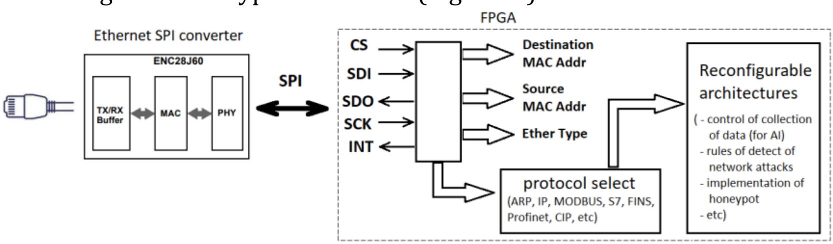

Figure 3: The scheme of architecture of datalogger

The complete data acquisition sensor (and our special solution that can be reconfigured even during operation) is implemented in the FPGA (Figure 3).

The reconfigurable block may contain the following module:

- control of collection of data for AI
- rules of detect of network attacks (detection of PLC discovery, detection of port scanning, detection of ARP poisoning and MAC flooding, detection of data of services, detection of D(D)oS, detection of brute force)
- implementation of honeypot

It is important to note that the modules have not yet been implemented in FPGA.

2 Data logger placement options in industrial network

The data acquisition sensor must be physically located at the manufacturer's site. Therefore, this device must be connected to the industrial network. It is important that this device can not interfere with the high-speed traffic of the industrial network and be able in real time to capture, process and store special data. Unfortunately, data can not be stored in FPGA because there is little memory in this programmable logic device.

Therefore, plus a database must be used in layer 1. The different alerts (e.g.: network attack) and logs should be saved in a database (in layer 1.) for network forensics [9]. This database is not the SCADA database, which is in layer 2. [6].

2.1 General solution in industrial network

For low-speed industrial systems with few network devices, the solution shown in Figure 4 can be used. The PLCs are located in the second layer of the Purdue model [6].

A data acquisition sensor is placed in the industrial network. Although we use a high-speed FPGA, thanks to the use of the SPI protocol, this solution can be used in networks with about 8-10 programmable devices.

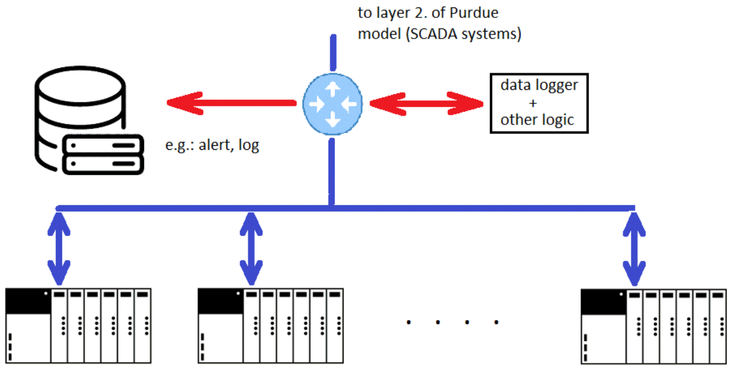

Figure 4: The (part)architecture of industrial network and data logger with other reconfigurable module

2.2 Optimized solution in industrial network

If you want to use data collection or protection in a high-speed network with several industrial devices, the network required be segmented. However, this is not always possible, so we propose a solution that does not affect the structure of the industrial network: a small data acquisition sensor will be installed next to each TCP/IP-based industrial device. This solution can be seen in Figure 5.

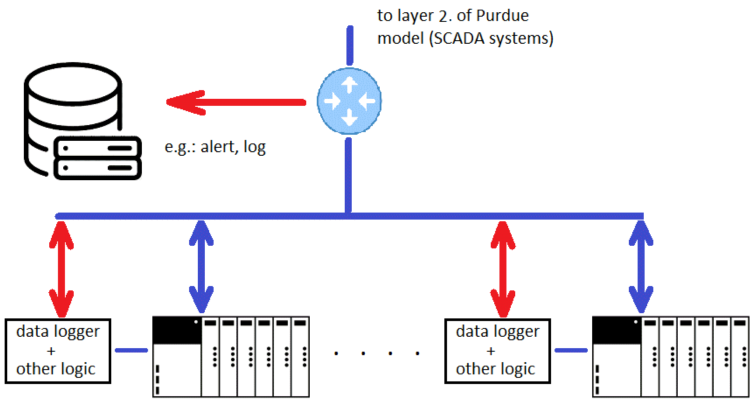

Figure 5: The (part)architecture of industrial network

3 Conclusion

The architectural arrangement that can be used in the industrial network we propose greatly helps to detect a possible network attack, to monitor the execution of the attack. This helps us to strengthen the defence lines.

In addition, our solution can be used to search for special patterns, as it provides the ability to re-configure a configurable block, even during the operation. This can be even a digitally implemented honeypot if needed. Using the industrial honeypot, the focus of the attack can be diverted from the industrial devices that actually play a role in production.

Also, our special data logger can be used to collect data for artificial intelligence or network forensics.

The FPGAs are not good for monitoring large industrial networks because of the high-speed of the network. Therefore, one FPGA per PLC is needed, because network segmentation can not always be achieved.

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TEST ENVIRONMENT FOR SPECIAL PROTOCOLS FOR INDUSTRY COMPUTER SYSTEMS

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Abstract: The security of industrial networks is today a serious requirement, but industrial machines and production lines are not yet prepared for this. The use of unencrypted protocols and default passwords is commonplace even in large companies as well. Our article describes a test environment or protocol proposal that can be conveniently implemented in existing industrial networks..

Keywords: modbus, industry computer system, plc, fpga, vulnerability, OT network, iot, encryption, decryption, cve

1 Introduction

The appearance of Industry 4.0 was unprepared for various factories and production plants. Today, the expectation is that all measurement results and data will be stored in the cloud. Various recommendations [1], [2], tools and architectures have emerged to make this expectation as convenient as possible. However, the basic problem remained, namely that industrial devices (PLCs, actuators, robots, etc.) communicate with each other using unencrypted protocols. For industrial devices communication, Modbus is usually used, which is very convenient to use but unencrypted, i.e., sensitive data (e.g., password, measurement results, etc.) are visible in network traffic.

One of the main features of production lines is that they are rarely shut down, and a timetable must be drawn up for the implementation of the various upgrades [2]. Therefore, industrial systems that have been completed and operating for years are unfortunately not expected to switch to using encrypted protocols. These protocols are generally not yet prepared by PLC manufacturers [3].

In our article, we present the generally accepted Purdue model, the test environment we have created, and we suggest the construction of encrypted protocols that can be easily implemented in an industrial environment and appropriate to the OSI model.

2 Network model of industry

The network of industrial systems and the so-called office network is often interoperable, making an attack easy to execute that causes serious

damage to the company. Therefore, the so-called Purdue model [3] was born, this is a recommendation by which the two given networks can be easily separated, however, this model does not provide perfect protection either.
The three bottom layers are located on the company's production line where the specific production takes place. On the fourth layer we find the different data collection servers, SCADAs [4]. A well-configured DMZ separates the top two layers that belong to the office network (and the Internet).
Thanks to the poor DMZ settings, unencrypted industrial protocols, and default settings can make the industrial network vulnerable even when using the Purdue model (Figure 1).

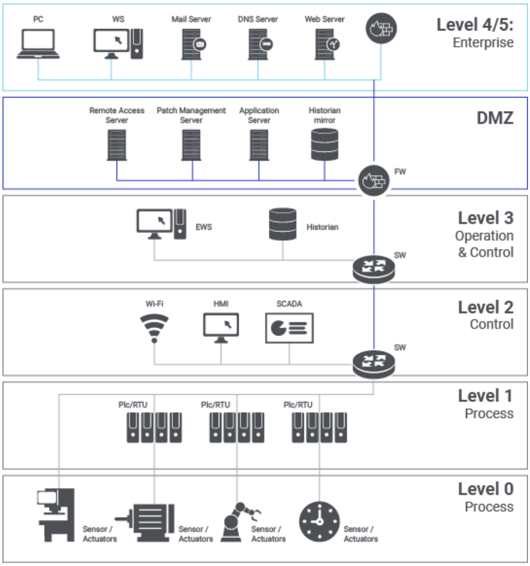

Figure 1: The Purdue model

Some attack modes:

- using of malicious codes
- using of unencrypted protocols
- bad DMZ settings
- using of WIFI

3 Different protocols for industry

Mainly the Modbus TCP is used in industry, which is unencrypted [3]. The TCP protocol (EMP) we propose is an optimized and encrypted protocol that is also based on TCP.

4 Our test Environment

In this article, we propose an encrypted protocol that can be easily and simply implemented on most industrial devices already in use. To test this protocol, a system was developed that implements the lower three layers of the Purdue model (except for level 1, because there are only actuators, valves, robot arms). Included in Level 2 is an S7-1200 PLC, Raspberry Pi 2 and 4, as well as a programmable router. An Ethernet Cap has also been used to monitor network traffic.
Our test environment can be used to conveniently simulate industrial networks that can even be found on the production lines at companies. However, with this test environment, we can easily test and optimize new protocols, as well.
For industrial systems (including the IoT devices, as well), it is very important to be able to implement encryption algorithms in the devices on the network that cause minimal latency and do not reduce device performance. The PLCs (or HMIs, etc.) on the industrial network shown in the following figure are supplemented with encryption/decryption algorithms that cause minimal latency and do not reduce the computing power, and fit in the memory of the industrial device (Figure 2.). There are encryption algorithms in FPGA [9].

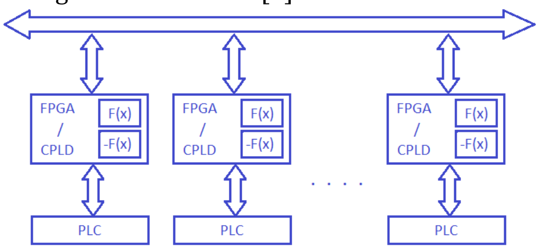

Figure 2: PLCs and Programmable Logic Circuit (FPGA or CPLD) with encyption and decryption algorithms

This function is therefore simple, but can be used to significantly increase security and easily replace the encryption function over the network. In this example, ROT13 has been implemented in VHDL, which easy to implement in FPGA/CPLD as well.

5 Own protocol

Given that Modbus TCP [5], [6] has become widespread in the industry, our own protocol architecture follows this layout as well. We opted for the similar architecture so that industry players can easily implement this in their own systems.

Of course, our own protocol design was based on the structure of the Ethernet frame (Figure 3).

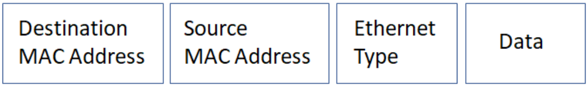

Figure 3: The Ethernet frame

The recommended value of Ethernet Type is 0x8AFF [7].

The next figure shows the structure of the OSI model, Modbus_TCP, and our own protocol (Figure 4). The "EMP TCP" section contains the encryption function whose inverse can be used to decrypt the encryption in real time.

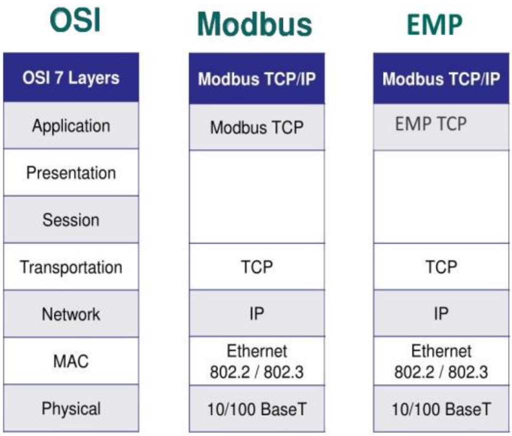

Figure 4: Layers of OSI, Modbus TCP and Own protocol

The next figure shows Modbus data traffic, Here the values of registers are read out. It is easy to notice that the traffic is unencrypted. So sensitive data can be accessed and even the measured values can be easily modified.

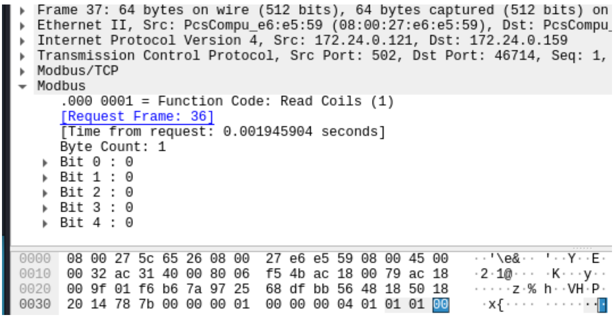

Figure 5: Data without encryption (sensitive data is visible)

There is an additional serious problem that the active scanners recognize this industry protocol thanks to the use of port 502 (Figure 6.).

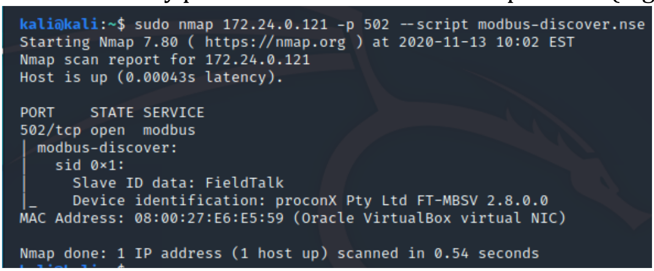

Figure 6: Sensitive data by active scan (nmap script)

Let us send the message "hello world" to the network with ROT13 encryption (f (x) = ROT13). "Hello world" is encrypted as "uryyb jbeyq". Now send the encrypted message and decrypt at the target device, but in the network traffic only the encrypted value is visible (Figure 7.).

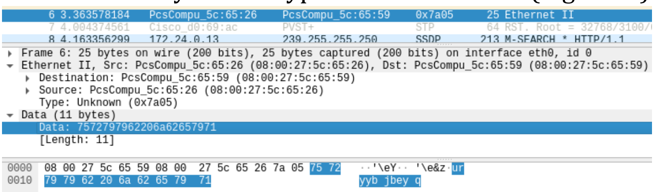

Figure 7: Encrypted sensitive data

The Wireshark does not recognize the protocol used, instead it identifies as 7A05. As the 7A05 is unknown, it is also difficult to produce a CRC with a subsequent packet injection.

Although ROT13 is a known and very simple protocol, using this we can very conveniently encrypt the data traffic.

6 Advantages of own protocols

The following table compares its own and Modbus properties. Some SCADA features were also included.

	Own protocol	*Modbus*
Port number	can be arbitrary, unique (except for special ports)	502
Vulnerabilities	Based on ASP.NET .NET 5, updates are handled by Microsoft	Known vulnerabilities, rarely updated, e.g. HTTP instead of HTTPS at SCADA
Encryption	encrypted	unencrypted

Table 1: Comparison of Modbus and own protocol

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ROZVOJ PRIESTOROVEJ PREDSTAVIVOSTI NA HODINE INFORMATIKY V 5. ROČNÍKU ZŠ

Tibor SZABÓ, Rastislav ŽITNÝ, SK

Abstrakt: Príspevok sa zameriava na rozvoj priestorovej predstavivosti žiakov v 5. ročníku ZŠ v rámci hodiny informatiky. V príspevku ukážeme niekoľko konkrétnych aktivít, ktoré slúžia na rozvoj priestorovej predstavivosti. Uvedené aktivity zohľadňujú aj obsah Štátneho vzdelávacieho programu. Napokon, snažíme sa nájsť synergický efekt spojenia priestorovej predstavivosti a príslušného predmetu na škole.

Kľúčové slová: priestorová predstavivosť, aktivita, informatika, interaktivita, vizualizácia.

DEVELOPMENT OF SPATIAL IMAGINATION IN COMPUTER SCIENCE LESSON IN THE 5TH GRADE OF ELEMENTARY SCHOOL

Abstract: The paper focuses on the developing of spatial imagination at the pupils in the 5th grade of elementary schools in computer science lessons. In this paper, we are trying to show some specific activities and task to support the developing of spatial imagination. These activities consider the content of the National Programme of Education. Finally, we are trying to find effective tools which leads to development of spatial with synergy of spatial imagination and subjects in school.

Keywords: spatial imagination, activity, informatics, interactivity, visualisation.

1 Úvod

Pre STEM (Science, Technology, Engineering and Mathematics) odbory je priestorová predstavivosť mimoriadne dôležitá. Na základe výsledkov Testovania 9, žiaci na Slovensku po dokončení základnej školy nedisponujú s dostatočnou priestorovou predstavivosťou. [11] Tieto schopnosti sa u človeka rozvíjajú postupne od narodenia, ale predsa existujú určité etapy života, kedy sa dajú rozvíjať efektívnejšie. Žiaci piateho ročníka patria práve do ideálnej vekovej kategórie (11 až 12 rokov) [1, 2], preto by sme mali venovať rozvoju priestorovej predstavivosti väčšiu pozornosť. Pri rozvoji týchto schopností v prvom rade by sme mohli myslieť na vyučovacie hodiny matematiky, hlavne na geometriu. Nakoľko priestorová predstavivosť má multidisciplinárny charakter, môžeme ju rozvíjať aj na iných vyučovacích hodinách. V rámci nášho KEGA projektu (Rozvoj priestorovej predstavivosti 10-12 ročných žiakov základných škôl) sa sústreďujeme na matematiku, informatiku a výtvarnú výchovu. Musíme spomenúť, že existujú rôzne typy aktivít, ktoré efektívne môžu prispievať k rozvoju priestorovej predstavivosti. Babály a Kárpáti (2015) pomenovali päť typov:

- používanie stavebníc v detstve,
- remeslá a kutilstvo,
- 3D počítačové hry,
- šport,
- rozvoj matematických schopností.

Okrem športu v rámci projektu využívame všetky uvedené aktivity. V tomto príspevku sa zaoberáme len úlohami pre hodiny informatiky.

2 Informatika v 5. ročníku ZŠ

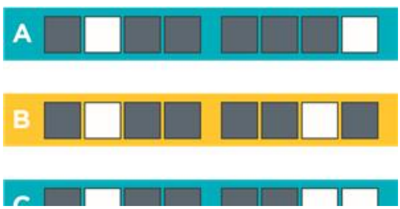
Štátny vzdelávací program (ŠVP) v predmete informatika sa na jednej strane zameriava na získanie konkrétnych skúseností a zručností pri práci s počítačom i aplikáciami, a na druhej na budovanie základov informatiky. [5] Výkonové štandardy pre 5. ročník nie sú definované zvlášť, ale sú spolu so 6. ročníkom, teda štandardy definujú len to, čo má žiak vedieť na konci 6. ročníka. V prípade nami vytvorených aktivít sme sa prvom rade sústredili na prácu s grafikou a na algoritmické riešenie problémov (analýza problému, jazyk na zápis riešenia, postupnosť príkazov, cykly).

3 Aktivity

Pri tvorbe aktivít okrem obsahu ŠVP sme brali do úvahy aj ďalšie dôležité aspekty, ako napríklad vizualizácia, interaktivita, motivácia a konštruovanie objektov. Správna vizualizácia a interaktivita pozitívne prispievajú k zvyšovaniu efektivity učebných materiálov alebo aktivít. Dôležitosť vizualizácie je zrejmá, veď už na to upozornil aj Ján Amos Komenský. Podľa Pšenákovej a Hegedűs (2017) „interaktivita je aktívne zapájanie sa účastníkov do edukačného procesu“. Teda interaktivita určitým spôsobom dokáže zabezpečiť aktívnejšiu účasť žiakov pri riešení úloh. Nagyová Lehocká (2008) hovorí, že „optimálny stupeň náročnosti úloh je tiež podmienkou rozvoja motivácie a záujmu”. Aby sme si udržali neustály záujem, snažili sme sa mať túto skutočnosť na pamäti pri optimálnom výbere a zvyšovaním náročnosti jednotlivých úloh. Podľa Nagyovej Lehockej (2020) „konštrukcia rôznych geometrických telies rozvíja priestorovú predstavivosť a konštruktívne schopnosti študentov.“ Je dôležité si spomenúť, že masívnejšia prítomnosť takýchto aktivít vo vzdelávacom procese môže prispieť k dosiahnutiu mnohých vzdelávacích cieľov. [10] V nasledujúcich podkapitolách predstavíme štyri aktivity, pri tvorbe ktorých sme využívali niektoré z uvedených aspektov.

3.1 Kódovanie

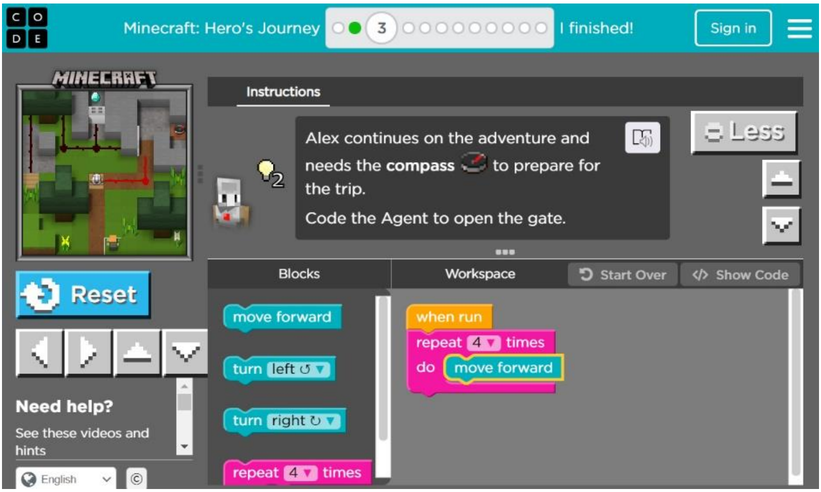
Binárne kódovanie je úloha, ktorú sme zaradili do programu zlepšovania priestorovej predstavivosti v piatom ročníku základnej školy. V tejto úlohe vychádzame z problematiky binárneho kódovania alfanumerických znakov vo forme zobrazenia týchto znakov vo formulári vytvorenom z geometrických objektov, t. j. pásikov a štvorčekov usporiadaných v rovinnej schéme. Táto úloha prezentuje alfanumerické znaky ako unikátnu kombináciu jednotiek a núl, ktoré sú na rovinnom objekte zobrazené ako tmavé, resp. bledé objekty. Plocha obrazca je tvorená plochou riadku s ôsmimi štvorcami na zapísanie kódu, kde jednotku reprezentuje tmavý štvorec a nulu prázdny, nevyfarbený štvorec. Na farebnom pozadí sú vytvárané polia, ktoré tvoria binárne pásiky, ktoré vytvárajú geometrický charakter kódu. Žiaci získajú trojdimenzionálny geometrický vzor, ktoré vytvárajú hĺbku obrazca. Úlohou žiakov je vytvoriť takýto geometrický obrazec na základe vytvorenia binárneho kódu svojho mena a priezviska. Súčasťou materiálov je šifrovací kľúč, kde žiaci obdržia jednotlivé znaky abecedy a ich reprezentáciu v binárnom tvare. Úloha je zameraná na tvorbu geometrických objektov a zároveň na budovanie precíznosti zápisu kódu mena a priezviska žiaka. V tejto úlohe sa snažíme položiť základy na budovanie priestorovej predstavivosti. Učiteľ hodnotí správnosť kódu a počet chýb.



Obrázok 1: Ukážka šifrovania znakov v binárnej sústave.

3.2 Minecraft – Cesta hrdinu

Úloha je založená na popularite hry Minecraft. Táto hra je dostupná online na stránke https://studio.code.org/s/hero/lessons, ako vzdelávací projekt neziskovej organizácie Code.org®, s ambíciou podporiť informatické vzdelávanie. Do projektu je zapojená aj spoločnosť Microsoft. V hre vystupujú hrdinovia Alex a Steve, ktorí v štýle Minecraftu využívajú príkazy ako napríklad dopredu, dozadu, doprava, doľava, počet krokov, vybuduj objekt (piesok, skala, koľajnice, voda a pod.) tak, aby sa hrdina mohol pohybovať po scéne. Hra má dvanásť úrovní a žiaci prechádzajú cez jednotlivé scény vytvorením správneho algoritmu v štýle programovania Scratch, aby dostali hrdinu do cieľového miesta. Hoci scény majú charakter 2D, tretia dimenzia je vytvorená hĺbkou scény. Hra Cesta hrdinu pomáha budovať priestorovú predstavivosť pohybom a orientáciou po scéne, podporou neverbálneho myslenia, manipuláciou s objektmi najprv v mysli a potom vo virtuálnej scéne. Učiteľ potom zaznamenáva správnosť napísaného kódu, prípadne počet chybných krokov.



Obrázok 2: Cesta hrdinu v prostredí Minecraft a priestorová orientácia v jednotlivých scénach.

3.3 Kreslenie 3D objektov alebo obrázkov

Dobre známy počítačový program Skicár (Paint) má svojho „nástupcu" v podobe počítačového programu s názvom 3D Skicár (3D Paint), ktorý umožňuje „kreslenie v priestore". Umožňuje vytvárať priestorové útvary (modely) a manipulovať s nimi. Pomocou tohto programu, sa žiaci môžu oboznámiť so základnými priestorovými útvarmi, a popritom majú možnosť pozorovať aj prechod medzi rovinnými a priestorovými útvarmi. Túto aktivitu môžeme členiť na tri úlohy:

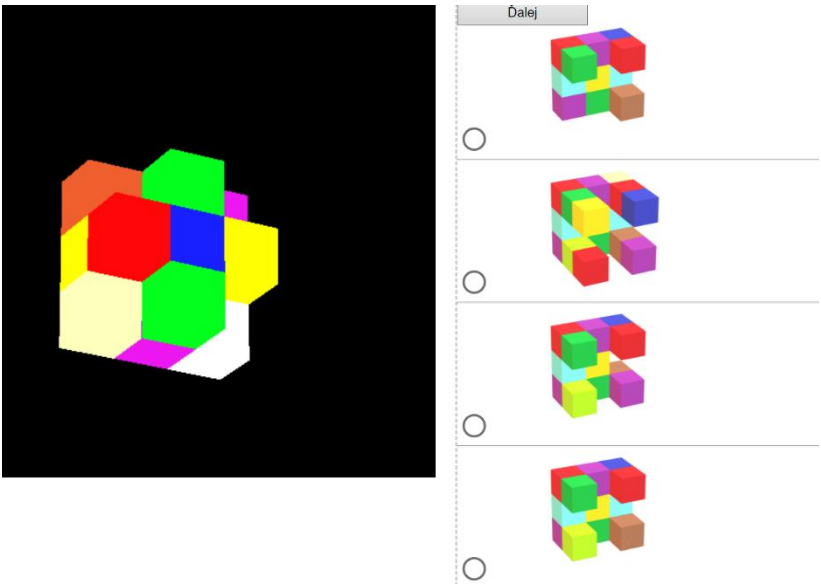
- Žiaci sa oboznámia s prostredím programu 3D Skicár. Vložia rôzne prvky, zafarbujú, presúvajú a otáčajú ich. Vyskúšajú možnosti uloženia svojej práce. Oboznámia sa s kreslením 3D čiar (3D doodle). Pospájajú priestorové útvary na základe vopred určeného miesta.
- Vytvoria si model stoličky (obr. č. 3), ktorej aspoň sedadlo musí mať inú farbu, a majú postupovať na základe nasledujúceho plánu: 4 nohy a sedadlo, operadlo, opierka.
- Vytvoria si model „pravekého parku". V parku majú byť aspoň dva (maximálne 4) praveké zvieratá rôznych druhov (modely pravekých zvierat sa nachádzajú v 3D knižnici). Park má obsahovať aj jedno jazero a jeden strom. Pri vchode parku sa nachádza tabuľa s nápisom „Jurassic Park".

Obrázok 3: Práca žiakov.

3.4 Hľadanie doplnkového priestorového objektu

Webová aplikácia obsahuje úlohy založené na využití počítačových 3D modelov. Pri jednotlivých úlohách, priestorové objekty (objekt **A,** viď. obr. č. 4) žiak môže preskúmať, nakoľko je umožnené ich zväčšenie/zmenšenie ako aj otáčanie. Priestorový objekt **A** sa skladá z jednotkových kociek rôznej farby, ich farba nezohráva špeciálnu rolu, len pomáha pri zisťovaní štruktúry priestorového objektu **A.** Úlohou žiaka je vybrať si správny doplnkový priestorový objekt k objektu **A** tak, aby pri ich poskladaní dostal väčšiu kocku . Pri riešení týchto úloh žiak môže postupovať napríklad na základe nasledujúceho algoritmu:

- spočítať počet chýbajúcich jednotkových kociek potrebných k doplneniu priestorového objektu **A,**
- na základe počtu chýbajúcich jednotkových kociek eliminovať nesprávne riešenia z možných odpovedí,
- na základe zúženého počtu možných vyhovujúcich riešení, pomocou mentálnej rotácie týchto objektov a manipulácie s objektom **A** hľadať riešenie.



Obrázok 4: Ukážka webovej aplikácie (vľavo objekt A, vpravo doplnkové priestorové objekty).

Žiaci sú vopred zaregistrovaní do webovej aplikácie, po prihlásení riešia 5 podobných, ale postupne náročnejších úloh. Pri každej úlohe sú uvedené 4 možné odpovede. Po odoslaní všetkých odpovedí, teda po ich ukončení, sa odpovede uložia na server a žiak bude automaticky odhlásený. Prihlásiť sa do aplikácie ešte raz žiakovi nie je povolené. Aplikácia je responzívna, teda okrem počítačov plne funkčná aj na zariadeniach s menším displejom (mobil, tablet).

4 Záver

Pri tvorbe uvedených aktivít sme sa snažili zohľadniť obsah ŠVP, aby sa výstupné ciele aktivít s ním v čo najväčšej miere prekrývali. Samozrejme spoločným cieľom týchto aktivít je rozvíjanie priestorovej predstavivosti žiakov. Ďalšími cieľmi sú napríklad: žiak dokáže použiť algoritmus pri hľadaní riešení; dokáže uložiť svoju prácu ako projekt; otvoriť projekt a editovať ho; dokáže uložiť svoju prácu ako obrázok a video; dokáže používať jednoduché nástroje: kreslenie/maľovanie, 2D tvary, 3D tvary, text, 3D knižnica; dokáže selektívne označovať, kopírovať, vystrihnúť a vymazať jednotlivé prvky; dokáže správne pospájať prvky; dokáže otáčať, preklopiť a premiestňovať jednotlivé prvky; dokáže prefarbiť jednotlivé prvky; dokáže zoskupovať prvky. S cieľom prezentovať problematiku tematického celku informácie okolo nás, prinášame žiakom pohľad na spracovanie informácií a mechanizmov prevodu analógových informácií do binárnej sústavy a pre okruh Postupy, riešenie problémov, algoritmické myslenie sa žiaci stretávajú so základmi tvorby algoritmov prostredníctvom bublinového algoritmu v štýle Scratch.

Projekt je plánovaný na dva roky, pričom jednotlivé úlohy sú tvorené a aplikované v prostredí, ktoré využíva priestorové scény, geometrické útvary a postupy simulácie priestorových vzťahov v matematike, informatike a výtvarnej výchove s cieľom zlepšiť priestorovú predstavivosť experimentálnej vzorky. Výsledky získané hodnotením výkonu jednotlivých úloh spracujeme pomocou štatistických metód, analyzujeme koreláciu výsledkov s výsledkami dosiahnutými vo vstupnom teste a s jednotlivými známkami v rozhodujúcich predmetoch. Na konci experimentu pomocou testu na priestorovú predstavivosť porovnáme významnosť rozdielov medzi kontrolnou a experimentálnou vzorkou.

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VYUŽÍVANIE INFORMAČNO-KOMUNIKAČNÝCH TECHNOLÓGIÍ A INTERAKTÍVNEHO SOFTVÉRU NA ZŠ

Veronika GABAĽOVÁ , Anna KRIŠOVÁ, SK

Abstract: Vyučovanie na základnej škole si bez moderných digitálnych didaktických prostriedkov nevieme ani predstaviť lebo sa stali každodennou súčasťou vyučovania. Dobrá technická a technologická vybavenosť škôl automaticky nezabezpečuje vysokú efektivitu vyučovania [1]. Využívanie ich edukačného potenciálu predpokladá určitú digitálnu gramotnosť nielen učiteľov, ale aj žiakov. Učiteľ, ktorý je erudovaný používateľom didaktickej techniky a edukačných technológií vie navrhnúť a implementovať na vyučovanie tematických celkov, také edukačné aktivity, ktoré pomocou interaktívnej tabule a vhodného softvéru zaujmú žiakov a zabezpečia ich spontánnu aktívnu účasť na vyučovaní aj na prvom stupni základnej školy [2]. Článok okrem opisu, ako sa využívajú moderné vzdelávacie technológie na hodinách matematiky, prináša aj výsledky dotazníkového prieskumu samotného používania IKT v školskom i domácom prostredí, realizovaný so žiakmi prvých ročníkov primárneho vzdelávania [3].

Keywords: Informačno-komunikačné technológie. Interaktívny softvér, IKT vo vyučovaní matematiky. IKT vo vzdelávaní.

USING ICT AND INTERACTIVE SOFTWARE AT PRIMARY SCHOOL

Abstract: I We cannot even imagine teaching in primary school without modern digital teaching aids, because they have become an everyday part of teaching. Good technical and technological equipment of schools does not automatically ensure high teaching efficiency [1]. Utilizing their educational potential presupposes a certain digital literacy not only of teachers but also of students. A teacher who is erudite user of didactic techniques and educational technologies can design and implement thematic units for teaching, such educational activities that will use the interactive whiteboard and appropriate software to engage pupils and ensure their spontaneous active participation in teaching in primary school [2] . In addition to describing how modern educational technologies are used in mathematics lessons, the article also presents the results of a questionnaire survey of the use of ICT in the school and home environment, conducted with first-year students in primary education [3].

Keywords: ICT. Interactive software. ICT in the teaching mathematic. ICT in education.

1 Úvod

Kalaš a kol. [4, s. 34] zhrnul benefity využívania IKT deťmi do jednej veľmi dôležitej myšlienky. „Digitálne technológie patria do rúk deťom ako prostriedok a príležitosť na to, aby mohli lepšie premýšľať a skúmať, komunikovať, vyjadrovať sa, tvoriť, rozvíjať sa a spolupracovať, aby sa mohli lepšie učiť." Autorky článku zastávajú názor uvedeného autora na používanie interaktívnych technológií deťmi. I preto autorky počas vyučovacieho procesu považujú tieto za dôležitý prostriedok dosahovania edukačných cieľov. V rámci príspevku sa venujeme popisu implementácie IKT do edukačného procesu s tým, že sme pri realizácii aktivít počas pedagogického experimentu, využívali pedagogický softvér. Tento softvér Kalaš [5] definuje ho ako softvér vyvinutý na podporu učenia sa, poznávania a na rozvoj informačnej gramotnosti. Krnáč a kol. [6] uvádza základné znaky edukačného softvéru:

- vzdelávací cieľ,
- ľahká ovládateľnosť,
- príjemné užívateľské rozhranie,
- pútavosť,
- ovplyvňovanie zmyslov žiaka v čo najväčšej miere,
- primeranosť,
- hravá a pútavá forma.

2 TEÓRIE UČENIA SA A ICH SPOJITOSŤ S IKT

Na to, aby mohol učiteľ kvalitne a kvalifikovane plánovať edukačný proces a aby jeho práca bola produktívna, zmysluplná a prínosná pre žiakov, ale i pre neho samého, je nevyhnutné rozumieť samotným kognitívnym procesom žiakov, kriticky myslieť, hodnotiť, analyzovať, či poznať pedagogické stratégie, ktoré podľa Kostruba [7, s.8] znamenajú *„určitú filozofiu uplatňovania zvolených metód, teda komplex určitých spôsobov učiteľovho vyučovania, ktoré zodpovedajú podmienkam navodeným organizačným modelom výučby. Ide o učiteľovu premyslenú, cieľavedomú koncepciu efektívneho rozvíjania edukačných operácií, pomocou ktorých je možné osobnosť dieťaťa edukačne ovplyvňovať, napomáhať jej pozitívnemu sebarozvoju."* Činnosť učiteľa by mala byť samozrejme založená na teórii učenia, ktorá tvorí *„ucelený a vnútorne konzistentný súbor všeobecných predpokladov a tvrdení, ktoré sa snažia vysvetliť podstatu psychického procesu učenia, predvídať jeho priebeh a umožniť do neho účinne zasahovať."* [8, s.248]

Proces výučby je tak, ako uvádza Kostrub a kol. [9, s. 23] *„interpretáciou učiteľom preferovanej koncepcie. Je to zosobnený koncept výučby zo strany učiteľa, istý svojbytný fenomén, charakteristický pre konkrétneho učiteľa.“* Autori publikujúci v danej oblasti ďalej tvrdia, že IKT sú veľmi dobre kompatibilné s tradičnou paradigmou, pričom sú v súčasnosti využívané najmä pri tvorbe multimediálnych výučbových programov vhodných pri výučbe jazyka, matematiky, chémie [10]. Kostrub a kol. [9, s. 53] konštatuje, že *„behavioristická teória redukuje digitálne technológie na (slovami tejto teórie) nácvik zručností pri práci s počítačom. Výučba je preto zväčša orientovaná na nácvik mechanických úkonov vyžadujúcich si pozornosť, auditívnu a vizuálnu diskrimináciu, vnímanie a pamäť. Bázické sú v tomto nácviku externe prichádzajúce podnety v podobe úloh (tzv. krokov), pričom sa sleduje ich (správne, či nesprávne) splnenie, ktoré je opätovne posilňované odmenou (pochvalou, ďalším krokom v systéme, dobrým hodnotením a pod.), či trestom (zabránením ďalšieho kroku v systéme a vrátením sa nazad). V takto poňatej výučbe sa uplatňujú neinteraktívne videá a uzatvorené PC programy, tzv. edukačné balíky (softvéry), pretože tieto sledujú splnenie uzatvorených a preskriptívnych (vopred určených, predpísaných) programov operačných cieľov (vedomostí, zručností a pod.) rovnakých pre všetkých účastníkov výučby.“*
Modernú paradigmu reprezentuje konštruktivizmus. V didaktike je považovaný za dominantnú paradigmu súčasnosti. Delí sa na niekoľko prúdov, a to: kognitívny konštruktivizmus, ktorého hlavnými predstaviteľmi sú J. Piaget, J. S. Bruner a sociálny konštruktivizmus, ktorého hlavnými predstaviteľmi sú A. Bandura, L. S. Vygotskij. V praxi však dochádza k ich syntéze, pričom sa presadzuje výučba zameraná na riešenie problémov zo života, tvorivé myslenie, skupinovú prácu, menej teórie a drilu. Zdôrazňuje sa manipulácia s predmetmi.
Komplexný pohľad na konštruktivizmus poskytujú Zounek a Šeďová [11], podľa ktorých:

- Učiteľ je facilitátor a mediátor.
- Je dôležité interaktívne, dialogické ponímanie výučby. a kognitívna podpora (navrhovanie, odporúčanie, tvorivosť, podpora nezávislého myslenia). Výučbu prispôsobovať existujúcim konceptom a skúsenostiam žiaka.
- Žiak je vnímaný ako aktívny subjekt konštruujúci si svoje poznanie a rozvíjajúci si svoje kompetencie.
- Typické pre nich sú dva druhy učenia, a to učenie sa novým informáciám a učenie sa novým spôsobom ako sa učiť. Učenie

prebieha v kontexte (vo vzťahu k životu, vlastným predsudkom, obavám) a je sociálnou aktivitou.

- Veľmi podnetná a dôležitá je veľká variabilita učebných aktivít, skupinová práca, projektová výučba, experimentovanie, hľadanie a syntéza informácií, prezentovanie.
- Zdrojom informácií pre žiakov sú učebnice, knihy, časopisy, audio a video nahrávky, internet, elektronické encyklopédie, ale i učiteľ, spolužiaci a i.
- IKT plnia informačnú, konštruktívnu, kognitívnu, komunikačnú úlohu.

Kostrub a kol. [9, s. 54] rovnako konštatuje, že v kognitívnom konštruktivizme sa digitálne technológie javia ako prostriedok a nie ako cieľ. Pri výučbe sa, ako tvrdí, využívajú „hry, audiovizuálne, simulačné, interaktívne PC programy a obsahy sú prezentované explikatívnou (vysvetľujúcou) a otvorenou formou." Autor sa ďalej vyjadruje i k využitiu IKT v rámci sociálneho konštruktivizmu, ktorého základom je „interpersonálna interakcia a vzájomná transakcia s ostatnými subjektmi (v učiacej sa i mimo učiacej sa skupiny) prostredníctvom kognitívne situovaného dialógu (diskusia) v špecifických kultúrnych kontextoch, ktoré subjekty spoločne, symbolicky, vzájomne konštruujú a zdieľajú. I tu sú digitálne technológie chápané ako prostriedok."

3 Charakteristika edukačného softvéru (kritéria výberu vhodného softvéru)

Vzhľadom na to, že na trhu je veľké množstvo rôznych typov a druhov softvéru, Žilková [12] ho navrhuje posudzovať z viacerých hľadísk, a to:

- vzdelávací aspekt (zameranie programu, cieľová skupina, miesto používania, odborné požiadavky predmetu a i.);
- užívateľské hľadisko (obsluha softvéru, vzhľad, rušivé prvky, užívateľské pomôcky);

technické parametre softvéru (hardvérové požiadavky, inštalácia a i.).

Počas prezenčnej výučby v školskom roku 2019/2020 jedna z autoriek článku, ktorá pôsobí ako učiteľka v Základnej škole vo Veľkom Bieli, realizovala prieskum používania interaktívnych technológií v procese vyučovania. Po uskutočnení prieskumu spoluautorka článku realizovala výučbu s implementáciou IKT a voľne dostupného edukačného softvéru [3]. Pri realizácii aktivít využívala voľne dostupný edukačný softvér v rôznych fázach vyučovacieho procesu. Zamerali sme sa na neplatený, voľne dostupný softvér. Vo výučbe využívala tri web stránky. No počas

plánovania aktivít sme pracovali aj s inými web stránkami, ktoré považujeme za alternatívne a plne implementovateľné do vyučovania matematiky. Uvádzame niekoľko z nich:
https://www.coolmath4kids.com/, http://matematika.hrou.cz/, https://www.umimematiku.cz/, http://www.pastelka.sk/, https://www.onlinecviceni.cz/exc/list_topic_mat1.php, https://www.khanacademy.org /math/k-8-grades#cc-1st-grade-math, https://www.abcya.com/. Voľne dostupné sú tiež aplikácie zamerané na Hejného matematiku uvedené na stránke http://www.hejny.sk/.

4 Metodológia dotazníkového prieskumu

Tak ako už bolo vyššie napísané, v rámci pedagogického experimentu sme realizovali prieskum používania interaktívnych technológií v procese vyučovania a rovnako tak sme mali v záujme zistiť používanie IKT samotnými žiakmi v domácom prostredí. Za nutnosť považujeme pojem prieskum vysvetliť. Rusnáková [13, s. 21] konštatuje, že pojem nie je jednoduché špecifikovať, nakoľko je extrémne variabilný. Ďalej uvádza, že *„v slovenskej (českej) metodológii sú dva názorové pohľady na váhu prieskumu v empirickom skúmaní. V prvom pohľade hrá prieskum úlohu predvýskumu, v druhom pohľade má úlohu regulárneho typu, či plánu alebo projektu výskumu."* Podobný názor zastáva i Kalaš [14, s. 21] , ktorý tiež konštatuje, že prieskum nemá za cieľ tvoriť závery a teórie, ale poskytovať informácie o stave skúmaného javu. Zastávame názory uvedených autorov a prieskum považujeme za nižšiu formu empirického výskumu, v článku práci budeme využívať pojem prieskum. Realizovali sme zber dát v teréne, aby sme si vytvorili prehľad o danej problematike a mali tak možnosť získané informácie využiť pri realizácii nami plánovanej výučby s využitím interaktívnych technológií a interaktívneho softvéru.

4.1 Realizácia prieskumu

Našim cieľom bolo zistiť, aké IKT deti poznajú, ktoré technológie reálne využívajú počas edukačného procesu a ktoré používajú vo svojom domácom prostredí. Zaujímalo nás tiež to, či spoznávajú logá niektorých bežne používaných aplikácií, s ktorými sa denne dostávajú do kontaktu. Prieskum a aj realizáciu výučby sme uskutočnili v Základnej škole Veľký Biel, ktorá v plnej miere do vyučovacieho procesu integruje interaktívne technológie. Každá trieda primárneho stupňa má v triede k dispozícii interaktívnu tabuľu, počítač, tablety a včely Bee-bot. Prieskumná vzorka bola vybratá zámerne, zahŕňala 30 žiakov z dvoch tried prvého ročníka. Uvádzame tiež, že žiaci navštevujú i krúžok „Bez kriedy", ktorý je počítačovým krúžkom. Cieľom je zdokonaliť prácu žiakov s počítačom a popritom rozvíjať nielen informačnú gramotnosť, ale i matematickú, čitateľskú, či prírodovednú gramotnosť s využitím rôznych platených a neplatených druhov softvéru [15].

4.2 Charakteristika respondentov

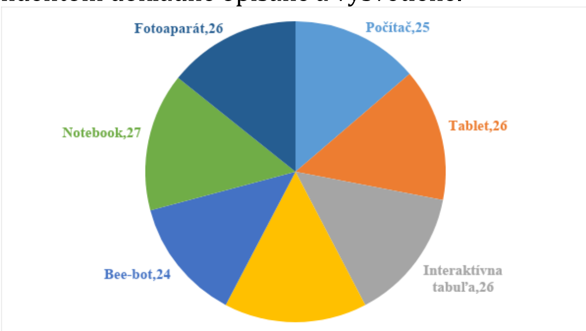
Prieskumná vzorka bola vybratá zámerne, zahŕňala 30 žiakov z dvoch tried prvého ročníka. V jednej triede vyučuje práve spoluautorka článku. Uvádzame tiež, že žiaci navštevujú i krúžok „Bez kriedy", ktorý je počítačovým krúžkom. Cieľom je zdokonaliť prácu žiakov s počítačom a popritom rozvíjať nielen informačnú gramotnosť, ale i matematickú, čitateľskú, či prírodovednú gramotnosť s využitím rôznych platených a neplatených druhov softvéru .

4.3 Etické otázky prieskumu

Pri realizácii a spracovávaní prieskumu sme dodržiavali etické zásady a to dôvernosť, informovaný súhlas zákonných zástupcov žiakov, (nakoľko boli respondenti neplnoletí). Informovanie o prieskume sme považovali za samozrejmosť jednak žiakov ale i zákonných zástupcov. Títo boli informovaní o účele, získanie údajov bez akéhokoľvek psychického, či fyzického nátlaku.

5 Hiba! A könyvjelző nem létezik.**výsledkov**

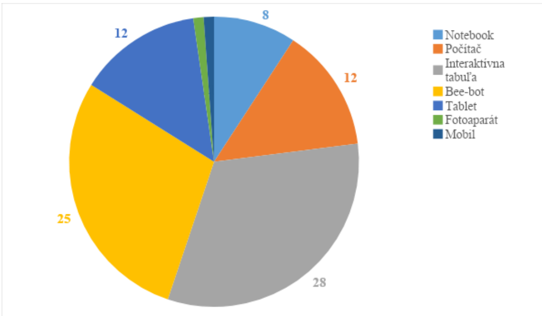
Zozbierali sme odpovede tridsiatich žiakov. táto skupina žiakov pozostávala z 15 chlapcov a 15 dievčat vo veku 6 a 7 rokov. Dotazníky boli respondentom dôkladne opísané a vysvetlené.



Graf 1 Znalosť IKT

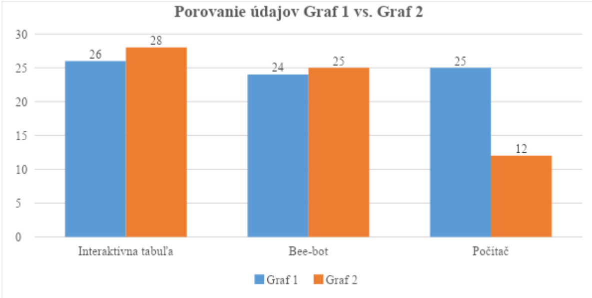
Každá otázka bola žiakom prečítaná samostatne a na vyplnenie odpovedí mali dostatočný čas. Po porovnaní výsledkov sme pri tvorbe grafov nezohľadňovali vek a pohlavie respondentov, nakoľko rozdiely medzi

skupinami 6 a 7 ročných žiakov a skupinou chlapcov a dievčat boli minimálne, z nášho pohľadu v momentálnom prieskume nepodstatné.
Ako vidíme z grafu 1 žiakom sú veľmi dobré známe všetky druhy interaktívnych technológií, najväčšie zastúpenie má mobil, čo nie je prekvapujúce, nakoľko predpokladáme, že s ním žiaci najčastejšie prichádzajú do kontaktu. Nasleduje notebook, potom zhodne fotoaparát, tablet a interaktívna tabuľa. Zaujímavosťou je fakt, že i keď žiaci prichádzajú do kontaktu s interaktívnou tabuľou denne, i tak ju označilo iba 26 žiakov. Podobne sa vieme vyjadriť i v prípade počítača, ktorý označilo ako „známy“ 25 žiakov aj napriek tomu, že sa nachádza na katedre učiteľky a všetci žiaci navštevujú počítačový krúžok. Veľmi dobre známy je aj Bee-bot, bežne využívaný v skupinových aktivitách pri vyučovaní.



Graf 2 IKT reálne využívané počas edukačného procesu

V prípade používania interaktívnych technológií počas edukačného procesu už jasne dominuje používanie interaktívnej tabule a včely Bee-bot. Predpokladáme, že práve s nimi žiaci pracujú najčastejšie. Zhodný počet vykazuje počítač a tablet. Podľa našich informácií, notebook, fotoaparát a mobil žiaci počas vyučovania zatiaľ nepoužívali.
Vzhľadom na záujem autorky predkladanej práce o vizualizáciu porovnania uvádzame v grafe 3 porovnanie údajov zobrazených v grafoch 1 a 2.



Graf 3 Znalosť IKT vs. ich reálne používanie v praxi

V grafe č. 3 sme porovnávali zariadenia, ktoré žiaci označili ako „známe" a zariadenia, ktoré reálne používajú v školskom prostredí. Ako je vidieť, hodnoty sa nerovnajú a vyskytujú sa menšie rozdiely. Je zaujímavé, že 25 žiakov označilo počítač ako „známy", no iba 12 žiakov ho označilo ako zariadenie, ktoré v škole využíva, i keď všetci žiaci prvého ročníka navštevujú počítačový krúžok, ktorý je realizovaný v popoludňajších hodinách jedenkrát týždenne a každý žiak má k dispozícii svoj vlastný počítač.

Z uvedeného vyplýva, že žiaci poznajú mnohé bežne používané zariadenia, správne ich identifikujú ako zariadenia používané v škole a zariadenia používané doma. Menšie rozdiely, ktoré sme opisovali vyššie, pripisujeme nízkemu veku respondentov a možnej nepozornosti a nesústredenosti. Usudzujeme, že by bolo veľmi zaujímavé realizovať výskum na početnejšej skupine respondentov, čo by z nášho pohľadu mohlo priniesť komplexnejší pohľad na používanie interaktívnych technológií deťmi v školách i v domácom prostredí. Rozpracovať by tiež bolo možné i otázku č. 6, ktorá bola v našom výskume zameraná na aplikácie, s ktorými žiaci prichádzajú do kontaktu, teda ich buď reálne používajú alebo ich registrujú len ako súčasť používaných IKT.

6 Záver

Informačno-komunikačné technológie sú v súčasnej dobe veľmi frekventovaným pojmom, najmä čo sa týka školského prostredia. Žiaci sa s IKT stretávajú denne nielen v škole, ale i doma. Učitelia sa snažia vyučovanie obohatiť o mnohé aktivity realizované v prostredí digitálnych technológií i s použitím interaktívneho softvéru. Je však dôležité pri jeho výbere postupovať zodpovedne. Vyberať taký softvér, ktorý spĺňa znaky kvalitného, ľahko ovládateľného, pútavého, veku primeraného softvéru s tým, aby sme prostredníctvom neho dosiahli, resp. napomohli k dosiahnutiu požadovaného vzdelávacieho cieľa. Konštatujeme, že komplexnejší a rozsiahlejší výskum by mohol pre prax priniesť užitočné informácie, čo sa týka samotného používania IKT žiakmi, najmä počas vyučovacieho procesu. [10, 15] V kombinácii s ďalšími výskumnými metódami, napr. pozorovania, by poskytol reálny obraz o tom, ako a akým spôsobom sú informačno-komunikačné technológie implementované do edukácie, či ich žiaci pri svojej práci aktívne využívajú, alebo sú len prostriedkom učiteľa na dosahovanie vyučovacích cieľov.

Našou snahou bolo celý prieskum, plánovanie aktivít a ich realizáciu viesť tým najlepším smerom. Tak, aby sme plnohodnotne využili potenciál digitálnych technológií, ktoré sme mali k dispozícii. Softvér sme starostlivo skúmali, vyhľadávali, hodnotili. Vzhľadom na rozsah práce bohužiaľ nebolo možné realizovať všetky naše nápady, či využiť každý softvér, ktorý bol z nášho pohľadu vhodný na použitie sa vo vyučovacom procese. Z toho dôvodu sme ho v práci aspoň okrajovo spomenuli.

Na záver chceme citovať profesora Kalaša [4, s. 101], ktorý hovorí: „Počítače nepotrebujete, aby ste sa mohli učiť. To, čo potrebujete, sú dobré podmienky. Ak máte na hudbu dobré podmienky, hudobné nástroje vám ich ešte zlepšia. Ak učiteľ vytvorí dobré podmienky na učenie sa, počítač ich môže fantasticky vylepšiť.“ V tomto prípade iba dodáme, že tento citát chceme aplikovať na všetky digitálne technológie. Stotožňujeme sa s tým, že ak učiteľ vytvorí vhodné a kvalitné prostredie na ich používanie, tak i samotný edukačný proces bude pre žiakov oveľa prínosnejší.

POĎAKOVANIE

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NEW METHODS IN EDUCATION, NEW E-LECTION VERSION

Viktória BAKONYI, Zoltán ILLÉS, HU

Abstract: A few years ago, we introduced a real-time CRS (Classroom Response system) to meet the need to activate a large number of students. We used it with 2-300 students in 2-300 face-to-face live lectures, fine-tuning it time to time. Last year, in 2020, Covid-19 changed our lives and education too moved to the online space. Because of this, classical universities faced problems they had not encountered before, but with further efforts we found good solutions. E-Lection and similar systems have done their part and helped to facilitate the interactions between professors and students, the lack of which was the biggest fear of the participants. At the time of writing this paper, the situation became even more complex. Covid-19 is still with us, but we can be confident that vaccination will eventually overcome it. The question now is what type of semester we can prepare for: online, in-person or hybrid semester according to the current pandemic level in September - or will we have to switch on the fly? The problem is not a simple one, therefore we have developed a flexible model to manage the learning process in a rapidly changing environment, introducing a new, appropriate version of E-Lection.

Keywords: Classroom response system, activity, interaction, real-time, online, hybrid education

1 Introduction

Classical universities time-to-time adopt new methods and possibilities though the change should not be scraping, which is particularly true for universities with a long history, because we should make sure before implementation that the result will be effective.

Our university ELTE (Eötvös Loránd University) was established in1635 and one of the biggest ones in Hungary with its eight faculties. Worthy of its reputation step-by-step new digital tools were integrated into the education. This calm well thought out process was cancelled by Covid-19 which forced an immediate changeover from face-to-face to digital teaching.

The start was not easy, nobody knows punctually whether the resources will be enough for video streaming lectures and other courses, are there adequate devices and network at home for professors and students. Meanwhile a lot of colleagues had to learn on the fly new applications to make their lessons more involving though in the case of programming trainings these problems were not so tragical. Most of the educators declared after the first semester that they want to use the new tools later, when we are back to face-to-face classes.

Informatic Faculty ELTE decided to go on with synchronous, streamed and recorded courses in Teams supported by digital documents in Canvas LMS – course organization remained in Neptun see Figure 1.

1. Figure: Neptun + Canvas + Teams in ELTE remote teaching period

We made a survey (https://forms.gle/SuRMcmUGuPHcgM756) in Spring 2020 and students detected 3 problems as follows. The biggest rate has got the lack of interaction see table 1.

2. Table Survey, problems of virtual classes

		Reduced interaction	**Impersonality**	**Concentration**
Spring	Together (H+E)	26,39%	21,53%	17,36%
	Hungarian	24,24%	22,22%	19,19%
	English	31,11%	20,00%	13,33%

During the last 2,5 semester the teaching process become commonplace and were fine-tuned by professors – though focusing on interactivity and student activation was never forgotten.

Whilst Covid situation slowly gets better, we shall have a new challenge: hybrid training.

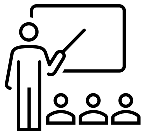
2 New challenge

We all hope that we can go back to face-to-face teaching in Autumn 2021, because personal relations, metacommunication, feedback enhance the quality due to researchers and to our own experiences. Maybe it will happen only not for everybody and not for all the time. The new concept is that persons – both professors and students – may ask to go on with virtual classes if their state of health requires so. In the time of writing the paper the most possible way is hybrid teaching. (It is a pity but go back to virtual classes is also a slight possibility during the semester if the pandemic situation became worth. So, everything is extremely flexible now.)

2.1 Hybrid teaching

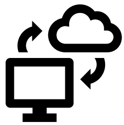
First let us define what do we mean under hybrid teaching.

- Everybody knows what a face-to-face teaching model, teachers and students is are at the same place at the same time, remember all of us grew up in classical schools. (Figure 2) Naturally there may be additional digital quizzes, documents, videos to help learners.



2. Face-to-face

- During Covid, during the remote teaching period classes were organized in digital area. (figure 3) They may be synchronic, asynchronous ones or mixed. The level of digital may differs from just email using to real-time video streaming. Naturally in this case additional digital tools are also appreciated.



3. Figure Digital classroom

- It is an evident, that hybrid teaching model should be the combination of the above ones. It may contain face-to-face and digital elements. But what is the difference between hybrid and blended learning what appears as a question sometimes? Let's see the definition of them:
    - "*Hybrid learning is an educational approach where some individuals participate in person and some participate online. Instructors and facilitators teach remote and in-person learners at the same time using technology like video conferencing.*
    - *With blended learning, instructors and facilitators combine in-person instruction with online learning activities. Learners complete some components online*

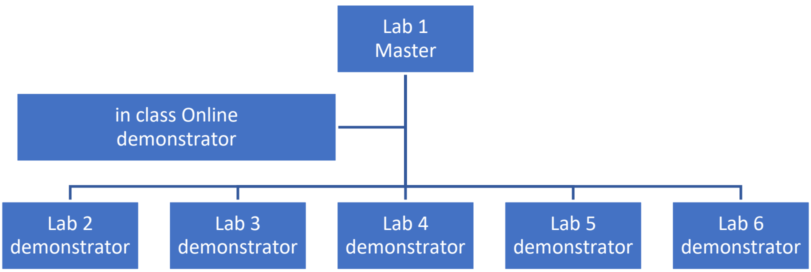
and do others in person." https://www.leadinglearning.com/hybrid-vs-blended-learning/

Hybrid teaching has several models, faculty choose the model where students are divided into 2 groups (in class on board / in class online) and they are rotating weekly. As we mentioned in the introduction, we were not fully satisfied with the student's activity during the digital classes. Therefore, in this new hybrid model we do have to focus on this problematic field too.

2.2 Master teacher driven courses

Besides hybrid teaching model we shall face to a very new idea in the case of first semester students. They came from different schools, applied university with different results, their base knowledge is not the same so we must support them with extra care. Naturally professors are not teaching at the same level though they all know their profession excellent.

The idea is, that there will be joined laboratories for the first-year students – six laboratories will be joined together. There will be a master teacher and 6+1 others who help him and the on-board students of their class. The +1 will be responsible for the online students. The master' role is very similar to a conductor's; he should present the newness and organize learning process all over the classes. It is an exciting task – we never tried before see Figure 4.



4. Figure Structure of joined hybrid model

Naturally this type of work needs a lot of additional software to be able to get immediate feedbacks about the joined classes and *activate* them.

You are right we again mention activation because we think it is very important to involve students into the learning process. "*The importance of stimulating pupils*' interest" has a key role [11].

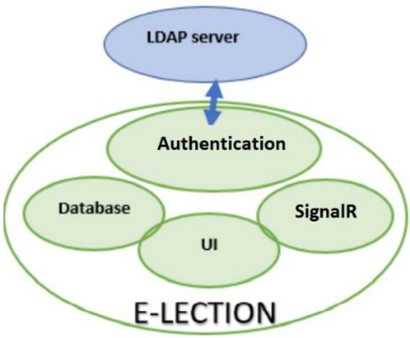
3 How to activate students

Whether it is a face-to-face or a digital class we need a lot of tools to make the lessons and the learning process variable and involving. You may use different things like group work, discussion, quizzes etc. One of the best practices is using a CRS (Classroom Response System) to get immediate feedbacks and map the actual knowledge or interest of the students. "*Growing up in front of a screen" [13]* researchers found nowadays young people prefer text messaging than speaking and it is more relevant if the lesson is recorded.

Several years ago, we faced the decreasing activity of students this was the starting point of a long developing process. We examined the ready-made CRS-s in the market, but neither was totally good for our aims. Without a strong financial background, we should have settled for reduced functionality of free versions.

3.1 History of E-Lection

Therefore, we decided to implement an own web-based real-time bi-directional lecture management system named by us E-Lection available at *https://election.inf.elte.hu*. It uses faculty LDAP to authenticate see on Figure 5.



5. Figure Basic architecture of E-Lection

The very first version was implemented in PHP. Soon we changed to use ASP.NET with C# and SignalR. We used it during face-to-face lectures and measured its efficiency (Table 2), but we used it later as well during the pandemic at virtual courses and it produces good results.

3. Table Comparing the result with and without E-Lection

		2017	2018
Spring	Missed exam	20,5%	17,8%
	Avarage	9,9	10,6
	Dispersion	4,8	5,2
	Median	10	11
Autumn	Missed exam	15,5%	14,2%
	Avarage	10,3	12,2
	Dispersion	4,9	5,5
	Median	10	12,2

We had some new ideas what functionalities we should add to our system to enhance learning experience like streaming (which was successfully tested) or joining it to Neptun (to get official course data) or create a practice module from the question bank for preparing exams.

Now we have a more important task to make a model for hybrid teaching and handling of joined classes and rewrite our system to help us in it.

4 New teaching models with E-Lection

In the last semesters we tested and used E-Lection both in face-to-face and in synchronous teaching situation. We state and the measures proved that it was valuable, produced higher result (see Table 2) and activated students. What is the situation with hybrid teaching model?

4.1 Basic hybrid model

While any of our students from anywhere with any device (having a browser) can join to the bidirectional communication started by the professor – basic hybrid model will not produce any problem. From the 2.0 version of E-Lection we are able to detect to logins from the spot or remote – so proper rotation can be checked. Naturally we should add some notifications towards the students who must be on the spot or filter the not good logins. IP address filtering is built in the system already – only it has to be joined to the weekly in class online and in class on board groups. It is a need but not urgent – everything can be done using the actual version.

4.2 Joined hybrid model

Joined hybrid model is far more difficult. Naturally we need the weekly rotating students per group – it is the same as in basic hybrid model. The real problem is the handling of the joined courses with a master and several demonstrators to keep personal data secrets due to law.

- Naturally master should handle everybody in the set of groups, Questioning and real-time measuring of students' answers, and the csv downloadable results are ready – no need to make any changes. It would be good if there would be any possibility to send personal messages to demonstrators and they can send back such messages.
- Demonstrator who is responsible for online students questioning should handle all of their questions send through E-Lection. In the actual version of E-Lection students may send questions to teacher and he can send back personal messages. But there is a big difference: only one teacher was able to do it. Now we have an additional "online" demonstrator, who should get the questions and answer for them instead of master. Moreover, it would be good if questions and answers could be sent to a "public" area if they may be interesting for everybody. So, we have to add new permission levels and functionality to the application.
- Laboratory demonstrators may see the questions of their own group to detect problems easier. Do not forget the group is rotating, therefore, to be able to help efficiently to on board students' demonstrators need to overview the previous week online students' questions. It means we have to add new permissions and functionalities to demonstrators. They should access only the data of their own group.

If during the semester from hybrid model we must change to virtual or back to face-to-face – nothing special happens, everything may go on. Moreover, we have to teach talented students, so we need to use methods which are useful to them [12].

4.3 New E-Lection

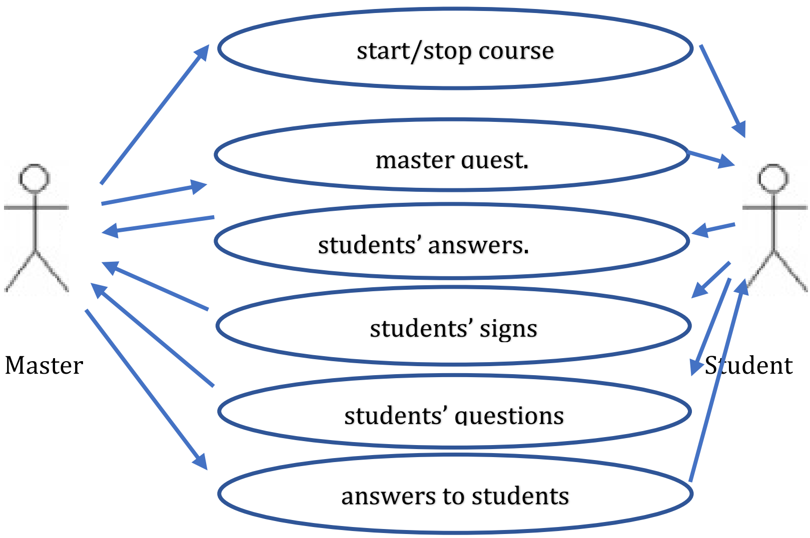
We plan to change to a new technology, to .net Core answering to the modern requirements. A .NET Core application will be more flexible on different devices and it ensures much more safetyness with using encrypted connection and data. Besides technology point of views referring to the above-mentioned new joined hybrid model we should change our database and add new roles.

4. Table Roles E-Lection

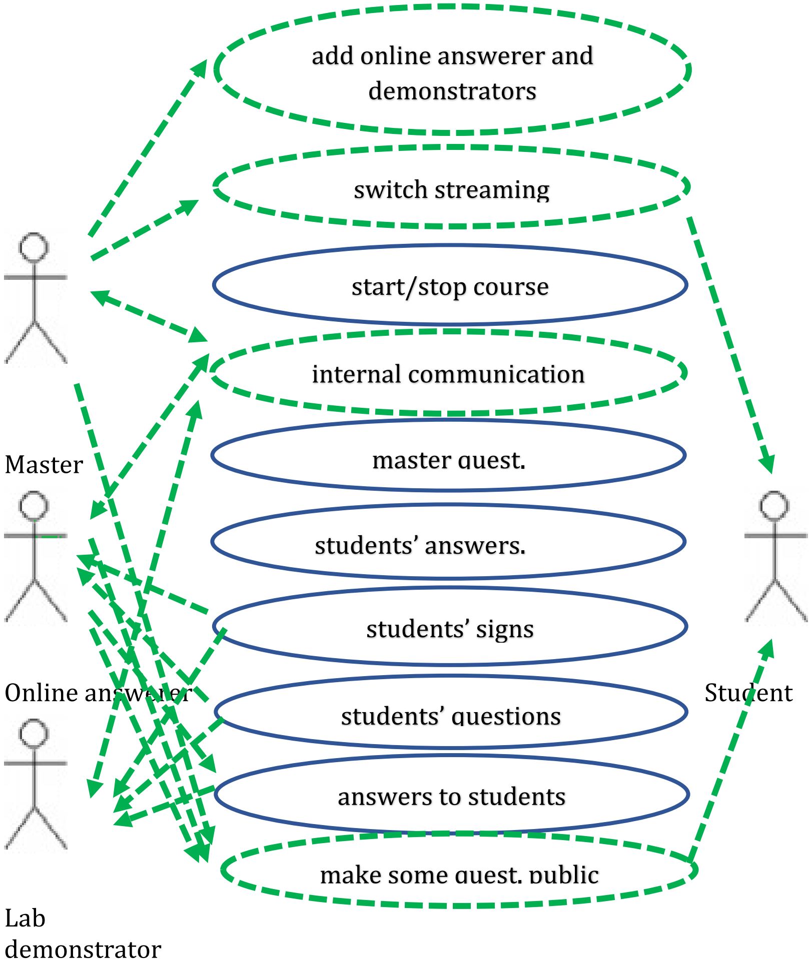
Roles	Previously	Planned
Master (teacher)	✓	✓
Online answerer	-	✓
Lab. demonstrator	-	✓
Student	✓	✓

Roles are checked by faculty LDAP. In LDAP there are only two roles in the moment. We should apply to insert an online answerer and a demonstrator role though it is important that a teacher can be in any role, a demonstrator can be in student's role too. According to the above-mentioned new needs we should add some new functionalities too. Actual version model is given in Table 4, new planned version see Table 5.

5. Table E-Lection actual version



6. Table New E-Lection with new actors and joined events
blue line – original events
green dotted line – new event or connection



In the database itself we do not need a big modification except in the case of persons – because the role may change course-to-course (a teacher may be a master or may be an online answerer or even a demonstrator.) A very new thing is internal communication which can be logged – in that case it needs a new table with participants and messages, but it is not important. For streaming we do not have to store only some basic data –

the recorded video will be available in faculty streaming server. As we already have a connection table between teachers and the courses it does not need the change of the database. As the reader can see we can build on the bases of our E-Lection, but some modifications must be done to be able to use in hybrid joined model.

5 Conclusion

21st century one of the key elements of education to find effective, interactive tools. On the market there are lot of ready-made applications to help our goals. We voted for classroom response systems and implemented an own which fits our special requirements. During the years it proved its efficiency first in face-to-face and in virtual courses too. Now there is a new idea hybrid and joined hybrid models. What kind of modifications do we have to make to use our system during any circumstances?

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KNOWLEDGE TRACING: A SIMPLIFIED ROAD MAP TO THE STATE OF THE ART

Jose NARANJO, Veronika STOFFOVA, Changsheng ZHU

Abstract: The current world situation has boosted the importance of online education and with-it platforms that provide computer-aided learning that enhances the students' autonomy in the learning process. Those platforms also promise broad access to world-class training while also lowering the rising cost of tuition.

Knowledge tracing is the process of predicting how pupils will perform in future encounters by modelling their knowledge across time. Learning models can be created using large-scale student trace data on prominent educational sites like Udemy, EdX, Coursera, etc. Furthermore, the learning model may be utilized to create clever curriculums and enables simple interpretation and finding of structures in student activities.

The learning process may be improved by suggesting resources to students based on their requirements, and information that is expected to be too simple or too difficult can be avoided or delayed. Therefore, in the field of online education, the problem of providing suitable material to students based on their current knowledge, learning rate and personal skills can be solved by different designs. Available designs are Dynamic Probabilistic Models (Partially Observable Markov Decision Processes), Recurrent Neural Networks, Bayesian Knowledge Tracing, etc. All these designs have advantages and disadvantages. We analysed the designs and proposed a synthesized road map towards the currents state of the research that illustrates the strong and weak points of the existing designs.

Links to the academic articles and source code of freely available resources are provided. Additionally, future challenges are discussed at the end.

Keywords: Knowledge Tracing, Artificial Intelligence, Neural Networks.

1 Introduction

Because of the current world condition, the need of providing students with proper advice to allow them to gain relevant knowledge and empower them to solve problems correctly and efficiently has been shown to be critical.

The knowledge tracing conception is not new, earlier Corbett et al. [1] attempted to simulate students' shifting knowledge state during skill learning for the first time in 1994.

Students learnt programming skills utilizing a software platform that allows the tutor to work with the student on exercises and aid as needed. In a process known as knowledge tracing, the system keeps track of the probability that the learner has learned each of the rules while working on them.

However on [1] a two-state learning model is assumed in knowledge tracing. Each coding rule is in one of two states: learned or unlearned. A rule can move from the unlearned to the learned stage prior to practice by reading the text or by applying the rule in practice at each opportunity. Furthermore, it is presumptively assumed that there is no forgetting; rules do not reverse course.

The definition of knowledge tracing can be formalized as follows:

Given interactions of a learner $x_1, \dots, x_t$ on a particular learning task, how will he behave at $t+1$? The goal being to estimate the probability $p(x_{t+1}|x_1, \dots, x_t)$—probability to give a correct answer on x_{t+1} given the answers on $x_t, \dots, x_1$ [2]

One of the most significant goals of KT is to customize the practice sequence so that students can master knowledge ideas more quickly.

The fundamental purpose of knowledge tracing is to track students' knowledge levels based on their previous exercise performance. This will help students become more aware of their learning process and dedicate more energy to less familiar topics, allowing them to learn more quickly. At the same time, they assist the instructor in understanding how to offer the subject in a more effective and straightforward manner.

A slew of new solutions has shown up recently, but we'll focus on the most important ones here.

The most significant models and their characteristics will be discussed in section 2. Section 3 discusses the potential applications of KT and provides several publicly available datasets as well as some unsolved challenges. In section 4, we give various evaluation measures as well as a discussion of future research topics, and in section 5, we present the review's conclusion.

2 Relevant Existing Models

In this section, we'll go over some of the most important models and their key features.

First, we classify the KT approaches that have been found in the literature. These include approaches that are based on techniques that are used as baselines and techniques that are utilized for comparison. The review of these models, in our opinion, is the first step toward comprehending the status of research in the KT roadmap.

2.1 Bayesian knowledge tracing.

Is the 1st and most popular model used by intelligent tutoring[3], Here the students' knowledge represents whether a student understand or not a concept. Generally, that knowledge is represented using binary variables 0 and 1. This model used Hidden Markov Model **(HMM)** to learn.

- Characteristics:
  - This model is highly constrained.
  - The prediction of the model degrades substantially when the number of hidden concepts increases[3].
  - The model does not have a mechanism to learn unlabelled concepts.
  - Allows inferring the probability of mastering a skill from a specific response pattern[2].
  - The standard model is defined by four parameters: initial knowledge (likelihood of knowing a concept before studying it), learning rate (the opportunity to acquire the skill having the opportunity of practicing), slip (false negative) and guess (false positive).
  - Lacks the ability of handle multi-skill questions.
  - Cannot capture the relationship between different concepts[4].

A version that involves forgetting (BKT+F), a version that incorporates skill discovery (BKT+S), a version that incorporates latent abilities (BKT+A), and a version that incorporates all three extensions (BKT+FSA) have all been presented as upgrades to the original model.

2.2 Probabilistic models

Among the bunch of models in this category, the most prominent ones are:

- POMDPs: partially observable Markov decision processes
- PFA: performance factor analysis

Figure 1: Road chart of the KT[7]

- LFA: learning factor analysis
- IRT: Item response theory (which uses Kalman filters)

2.2.1 POMDP model

In the lack of perfect information about the actual state, partially observable Markov decision processes are used to calculate an optimal conditional policy for selecting actions to achieve a goal[5].

Modelling learner knowledge within the POMDP requires specifying the space s of possible knowledge states and a transition model $p(s'|s,a)$for how knowledge changes, here s', represents the new state and a the action taken in the current state s. The observation model, maps to modelling the learner's behaviour given her knowledge. Intuitively, this model provides noisy information about the learner's understanding by specifying the probability $p(z|s,a)$ that a learner will give a particular response z to an item given her current knowledge state s.

2.2.2 Performance Factor Analysis model (PFA)

This is done in this paper[6]

It is a variant of learning decomposition, based on reconfiguration of learning factors Analysis. It can handle multiple skill questions. This model estimates parameters for each item's difficulty and also two parameters for each skill reflecting the effect of the prior correct and incorrect response achieved for that skill[7].

2.2.3Learning Factor Analysis model (LFA)

[7] https://whimsical.com/knowledge-tracing-JSCkpLJcMt7kTggVQpoyDN

LFA has three components: a statistical model that quantifies the skills, the difficulty factors that may affect student performance in the tutor curriculum, and a combinatorial search that does model selection[8].

To extend the power law model, the model made four assumptions about student learning. 1. Initially, different students may have some expertise. 2. All students progress at the same pace. 3. Certain concepts are more well-known than others. 4. Some topics are easier to grasp than others.

2.2.4 Item Response Theory (IRT)

IRT assumes the student knowledge state is static and represented by her proficiency when completing an assessment during an exam. IRT models a single skill and assumes the test items are unidimensional.[9] It assigns student i with a static proficiency θ_i . Each item j has its own difficulty β_j. The main idea of IRT is estimating a probability that student i answers item j correctly by using student's ability and item's difficulty. The widely used one-parameter version of IRT, known as the Rasch model, is:

$$p_j(\theta_i) = \frac{1}{1+e^{-(\theta_i-\beta_j)}} \qquad (1)$$

This method also has been integrated with knowledge training[10].

2.3 Deep learning models

Deep learning is an emerging approach to model the learning knowledge, the most prominent ones are Recurrent Neural Networks and from them one complex variant known as the Long Shot Term Memory (LSTM) networks[11] have performed best. They retain the information until it is explicitly told to delete it.

In general, the models based in deep neural networks have achieved the best performance.

- Characteristics:
  - This model is highly constrained.
  - The input to the network is one-hot encoding of the student interactions tuple $h_t = \{q_t, a_t\}$ that represents the exercise and the answer.
  - When the number of unique exercises is too big, then a random vector of tuples is selected using a normal distribution [12].
  - The model is highly parametrized.
  - The model uses minibatch, hidden dimensionality and applies dropout techniques to avoid overfitting.
  - Does not need expert annotations (human-labelled).

- It can work in any input that can be vectorized.
- Requires large amount of training data, it fails to predict in stills that are too easy or too hard to master.
- The student knowledge is modelled as a latent variable.
- This model observes knowledge at both the skill and problem level.
- Only considers the knowledge components of the problem and correctness, neglecting the breadth of other features.
- Some evolved models can automatically discover concepts.

The usage of laten variables is based on the difficulty of determining all of the elements that influence student achievement, some of which include: available material, time spent learning the course, individual capacity, and others.[13].

Another approach is to combine DKT with a Bayesian Network using the attention mechanism proposed on [14]. The objective here is to enforce Neural Networks' intrinsic property of being a tiered graph, with one node's output feeding into one or more nodes in the following layer.

2.3.1 Dynamic Key-Value Memory Networks[4]

This network is built on top of a Memory Augmented Neural Network (MANN), which is a type of RNN.
The memory structure of the DKVMN is made up of key-value pairs rather than a single matrix. In contrast to MANN, which attends, reads, and writes to the same memory matrix, the DKVMN paradigm attends input to the immutable key component and reads and writes to the associated value component. DKVMN uses the correlation weights to read and write to the value matrix to track a student's knowledge.
The model is fully differentiable, and stochastic gradient descent may be used to efficiently train it.
DKVMN outperforms the standard MANN and other models.
It can produce better results with fewer parameters than DKT.
It does not suffer from overfitting, which is a big issue for DKT.
It can discover underlying concepts for input exercises precisely.

3 Application, Problems and Datasets

In this section we will talk about the applications of KT, and some of the problems that the current solutions still have, At the end of this section we provide a list of the public available datasets.

3.1 Application of the models:

- Intelligent Curriculum Design[3] (design effective exercises which vary in difficult level and design curriculum according to the observer knowledge state of the student).
- Discovery of structure in student task[3].
- Personalized content recommendation.

3.2 Problems of the KT models:

- A binary representation of knowledge is limited[3].
- The hidden variables and their mapping onto exercises can be ambiguous[3].
- Limit of the kind of exercises that can be modelled [3].
- The DKT model is biases towards the data seen during the training phase.
- The prediction of the DKT model degrades substantially when the number of hidden concepts increases[3]
- This BKT model is highly constrained.

3.3 Datasets Used:

- Simulated Data[3]
- Khan Academy Data[3]
- ASSISTments Benchmark Dataset[3](provides a link to the data)
  The ASSISTments 2009[8], contains issues [7]:
  - Duplicated Record.
  - Mixing main problems with scaffolding problems.
  - Repeated response sequences with deafferents skill tagging[7].
- The ASSISTments 2015[9]
- KDD CUP 2010 dataset[10] [15]
- Synthetic-5[11]
- Statics2011[12]

[8]https://sites.google.com/site/assistmentsdata/home/assistment-2009-2010-data/skill-builder-data-2009-2010

[9]https://sites.google.com/site/assistmentsdata/home/2015-assistments-skill-builder-data

[10]https://pslcdatashop.web.cmu.edu/KDDCup/downloads.jsp

[11]https://github.com/chrispiech/DeepKnowledgeTracing/tree/master/data/synthetic

[12]https://pslcdatashop.web.cmu.edu/DatasetInfo?datasetId=507

4. Evaluation metrics, features, and road chart

In this section there will be presented the most common evaluation metrics used to evaluate the effectiveness of each model. Additionally, we will mention the different features used for modelling the knowledge of the students, and finally we talk about future directions.

Evaluation Metrics

- Area Under the curve (AUC)[3]: is a reliable metric for evaluating prediction, where the projected value of 0 or 1 provides different information about the model's performance. A higher AUC indicates more accuracy.
- The square of Pearson Correlation (R^2)[13]: is a coefficient between the observed and predicted values of dependent variables, comparable to the Root Mean Square Error, the square gives an indirect assessment of how good the modelled values are, using one or more variables (RMSE)

Some of the features used in KT are:

Features used:

- Correctness
- Sill tag
- Number of hints accessed
- Student first response time
- Number of attempts

Dimensionality reduction (using autoencoders[16])*, this technique can be applied in order to lower the dimensionality of the vector given as input in the case that too many features have been used.

In the Figure 1, we present the road chart of the KT research.

5 Conclusion

In this paper, we provide a literature review of the current state of the art of KT. We introduce a road map of KT that contain important models, datasets, and evaluation metrics.

KT is a high-complexity modeling problem because it's extremely difficult to determine all the factors that influence a student's performance. There are numerous factors that influence how a student performs, including the available material, the time involved, the number of hints accessed, the student's initial response, the time and number of attempts, the individual's capacity, and so on. The use of all these components promises an increase in prediction accuracy, but also new problems, such as an exponential growth in dimensionality, but it has also contributed to the field being more active. Correctly assessing a student's ability provides vital information to models for predicting student performance in the next time interval and tracing their knowledge when students' abilities grow dynamically.

Finally, future study can consider additional features such as time taken, hint generation, student dropout prediction, and modelling how students forget. In future work, different models will be adapted to problems with many linked subskills in the system, and multiple features will be used to train the models.

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SEARCHING FOR IT TALENT AT SECONDARY SCHOOL

Pál SARMASÁGI, HU

Abstract: The concept of talent is complex; it is similar to the concept of computational thinking and both can be difficult to define. Pupils who have an open mind to computational thinking can become potential IT talents. How can we discover these pupils at secondary school, especially those pupils who are not interested in IT? Generally, the identification of talent is a long-term process that requires the results of several tests and observations. This paper investigates concepts and evaluation environments and presents some tasks and assessments that help to identify potential IT talents at secondary school. The classroom trial presents a novel combination of well-known methodologies and devices.

Keywords: CS unplugged, IT talent, talent searching, computational thinking.

1 Introduction

The ICT-related subject is mandatory at secondary school in most countries. Some pupils are interested in Computer Science, while some others are not, regardless of their digital competences. There are a lot of pupils who play computer games every day and some of them have deep knowledge of computer science as they have learned how they can create their own plug-ins and mods for their favourite game. It is easy to involve pupils who are interested in ICT in classroom work and specialization classes. Other pupils are not engaged in informatics and they are not so motivated during ICT lessons at school meanwhile, maybe there are some potential IT talents among them. How can we explore their potential regarding computer science and how can we involve them in the ICT study group? This paper investigates this question and presents a possible way to involve invisible potential IT talents into specialization groups and talent management programs.

2 Talent in the ICT world

Generally, talent management is divided into two main parts. Searching for – and finding – potential talents and, after the recognition, their long-term nurturing and development. The talent search is not so easy, especially in the case of IT talents. Several tests help to identify talents generally. Some tests focus on mathematical talent, some focus on language talent, while others focus on musical or other creative talents. The general idea is that mathematical talents can become IT talents if they are interested in computer science. On the other hand, some IT talents have difficulties with math.

Haiyan Su published his literature review regarding the concept and measurable of information and communication talent. [1] He cited and emphasised Ionica-Ona's integrated definition of technology talents, which described it "as the expression of the superior endowment in different areas of technical field, as the excellence, demonstrated by an outstanding performance in this field or as a potential of excellence demonstrated by the results in various forms of evaluation." [2] If we focus on IT talents, we use the digital competence definition of the EU that contains a hierarchical system of skills and competencies. [3][4] One of the conclusions of his literature review is that we know who the IT talent is, however, we need newer and newer assessments and tests to identify them.

We suppose IT talents possess high-level Digital Competences or at least a part of them. The Digital Competences of the EU covers a wide band of knowledge and skill and we can create groups within these competences. Job descriptions of companies differentiate between 3 kinds of digital competence:

- Application skills – it is a general requirement for employees
- IT Professional skills – it covers several digital competences like Algorithmic thinking, Data modelling, Problem-solving, etc.
- Creative skills – For instance image processing, animation, design, etc.

IT professional jobs – apart from coding - can be divided into several parts, like system design, network management, operation (system administration), security, etc. However, these parts of digital competences require special knowledge and skills that are not in the curriculum of secondary school, so we cannot use these competences when we are searching for IT talents at secondary school.

On the other hand, there are several national and international IT competitions for pupils of secondary school. The thematic of these competitions is similar to labour market expectations. Application contests measure the application skills of pupils. Programming competitions focus on algorithmic thinking, data modelling, and problem-solving competences. There is a 3rd category of contests where creative pupils compete their creative skills.

A reasonable conclusion is the limitation of IT talent searching for these 3 competences. However, application skills are needed by every pupil, [5][6] while the genetic factor is emphasized in the case of creative skills, besides the external factors. [7] Therefore, most IT-related talent searching and talent management programs focus on programming (coding) and algorithmic skill.

The major part of measuring giftedness or potential can be reduced to measuring competences. There are several available tests and assessments from simple multiple-choice assessments to modern assessments using machine learning and artificial intelligence algorithm. [8] Most of these tests assess adults' skills or students' skills who study at the IT faculty of the University. [6] According to Haiyan Su's paper, the rapid development of the IT sector has urged not only the change of school education, but it requires newer and more precise tests and assessments regarding digital competences. [1] Most papers regarding talent search refer to Martinson's triple rule: [9][10]

- The identification of the gifted is a long-term process
- To explore pupils' skills several sources are needed (marks, tests, con-tests, etc.)
- The non-intellectual factors are also important

Therefore, it is reasonable to create and test new tasks, tests, and assessments that can be helping to identify potential IT talent at secondary school. The objective of this paper is twofold. Expanding the pool of available assessments that gives an additional test for supporting talent search and extending the pool of pupils among whom we are looking for talent. So our objective is to create and compose further tests to measure the level of pupils' competences regarding algorithmic skills at secondary school.

3 Source of tasks

The target group is in years 8-9 (age group 14-15) who starts secondary school or stands before admission. The pupils who are interested in computer science can participate in contests like 'Bebras'. [11] Bebras was founded by Dr. Valentina Dagiene Lithuanian professor and nowadays it has developed into an international community. Bebras promotes informatics and computational thinking among school pupils of all ages. The tasks are interesting and require logical thinking rather than programming skills, so it can be useful to addressing pupils who are not interested in informatics. Bebras has collected a lot of interesting tasks for its competition series. These are available on its website, therefore it is a good source to select tasks for potential talent search.

The motto of Bebras is 'International Challenge on Informatics and Computational Thinking' which refers to an important concept of computer science. The concept of computational thinking is just as difficult to define as the talent concept or most concepts regarding information technology since it is one of the youngest science areas and knowledge areas and its development is extremely rapid. [4] Instead of an exact definition, I use Nardelli's specification that builds on 3 pillars. The algorithm, programming language, and an agent or machine that can implement the received statements. It involves a significant group of problem-solving skills and techniques that are important within digital competences. Considering the specificities of the age group we need to focus on the algorithm. Every pupil uses algorithms every day as they get a dress in the morning or cross the road, etc. On the other hand, algorithmization is not created by computer science. Guild masters or employees of manufacture worked based on an algorithm. The 14-15 years old pupils have already met this concept and learned some simple algorithms during math lessons. [4]

An additional source is the website of the CS Unplugged community. [12] 'CS' is the abbreviation of Computer Science, while 'unplugged' means doing it without using a computer. The target group of CS unplugged is the pupils of primary school so the tasks are very simple. The principle of CS unplugged tasks is to teach pupils the basic concepts of CS and some basic algorithms while they are playing. It is an introduction to informatics that helps to found computational thinking. The necessary devices are some paper and pencils, classmates, space to play, and a teacher who leads the activities.

There are 6 topics:

- Binary numbers
- Image representation
- Searching algorithm
- Error detection and correction
- Kidbots
- Sorting networks

The structure of each topic is similar. There is a short introduction with a description and explanation. The detailed explanation of the topic describes key questions, lesson activities extended with notes, and teachers' observation. If it is relevant, the mathematical links are also available to the given topic. Finally, the website provides background information, how the given topic helps to develop computational thinking from the following point of view: Algorithmic thinking, abstraction, decomposition, generalising and patterns, logic, and evaluation. This detailed information helps teachers to clarify what they must observe during classroom work. There is no significant difference between ages 6-10 and ages 14-15 pupils' activity when they are working on these tasks. The solution requires thinking and consideration while they are 'playing'. Of course, some tasks are too simple for pupils of secondary school, but some of those are usable if we change the text and background of the task. Binary numbers, searching algorithms, error detection and correction, and kidbot topics are useful for pupils ages 14-15.

The third source is the 1st round of the National Secondary School Academic Competition (OKTV). This contest focusses on ages 17-18. The tasks of 1st round don't require a programming environment, they focus on algorithmic thinking and logical thinking. Therefore, these tasks are also usable for searching for informatics talent among pupils aged 14-15 at secondary school.

What all three sources have in common is that you don't need a computer to solve the tasks, so you can also involve those pupils who are still avoiding the computer. In addition, these tasks are playful, so these can show the joy in thinking about informatics problems, which is an important objective of our educational goal. [13] While pupils think they are playing, the teacher can observe them and if the standard deviation of scores is significant, the teacher can notice potentially gifted pupils. The observation is emphasized, the talent searching doesn't work properly if the pupil response only to a test.

4 Implementation

There is a clarified goal and there are a lot of usable tasks, we need to find the proper environment for implementation. We need to consider the best way to handle the assessment. Is it a competition or an individual test?

Bebras and the National Secondary School Academic Competition are individual contests where pupils must not cooperate with each other. CS Unplugged tasks were developed for classroom work where pupils can cooperate. The latter is more comfortable for pupils as it is less stressful while the teacher can observe pupils' activity. On the other hand, pupils like competition with their well-known classmates and the contest motivates them in such a community.

The second key question regarding implementation is the 'platform': which is better, paper-based, or computer-based assessment? The tasks were developed for 'unplugged' usage (without a computer). The evaluation of computer-based assessment is easier for teachers and pupils also have the necessary skills at secondary school.

Timing is also a question. What is the best time to address pupils, when can we involve the most pupils? When are they the most motivated?

To answer these questions, all cases should be tested on a classroom trial. This paper presents only the first few pilots that should be continued. The mentioned sources contain interesting tasks, but we need some introductory as well as some thought-provoking tasks. The first step was the selection of tasks and the first pilot was based on CS unplugged 's source.

4.1 Binary numbers

The first group of tasks is binary numbers from CS unplugged source. The binary numbers are part of the numeral systems topic. A few tasks about general numeral systems help to put binary numbers in context. While CS un-plugged focusses on pupils of primary school, our target group is older, pupils aged 14-15. They can think about the problem of overflow, which is also part of binary numbers as well as computational thinking. Binary logic and binary arithmetic belong to math, however, these are some of the important bases of Computer Science. The recognition of binary numbers and the conversion between decimal and binary numbers require and develop abstraction ability. The positional system is also important as it prepares the concept and usage of pattern matching, bitmap, etc. This topic reinforces pupils' data modelling competence.

Task sequence – binary numbers

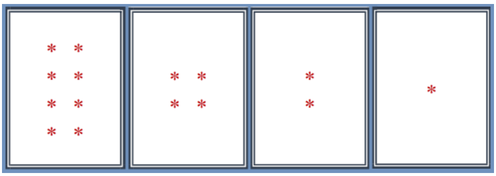
- (T1) What is the smallest base of the numeral system in which the number 762 can be interpreted?
- (T2) What is the smallest base of the numeral system in which the number 1233 can be interpreted?
- (T3) What is the smallest base of the numeral system in which the number F2 can be interpreted?
- (T4) What is the smallest base of the numeral system in which the number 101 can be interpreted?
- (T5) What's the next number after in the sequence 1, 2, 4, ... ?
- (T6) Which number in the decimal number system represents this binary number?

8x	4x	2x	1x
1	**0**	**0**	**1**

- (T7) Which number in the decimal number system represents this binary number?

1	**0**	**1**	**1**

- (T8) How many stars are there on the cards?



- (T9) Which number in the decimal number system is the binary number 1101?
- (T10) There are some more variations of these tasks...
- (T11) Whose cake is it?

- (T12) How old is the child who got this cake?

- (T13) What is the result of addition if there are 8 place values in binary?

01111111 + 1

- (T14) What is the result of addition if there are 8 place values in binary?

01010101 + 10101010

- (T15) What is the result of addition if there are 8 place values in binary?

11111111 + 1

4.2 Error detection and correction

The second group of tasks is close to binary numbers, but error detection and correction is a standalone topic. These tasks require more attention, however, the topic of the binary numbers helps pupils to be well prepared for it. Some people think the computer never makes mistakes. There are a lot of algorithms and technologies in Computer Science that have founded this thought. Pupils must understand that there is a huge difference between an intelligent implementer (like a pupil) and a machine (like a computer) as an intelligent algorithm-executor. The former checks and corrects mistakes while the latter only executes the predefined steps. [4] These tasks allow insight into error-checking algorithms, which supports computational thinking. They also require data modelling, modelling the real world, and problem-solving competences of pupils.

Task sequence – error detection and correction:

- (T16) There are parity bits in the yellow bar (with the help of these the sum of the bits in the given row and column will be even). Which cell is wrong?

	A	B	C	D	E	F	G	H	I
1	1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0

- (T17) There are parity bits in the yellow bar (with the help of these the sum of the bits in the given row and column will be even). Which cell is wrong?

	A	B	C	D	E	F	G	H	I
1	0	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	1	1	0
3	0	0	0	0	0	1	1	1	1
4	0	0	0	0	1	1	1	1	0
5	0	0	0	1	1	1	1	1	1
6	0	0	1	1	1	1	1	1	0
7	0	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1
9	1	0	1	0	1	0	1	1	1

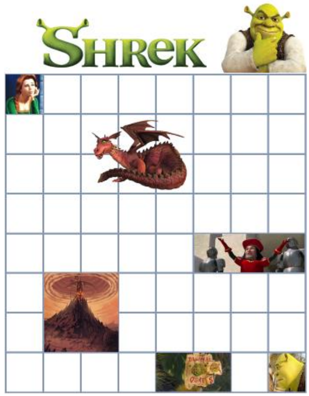
- (T18) There are parity bits in the yellow bar (with the help of these the sum of the bits in the given row and column will be even). Which cell is wrong?

	A	B	C	D	E	F	G	H	I
1	1	0	1	0	0	0	0	0	0
2	0	0	0	0	1	0	1	0	0
3	0	0	1	1	0	0	1	0	0
4	0	0	0	0	1	0	1	0	0
5	0	0	1	0	0	0	0	0	1
6	1	1	0	1	1	1	1	0	0
7	0	0	1	0	1	0	0	1	1
8	0	0	1	0	0	1	1	0	1
9	0	1	0	0	0	0	1	1	1

4.3 Kidbot

The third group of tasks is kidbot, which focusses on algorithmization. Most pupils have already gained knowledge about bots in primary school and some of them have experience in robot programming. They know some simple commands and statements and they have got practice in task decomposition to steps. The kidbot tasks allow a limited number of statements to achieve the goal so this helps to explore some of the fundamental principles in programming. Kidbot tasks reinforce algorithmic thinking and program solving competences.

Task sequence – kidbot:



- (T19) Take Shrek to Fiona in this table. You can use 2 kinds of commands: one step forward and one turn right (in right angle). Prepare the proper itinerary that avoids barriers and dangers (non-blank cells).
- (T20) The further tasks are similar: the pupils must find the route with the fewest commands or with the fewest turns right, etc.

4.4 Searching algorithms

The fourth group of tasks is searching algorithms. Searching for a specific piece of data is the basis of many computing applications so we need efficient algorithms for searching. [12] Searching in an unordered set, searching in a sorted set, and searching for a special pattern. These tasks help explore the nature of thinking of pupils. Is systematic thinking recognizable? Systematic thinking and systematic task approaches are important components of computational thinking. There are some problems where the best way is the regular systematic attempt. [14] Searching algorithm tasks require algorithmic thinking, data modelling, and problem-solving competences of pupils.

Task sequence – searching algorithm:

- (T21) There are 15 books with the same cover in an unordered sequence on a bookshelf. Please find Barry Burd's Java book. Repeat it at least 5 times.
- (T22) There are 15 books with the same cover in a sorted sequence on a bookshelf. Please find Barry Burd's Java book. Repeat it at least 5 times.

- (T23) Place 4 queens on a 4x4 chessboard so that no two of them attack each other.

Table 1 summarizes the tasks by their properties. The main source is CS un-plugged so the topics track its thematic. The topics were reduced to those which are interesting for pupils at secondary school. The CS unplugged tasks represent a standard level, meaning these are of average difficulty. Some easier introductory tasks prepare pupils to the resolution of standard-level tasks. The main goal is to identify potential talents so the assessment should contain some thought-provoking tasks.

Kahoot is a well-known tool that is popular among pupils as well as teachers. [15] Most pupils are motivated by competition meanwhile they usually think it is only a game. If we clarify before the Kahoot-based test that it is not testing, every pupil will be relieved. Kahoot uses a time limit so the pupils must make a decision before the time expired. They can select the right answer from 2-4 possible options. After each answer, Kahoot displays the right answer so it educates pupils during the test. A further benefit for a teacher is that Kahoot creates and fills the evaluation table automatically. However, some tasks are not compatible with Kahoot. The kidbot related tasks were planned as a parlour game where one pupil gives the statements and the other one implements those. It is useful when the pupil meets first time with program control at primary school, though it isn't necessary at secondary school. The pupils get a printed paper with a chart and their task is to write the necessary statements on the paper.

Tasks about algorithms required a third solution. A simple web application randomly displays 15 books with the same cover and when the pupil hovers a mouse over a book, the app displays the author and title. Once they search in the unordered sequence, and then they search in the sorted sequence. Whether they are looking for a book in a sorted or an unsorted order sequence, pupils need to count the number of their attempts. The searching should be repeated at least five times and the average of the number of trials should be recorded. Five trials can be enough to work out a systematic strategy for searching. In the case of this task, the platform contains a web application and a paper.

The source of most tasks is CS unplugged. Some self-made tasks had to be created for methodology reasons. However, these were influenced by the referred sources. (CS unplugged, Bebras and OKTV)

The tasks had three different implementations. In the case of Kahoot, it is not a question, it is a playful competition. The paper-based tasks can be homework or standard classroom test. The algorithm-related tasks require more attention and more sophisticated implementation. The recording of an average of searching steps and the description of the recognized strategy is suitable for evaluation. The best way to discover potential talent is if we can observe pupils' work step by step. It requires a special application or an individual face-to-face test.

5 Classroom pilots

The presented tasks were tested several times in the classroom, in the first year of secondary school as well at the primary school final year. The proper timing was important.

Generally, the classmates don't know each other yet at the beginning of secondary school and students are shy and want to introduce themselves well. Most teachers make pupils do a test for diagnostics aims in the first few weeks. They are motivated and they are not yet under pressure during this period, so it is a good time to search for talent in IT.

The sample size doesn't allow a detailed analysis; however, it reflects some important details regarding tests as well as tasks. Based on this feedback, the test needs to be improved. Of course, the improved task list also should be tested and the results should be analysed after we have reached the proper sample size.

Pupil	T5	T11	T12	T8	T9	T10	TX	T13	T14	T15	T16	T17	T18	Sum
V.E.	1	1	1	1	1	1	1	0	1	1	1	1	1	12
K.D.	1	1	0	1	1	1	1	1	1	1	1	1	1	12
L.E.	0	1	1	1	1	1	1	0	1	1	1	1	1	11
N.E.	1	1	0	1	1	1	1	1	0	1	1	1	1	11
D.L.	0	1	1	0	1	1	1	1	1	1	1	0	0	9
K.B.	1	0	1	0	1	1	1	0	1	0	1	1	1	9
N.B.	0	1	1	1	0	0	0	0	1	1	1	1	1	8
Sz.T.	1	1	0	1	1	1	0	1	0	0	1	1	0	8
M.B.	1	1	0	1	0	1	0	1	0	0	1	0	1	7
H.D.	1	0	1	1	0	1	0	0	0	0	1	1	1	7
M.P.	1	0	1	1	0	0	0	1	1	1	0	0	0	6
K.B.	1	0	0	1	0	0	1	0	0	0	1	0	1	5
D.J.	0	0	0	0	1	0	1	0	0	1	1	0	0	4
D.B.	0	1	0	1	0	0	0	0	0	0	1	0	1	4
Total	9	9	7	11	8	9	8	6	7	8	13	8	10	

Table 1: Results at class 9

The first trial contained only 13 tasks in a different order. 12 of them were identical to the presented task series, and there was only one 'external' task that contained a conversion between numeral systems (TX). It was a Kahoot contest. The pupils enjoyed it, but the result was ambivalent.

The result showed differences between pupils and it pointed out some potential talents, who got over 10 scores. Their result in the school year has confirmed this recognition. However, further pupils joined to elite club based on their classroom work, who got only 7 scores, while the average was 8.07. Some pupils said it was a difficult test because the context was not clear. The scores by task chart pointed out which the critical tasks are (the minimum points of the curve) and which the easiest tasks are (the maximum points of the curve). It also emphasized the pupils' learning, their quick correction where the curve is monotone growing within a similar task's section.

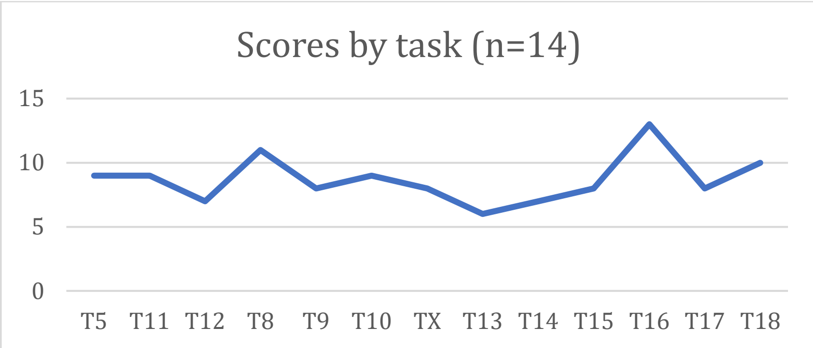


Figure 1: Scores by task at class 9

Most pupils gave the right answer to task T16, which is the introductory task of error detecting. Task T8 was also a simple calculation. Despite the first tasks referring to binary numbers and Kahoot displaying the right answer the cake with candles task was too difficult. (T3) The summation of binary numbers on 8 bits were the further tasks with the fewest good result. (T13-T15)

This assessment also was tested in some higher classes and the results were similar. These tests also brought some pupils to the IT study group with their high scores.

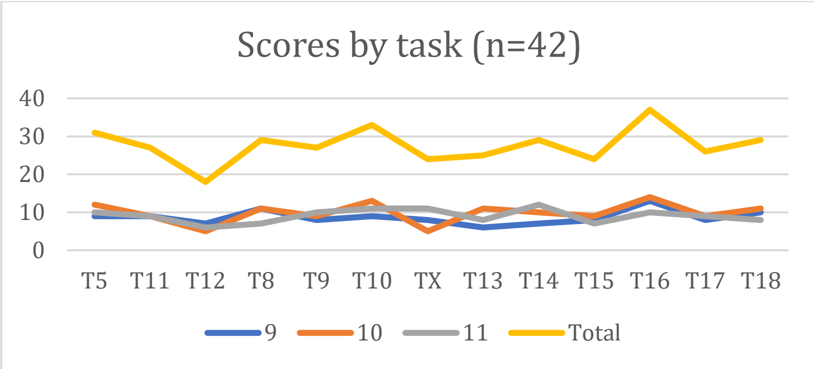


Figure 2: Scores by task at class 9-10-11 and total

Based on the results and the received feedbacks, the tasks and the order of tasks were reorganized and this renewed task list was described in the previous section. The tested task list was extended with several introductory tasks in binary numbers topic. Before the hardest tasks some preparatory tasks were inserted.

There is a central admission for a secondary school in Hungary. It is a very important assessment for every pupil, it influences their future study. So, they are very active and motivated at this period. Whether during the preparation period at primary school or during the oral exam at secondary school these tasks can be used to explore pupils' competences. A class of pupils participated in the Kahoot contest and some of them answered kidbot and searching algorithm questions as homework. The renewed Kahoot provided a wider range of scores for evaluation, which helped to explore more details within the target group.

The pupils over 10 scores can be potential talent. The details of their results are also interesting. The best pupil learned from his mistake as he gave the wrong answer to T11, but he gave the right answer to T12 (two similar tasks with cake and candles). He started the test with wrong answers, however, after a short warming-up, he gave the highest number of right answers. This 'warm-up' activity can be observed in each task group in his case. There are some pupils who got 8-9 scores, however, they gave the right answers to more difficult tasks. They also can be involved in the IT study groups. Most pupils over 7 scores have a lack of self-confidence: they were surprised when they noticed their result and they received a strong confirmation regarding their promising digital competences.

The summary chart (Figure 3) presents the levels of difficulties by tasks. The counting stars by the positional system was the simplest task again (T8), while the introductory task preceding it by two was the most difficult (T6). The learning activity during the test can be tracked better, except for the cake with candles tasks. These tasks require more introductory tasks for better preparation.

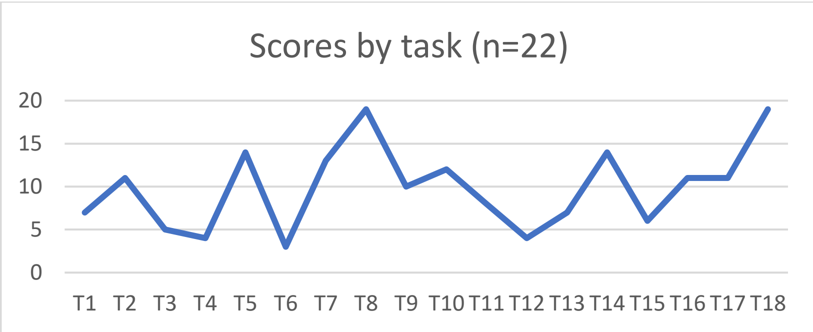


Figure 3: Scores by task at class 8

The paper-based tasks as homework were not so successful. Nine pupils sent their solutions. The kidbot tasks were not clear for every pupil, T19 was solved by 7, while T20 was solved by 4 pupils. The received solutions were correct and pupils prepared different solutions.

T21 and T22 searching algorithms tasks were done by every pupil. They searched five times for a book in an unordered sequence and five times in a sorted sequence and they recorded the number of attempts.

Pupil	T21	T22
B.S.	4	2,2
Cs.B.	6,6	3
F.L.	6,4	4,2
Gy.M.	7,3	3,4
H.Á.	8	3,2
H.E.	4	7,4
K.K.	2,8	2,4
R.L.	4,8	3,6
T.Á.	6,6	5,2

Table 4: Average number of trials during searching

Some pupils described their strategy and there was only one pupil who formulated an approximately binary search algorithm. There is another pupil who needed more trial during the searching in the sorted sequence than searching in the unordered sequence. Three pupils prepared a solution for the four queens task (T23) and all of them were correct. They didn't describe their strategy and the number of trials. To summarize, there is not any information about the pupil's way of thinking to reach the solution.

There was an additional trial with the searching algorithm tasks during the oral admission exam at secondary school. It was a good possibility to observe pupils during their attempts. This observation confirmed that most pupils in ages 14-15 cannot build the proper searching algorithm themselves. The few who recognized the essential of the binary searching algorithm can be potential IT talents. There were more pupils who searched systematically in the unordered sequence. They have also found a solution for the four queens task.

6 Conclusion

In this paper, we described some possible task sequences to identify potential IT talents at secondary school. In line with our objectives, every pupil was involved in these playful tests that help to explore their thinking and existing skills. Some pupils were surprised as they faced their good results, while their marks reflected that their digital competences are not so good. The positive feedback about their emerging computational thinking can build a good relationship between them and IT. The encouragement helps to involve them in the IT specialization group. The extended pool of pupils allows discovering more potential IT talents. On the other hand, these task lists, as well as CS unplugged tasks created to introduce ages 5-10 to the bases of computer science are suitable for assessing pupils. Therefore, these tasks can be an additional assessment that helps to identify IT talents.

The results of pilots pointed to some issues that should be solved, so we consider it as a work in progress. In order to save the motivation of pupils during the assessment, we need more introductory, preparatory tasks before searching algorithms and before the more difficult binary numbers tasks. Failure blocks motivation and pupils lose their interest in computer science. Pupils need to have a sense of achievement, so the result of the weakest pupil must be over 50%. On the other hand, achieving 100% could be made more difficult; the best if it poses a challenge for pupils. The presented tasks were not easy for anybody to reach 100%. The weakest pupil reached only 22% at primary school and 30% at secondary school, so these tasks are suitable to investigate digital competences of this age group.

Kahoot, as an online contest application is useful, but it could not meet our expectations. It displays the right answer after each question, thereby it educates pupils during the test, which was an additional important benefit. The time limit is an important feature, but the evaluation of the quickness of answering encourages pupils to make haste instead of think. The right answer is more important than the response time. In addition, Kahoot cannot handle searching algorithm tasks, so we need a special web application that can track and log pupils' steps during the search.

Most of the tasks and the applied application are known and available, and the current classroom trial presented a novel combination of well-known methodologies and devices. Further benefits were provided by pilots as these educated pupils during tests. This test is usable for finding potential IT talent, and it is also a playful motivation tool to support the education of computational thinking at secondary school.

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SYSTEM ELEMENTS IN SCIENTIFIC TERMINOLOGY

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Abstract: The study deals with system elements in scientific and technical terminology. It presents system elements as elements of terms and terminological connections that reflect any of the systemic relationships. Hierarchical relationships are presented as the main ones, but other relationships are also taken into account: cause-outcome relationship, whole-part relationship, opposite relationship, negative relationship and quantitative relationships. In every terminological system, there is a subset of terms that have the property of systemicity. This means that the term itself reflects some of the systemic relationships. In most cases, this is achieved using international or national prefixes and prefixoids. The existence of these relations is demonstrated by examples from several languages, mostly from the field of ICT. The study points out the advantages of applying system elements in educational processes.

Keywords: Scientific terminology, systemicity of terms, system elements in terminology, systemicity in acquiring of terms in education

1 Introduction

The term terminology is used in two senses. The first of them is the name of a scientific discipline that deals with the theory of terms formation. In the second sense, terminology is understood as a set of terms of a certain field of scientific or technical activity. Terms in this case are understood as names of concepts/notions that serve in communication as their equivalents. It is generally accepted that each department has the right to create its own system of terms. In fact, no system of terms can be created as independent. This is due to the existence of interdisciplinary relationships. As a result, each term system overlaps in part with the systems of other, especially basic and related disciplines.

The terminology of any field is not uniform. Inequality is manifested in the fact that in each term system there are established terms and new terms – neologisms, national language terms and terms taken from other languages, terms accurate or less accurate, or even inaccurate, concise or inaccurate, semantically transparent and non-transparent, reflecting some from systemic relationships, or non-systemic ones.

We consider the systemicity of terms as one of basic properties (Stoffa, 1996, 1999, 2000). The aim of the study is to point out a considerable number of system elements, which can be used to directly express any of the system relationships, or belonging to a specific subset of terms. Due to the limited scope of the contribution, we present only a limited number of examples.

Another goal is to point out the advantages of using system elements in the learning of scientific and technical terminology in educational processes, and also to some problems in their adoption.

2 The most frequently used system elements

Prefixes and suffixes as well as prefixoids and suffixoids can be considered as the most frequent system elements in terminology (Stoffa, 2000; Stoffa – Stoffová, 2017).

Prefixes are groups of vowels that are added to a word base to modify its meaning. Each language has a large number of prefixes. Some of these prefixes are used in several languages in the same or slightly modified form. Examples of such prefixes are the prefixes ***a-, an-, bi-, di-, de-***. Such prefixes are considered international. In addition, each language has a large number of national prefixes. Examples of English prefixes are ***en-, in-, under-***.

Suffixes are similar elements of terms as prefixes, but they are added in principle behind a word-forming basis and thus modify its meaning. The existence of international and national suffixes is similar to that of prefixes. Examples of international suffixes are ***-ent, -er, -ism, -ium, -or.*** Examples of English national suffixes include ***-able, -ation, -ible, -ility, -ity, -less, -ness***.

Prefixoids are parts of compound words that are added to their beginnings similar to prefixes and modify their meaning. Examples of international prefixoids are ***audio-, tele-, video-.*** Examples of English national prefixoids are ***half-, self-, short-***.

Suffixoids are parts of compound words that are added behind a word-forming basis similar to suffixes and modify their meaning. Examples of international suffixoids are ***-duct, -gram, -meter***. Examples of English national suffixoids are ***-bearing, -proof***.

3 System prefixes

System prefixes reflect one of the system relationships. There are national equivalents to some international prefixes. The opposing systemic relationship is reflected by the prefixes ***a-*** (*aperiodic, apolar,* *aspherical*), ***ab-*** (*abnormal, abrupt, absence*), ***an-*** (*anaerobic, anomalous, anorganic*), ***i-*** (*irrational, irrelevant, irreversible*), ***im-*** (*imbalance, immaterial, immutability, impossible*), ***in-*** (*inability, inacessibility, inaccuracy*), ***non-*** (*non-compressed, non-dimensional, non-linear, non-metalic*), ***un-*** (*uncompensated, uncontaminated, uncontrolled*), ***anti-*** (*anticorrosive, antiparticle, antimagnetic*). The same applies to the pair ***in-*** (*inboard, indoor, input*) and ***out-*** (*outboard, outdoor, output*) and to the pairs ***large-*** (*large-area, large-grained, large-scale*) and ***small-*** (*small-bore, small- scale, small-volume*), **micro-** (*microclimate, microinstruction, microstructure*) and ***macro-*** (*macroclimate, macroinstruction, macrostructure*).

The hierarchical system relationship of co-ordination expresses the prefix ***co-*** (*co-author, coaxial, collaboration*).

The system relationship of redundancy expresses the prefix ***over-*** (*overflow, overlapping, overload, overtime*).

Repetition of activity is expressed by the prefix ***re-*** (*reaction, recheck, restructuring*). In Czech and Slovak, there is ***znovu-*** its national equivalent of re- (*znovunastavení/znovunastavenie, znovuoživení/znovuoživenie, znovupoužití/znovupoužitie, znovuzapojení/znovuzapojenie*).

4 System suffixes

System suffixes reflect one of the system relationships. There are national equivalents to some international suffixes. The system suffix ***-able*** expresses the potential of a phenomenon (*extendable, programmable, transformable, undoable, unworkable*). Its national equivalent in Czech is the suffix ***-elný*** (*identifikovatelný, tavitelný, volitelný*)) and in Slovak the suffix ***-eľný*** (*rozťažiteľný, zameniteľný, zanedbateľný*). English system suffix ***-ing*** expresses some of the activities (*keying, loading, pacing, typing*).

5 System prefixoids

System suffixes reflect one of the system relationships. There are national equivalents to some international prefixoids.

The hierarchical relationship of subordination is expressed by the prefixoid ***sub-*** (*subaddress, subgroup, subset, subtree*).

The opposite relationship is expressed by a pair of prefixes ***im-*** (*implosion, import, importable*) and ***ex-*** (*explosion, export, exportable*).

The quantitative relation of individuality is expressed by the prefixoids ***mono-*** (*monochromatic, monolithic, monoprocessor*) and ***uni-*** (*unibus, unicode, unipolar, unidirectional*). There is a national equivalent ***jedno-*** to them in Czech and Slovak (*jednočlen, jednofázový, jednomocný*).

The quantitative relationship of a large number is expressed by the prefixoids ***multi-*** (*multidigit, multifunction, multilevel, multimedia, multiprogramming*) and ***poly-*** (*polyglot, polygon, polymer*). To them exist Czech national ekquivalent ***více-*** (*víceadresový, vícedílný, vícemocný*) and in Slovak ***viac-*** (*viacadresná, viacčipový, viackanálový, viacsúborový, viacúrovňový*), and also commmon equivalent ***mnoho-*** (*mnohočlen, mnohopólový, mnohostupňový*).

The prefixoid ***semi-*** (*semiautomatic, semimetal, semiconductor*) is productive and common. It also has national equivalents: in English ***half-*** (*halfaxis, half-axle, half-life*) and ***hemi-*** (*hemicompact, hemigroup, hemihydrate*), in Czech and Slovak ***polo-*** (*poloautomat, polodrahokam, polokov*), and in Slovak also ***pol-*** (*polčas, polhodina, polkruh*), in Polish ***pół-*** (*półautomatyczny, półkolc, półprodukt*), in Hungarian ***fél-*** (*félhornyolás, félgömb, félkör*).

The time relationship is expressed by the prefixoid ***post-*** (*postcondition, postprocessor, postscript*).

The opposite relationship is also expressed by the pair ***pre-*** (*pregradual, prediction, preimpregnation, previous*) and ***post-*** (*postcondition, postgradual, postprocessing, postprocessor*).

A group of prefixoids expressing one of the specific relationships is very numerous.

Examples are:

Prefixoid ***audio-*** expresses the relationship to sound (*audiogram, audiometers, audiovisual*).

Prefixoid ***bio-*** expresses the relationship to the living (*biochemistry, biophysics, biotechnology*).

Prefixoid ***info-*** expresses the relationship to information (*infobases, informant, informatics*).

Prefixoid ***kryo-*** expresses the relationship to low temperatures (*cryo-metry, cryostat, cryogenics*).

Prefixoid ***photo-*** expresses the relationship to light, resp. to photography (*photocell, photocopy, photodetector*).

Prefixoid ***pseudo-*** expresses the relationship of iniquity, resp. inaccuracies (*pseudocode, pseudoinstruction, pseudo-operation*).

Prefixoid ***tele-*** expresses the relationship to distance (*telecommunication, teleconferencing, telephone, teleprint*).

Prefixoid ***thermo-*** expresses the relationship to heat (*thermoplastic, thermostat, thermoswitch*).

Prefixoid ***video-*** expresses the relationship to the image (*videodisc/ videodisk, video-tape, video-text*).

The number of prefixoids expressing quantitative relationships is extremely large. International prefixoids like the ***tetra-, penta-, hexa-*** type have a high frequency. The national names of numerals, both definite (*fivefold, four-stroke, sexfoil*) and indefinite (*manifold, many-sided, many-valued*), are often used as prefixoids.

In English, the form of writing prefixoids with a hyphen predominates. In other languages, the form without a hyphen predominates.

6 System suffixoids

International system suffixoids are highly prevalent in terminology. Some national suffixoids are also used, e.g. ***-proof*** (*alkaliproof, fireproof, waterproof*).

The international suffixoid ***-meter*** expresses the relationship to measuring instruments (*ammeter, voltmeter, wattmeter*). There are several national equivalents to this suffixoid, e.g. ***-měr*** *(elektroměr, frekventoměr, vodoměr)* and ***-metr*** (*ampérmetr*, *wattmetr, volumetr*) in Czech, ***-metr*** (*fotometr, termometr, wolumetr*) and ***-mierz*** (*amperomierz, watomierz, woltomierz*) in Polish, ***-mer*** (*elektromer, frekventomer, vodomer*) in Slovak, and ***-mérő*** (*árammérő, voltmérő*, *wattmérő*) in Hungarian.

The international suffixoid ***-graph*** performs a similar function. It is used to name devices that simultaneously measure and register the measured result, e.g. *anemograph, barograph, polarograph, thermograph*. In several languages it has the spelling form ***-graf***.

7 Ambiguous system elements

Some system elements have a homonymous character, i.e. correspond to more than one meaning. Most such elements have two meanings. For example, the prefixoid ***un-*** in addition to a numerical relation can also express a negative relationship (*undesigned, undirected, unprotected*). Prefdixoid ***auto-*** is ambiguous. It can express the relationship to self-activity (*autocode, atocontrol, automated, autopilot*), motoring (*autocar,* *autocamp, automobile*) or the subject to itself (*autobiography, atodidact, autograph*).

The prefixoid ***inter-*** is also homonymous. It can reflect internationality (*intercontinental, international, internet*), intermediate position (*intercycle, interchip, interlayer, interphase*) or reciprocity (*interaction, interactivity, interchange*).

8 Specific national system elements

Some system elements occur in only one language or in a small number of languages. An example of such a system is the terminology of oxygen compounds in Czech and Slovak. While some national systems express the valency of elements using quantitative prefixoids, the Czech and Slovak system uses suffixes:

-ný (*oxid draselný*), in English (*potassium* ***mono****xide*);

-natý (*oxid indnatý*), in English (*indium* ***mono****xide*);

-itý (*oxid arzenitý*), in English (*arsenic* ***tri****oxide*);

-ičitý (*oxid kremičitý*), in English (*silicon* ***di****oxide*);

-ičný (*oxid jodičný*), in English (*iodine* ***pent****oxide*)

-ečný (*oxid fosforečný*), in English (*phosporous* ***pent(a)****oxide*);

-ový (*oxid chlorový*), in English (*chlorine* ***tri****oxide*);

-istý (*oxid chloristý*), in English (*chlorine* ***hept****oxide*);

-ičelý (*oxid osmičelý*), in English (*osmium* ***tetr(a)****oxide*).

9 Importance and values of system elements in education and problems in their acquisition

Based on the above, it can be stated that systemic elements are of great importance in education, this is mainly for the following reasons:

- They facilitate the learning process because their meaning is constant;
- They allow the creation of new terms and only the small number of system elements are less productive;
- Many system elements are used in several languages in the same or slightly different form, which facilitates international communication;
- Knowledge of international systemic elements facilitates the acquisition of foreign languages.
- Systemic elements occur in many neologisms and make it easier to understand their meaning.

When acquiring system elements, there are also some objective problems that make their acquisition difficult. These are in particular:

- Ambiguity, this is homonymy of several system elements;
- Factual equivalence of several system elements, this is. their synonymy.
- The need to respect the usage of the relevant professional community. E.g. in Czech and Slovak terminology, the prefixoid ***supra-*** (*superfluidity, superconductor, superconductivity*) is used instead of prefixoid ***super-***.
- Semantic opacity of several international system elements. It is therefore necessary to explain their meaning at the beginning of their acquisition.

10 Conclusion

System elements are an important part of many existing and emerging terms. Many of them are international, which facilitates not only communication between experts from different language areas but also the acquisition of foreign languages. They are also very important in education, but in this case special attention must be paid to the indicated problems.

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SOFTWAROVÉ PROSTŘEDKY NA PODPORU ON-LINE VZDĚLÁVÁNÍ

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Abstrakt, SK: Príspevok sa zaoberá používaním digitálnej techniky, on-line technológií a interaktívneho edukačného softvéru na dištančné vzdelávanie na základných a stredných školách. Predpokladom efektívneho využívanie digitálnych technológií na školách predpokladá, že učitelia majú prístup k potrebným technickým zariadeniam a technológiám a majú dostatočnú digitálnu gramotnosť a kompetencie na ich využívanie. To isté sa predpokladá na strane edukanta, čo sa týka jeho technického a technologického vybavenia a tiež jeho používateľských kompetencií a zručností v používaní digitálnych technológií. Článok referuje aj o tom, ako zvládli učitelia v ČR a SR dištančné vzdelávanie počas pandémie corona-vírusu COVID-19.

Kľúčové slová: Edukačný softvér, digitálna technika, on-line technológie, on-line vzdelávanie, dištančné vzdelávanie.

Abstrakt, CZ: Příspěvek se zabývá používáním digitální techniky, on-line technologií a interaktivního edukačního softwaru na distanční vzdělávání na základních a středních školách. Předpokladem efektivního využívání digitálních technologií na školách předpokládá, že učitelé mají přístup k potřebným technickým zařízením a technologiím a mají dostatečnou digitální gramotnost a kompetence na jejich využívání. Totéž se předpokládá na straně edukanta, co se týče jeho technického a technologického vybavení a také jeho uživatelských schopností a dovedností v používání digitálních technologií. Článek referuje i o tom, jak zvládli učitelé v ČR a SR distanční vzdělávání během pandemie corona-viru COVID-19.

Klíčová slova: Edukační software, digitální technika, on-line technologie, online vzdělávání, distanční vzdělávání.

SOFTWARE RESOURCES TO SUPPORT ON-LINE EDUCATION

Abstract: The paper deals with the use of digital technology, online technology and interactive educational software for distance education in primary and secondary schools. A prerequisite for the effective use of digital technologies in schools presupposes that teachers have access to the necessary technical equipment and technologies and have sufficient digital literacy and competence to use them. The same is assumed on the part of the educator in terms of his technical and technological equipment as well as his user competencies and skills in the use of digital technologies. The article also reports on how teachers in the Czech Republic and the Slovak Republic managed distance learning during the corona-virus pandemic COVID-19.

Keywords: Educational software, digital technology, online technologies, online education, distance education.

1 Úvod

Efektivní využívání digitálních technologií je bezpochyby nezanedbatelnou podmínkou jednak pro uskutečňování kvalitního vzdělávání, a jednak pro plynulý chod školy, ať už při administrativní práci nebo při komunikaci s veřejností, zejména rodičovskou.

Vývoj světa zcela zřetelně ukazuje, že vliv technologií na výukový proces již nelze opomíjet a myslet si, že dobrému pedagogovi prostě stačí, když své jinde získané odborné schopnosti v případě potřeby přenese i na využití technologií. Mylná je i hodně rozšířená představa, která vede mnoho odpůrců technologií k domnění, že nejlepší pro výchovu dětí je, když jsou do co nejvyššího věku od technologií zcela izolovány.

Technologie ovlivňují svět, myšlení lidí, výukové cíle i vzdělávací prostředí. Lidstvo je v situaci, kdy se bez technologií neobejde ani v osobním životě, ani v životě profesním. Technologie je ovšem třeba využívat efektivně a kvalitně. Je třeba vést žáky v užívání technologií tak, aby jim pomohli v osobním růstu a dosažení životních cílů. Totéž se týká i žáků hendikepovaných.

V současné době je realizována „Strategie digitálního vzdělávání“, která je nazývána digitální gramotností. S tímto přichází i změna stávajících Rámcových vzdělávacích programů i Standard učitele.

Teprve před několika lety začaly v evropských institucích snahy o vytvoření systematického popisu digitálních dovedností a kompetencí, kterými by měli být vybaveni učitelé. Také bylo stále více zřejmé, že ve sbližující se Evropě je nutné hovořit i v této oblasti společnou terminologií. Výsledkem těchto snah je rámec digitálních kompetencí pedagogů DigCompEdu. DigCompEdu je výstupem dlouhodobé výzkumné činnosti Společného výzkumného střediska (Joint Research Centre) Evropské komise.

K využívání digitální technologií učiteli i žáky k online výuce bylo v období COVID-19. V tomto období došlo od 11. března k úplnému uzavření škol v celé České republice. Všechny školy řešili online výuku. K dané výuce museli žáci i učitelé využít svá zařízení – počítače, notebooky, tablety i mobilní telefony. U učitelů i žáků došlo v tomto období k výraznému zlepšení v oblasti využívání digitálních technologií ve výuce. Tímto krokem budou třeba v budoucnu ve školách více využívána žákovská zařízení (BYOD).

2 Online výuka ve školách

Neobvyklá situace pro učitele i žáky nastala v České republice v období COVID-19. Od 11. března, kdy došlo k úplnému zavření všech škol. Všechny školy museli najednou řešit problém. Jakým způsobem výuku řešit? Jaké prostředky k tomu využít? Jaké prostředí využít? Jakým způsobem žáky aktivně zapojit? Budou mít žáci dostatečné množství techniky? Bude fungovat online výuka na mobilních telefonech, tabletech, počítačích či noteboocích? Tyto a podobné otázky si kladli učitelé i ředitelé škol. Každá škola si zvolila svůj postup, svoji strategii. Žádná rada či pomoc od Ministerstva školství, mládeže a tělovýchovy České republiky nebyla. Od začátku dubna začala Česká školní inspekce zjišťovat situaci na školách. Informace k online výuce prováděla telefonickým kontaktem ředitele školy a pokládala mu následující otázky:

- Jak se daří komunikace s učiteli, žáky a jejich rodiči?
- Jaká je ve škole digitální podpora distanční výuky?
- Jak se inspirujete v metodách distančního vzdělávání?
- Jak spolupracují učitelé při distančním vzdělávání?
- Jak se daří zapojovat žáky do distančního vzdělávání?
- Jak využívají učitelé digitální techniku?
- Jaké formy podpory digitální techniky distančního vzdělávání využíváte?
- Jak se daří komunikace učitelů se žáky? (jaké aplikace/platformy využívají apod.)

- Jak organizují učitelé obsah distančního vzdělávání? (jaké on-line zdroje využívají apod.)
- Jak učitelé hodnotí výkony žáků při distančním vzdělávání?

Školy očekávaly od Ministerstva školství, mládeže a tělovýchovy či České školní inspekce rady či pomoc. Bylo to zcela obráceně. Místo pomoci a rad si Česká školní inspekce zjišťovala stav na školách a mapovala situaci. Možná teď na základě zkušeností škol vydá Ministerstvo školství, mládeže a tělovýchovy příručku s možnostmi, co školy mohou v oblasti online výuky dělat, které platformy mohou využívat apod.

Vzhledem k tomu, že v době psaní článku jsme výsledky průzkumu školní inspekce neměli k dispozici, jsme udělali vlastní průzkum mezi učiteli základních a středních škol. Rozeslali jsme několik elektronických dotazníků s 12 otázkami na zmapování situace ve školním vzdělávání během pandemie. Výsledky průzkumu jsou v obou státech velmi podobné.

Bohužel omezený rozsah článku neumožňuje průzkum a jeho výsledky analyzovat a podrobně statisticky vyhodnotit. Plánujeme o výsledcích průzkumu napsat samostatný článek do časopisu CEJNTREP. V dalším jen popíšeme některé možnosti, které se v odpovědích nejčastěji vyskytovaly.

3 Možnosti on-line výuky

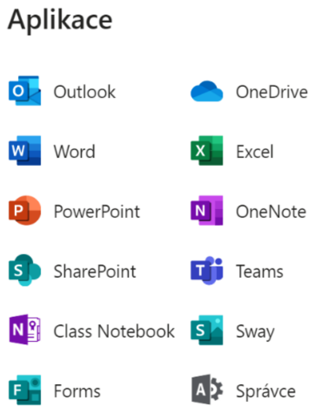
Online výuka probíhala na různých školách v různých platformách. Učitelé řešili výuku a zároveň i testování. Ve školách nejčastěji využívali a stále využívají:

- Microsoft office 365 – Teams (výuka) a Forms (testování)
- Google – Google Classroom (výuka) a EduPage (testování)
- Zoom – výuka.

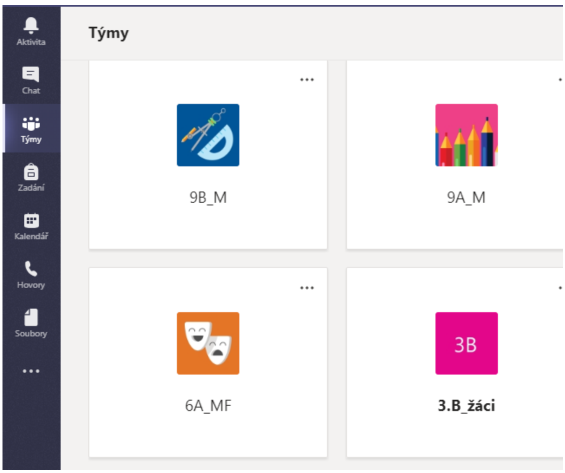
4 Microsoft office 365 – Teams

Firma Microsoft nabízí všem školám office 365 zdarma. Pouze si ověří, že škola je v rejstříku škol. Školy tuto nabídku hojně využívají. Stejně tomu je i v naší škole. Všem učitelům a žákům jsem založila účty. Roztřídila je do skupin dle tříd. Všichni žáci i učitelé mají svůj pracovní e-mail. Zdarma je Word, Excel, PowerPoint, což je velká výhoda při výuce, neboť všichni žáci i učitel pracují ve stejném a nejnovějším prostředí. OneDrive je úložiště o velikosti 5TB. Nechybí ani Forms na tvorbu kvízů či testů. Nejdůležitější součástí pro online výuku je Teams.

V prostředí Teams si mohou učitelé či žáci vytvořit své týmy. Vloží členy týmy a mohou spolu komunikovat. Ke komunikaci mohou využívat pouze chat nebo se spojí pomocí hovoru.



Obrázok 1: Aplikace Office 365



Obrázek 2. Teams – pracovní skupiny

Učitel prostřednictvím kalendáře naplánuje schůzku. Tím se odešle odkaz na danou schůzku všem účastníkům, kteří se ke schůzce mohou připojit.

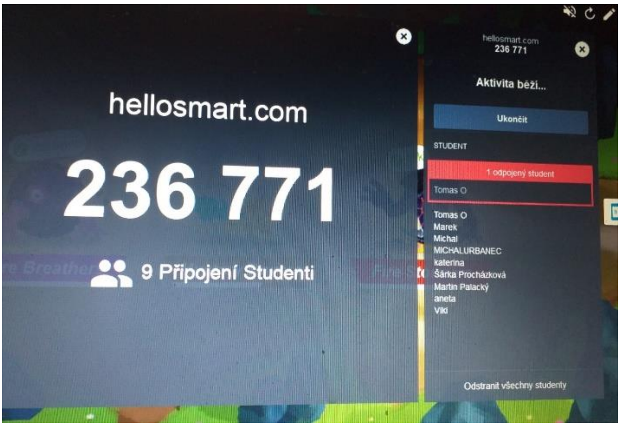
Učitel může schůzku nahrávat. Tím vytvoří záznam ze schůzky, který mají všichni žáci k dispozici. Je to obrovská výhoda, neboť žáci, kteří se dané výuky nemohli zúčastnit, si mohou záznam spustit. Žáci se tak mohou v jednotlivých hodinách vracet k různé problematice, které byla řešena. Učitel při výuce sdílí svoji obrazovku, na které může promítat prezentaci, videa. Žáci se mohou přihlásit do diskuze, popř. se zeptat „zvednutím ruky“. Je to novinka, která je velmi výhodná. Na obrazovce se u jména žáka objeví ručička a učitel může žáka „vyvolat“. Žáci se tak nepřekřikují zároveň či nevstupují učiteli do výkladu.

4 Microsoft office 365 – Teams a SMART Notebook

Ve školách ČR aj SR se využívají různé interaktivní tabule. Jednou z nich je i Smart Board s programem SMART Notebook. Propojením mobilních telefonů, tabletů, notebooků či počítačů žáků při online výuce s interaktivní tabulí a programem SMART Notebook je velmi efektivní.

Interaktivní tabuli můžeme použít k výkladu dané látky, k procvičování pomocí různých aktivit. Velkou výhodou je, že si můžeme v přípravách uložit i odkazy na různé internetové stránky, které potom nemusíme pracně dohledávat. K jednotlivým tématům se můžeme stále vracet. Pokud využíváme pouze klasickou tabuli, tak vše po hodině smažeme a pokud se chceme k učivu vrátit, musíme jej znovu napsat. Samozřejmě přípravy, které si vytváříme pomocí tohoto programu, nejsou vždy hotové během chvilky. Pokud vytváříme výklad látky, využíváme různé grafy a tabulky, práce je to i na několik hodin. Ale tato práce se nám okamžitě vrací, pokud vyučujeme v paralelních třídách. Přípravy můžeme snadno využít i v dalších letech. Úpravy jsou hotové už během chvilky. Využití cloudových aktivit SMART LAB zabere na přípravu jen několik málo minut a efektivita v hodině se obrovská. K procvičování těchto cloudových aktivit SMART LAB využíváme bez problémů různá zařízení – počítače, notebooky, tablety i mobilní telefony žáků. Na všech zařízení najednou nám aktivity bez problémů fungují.

Obrázek 3. Aktivita k připojení na zařízení



Obrázek 4. Připojení žáků

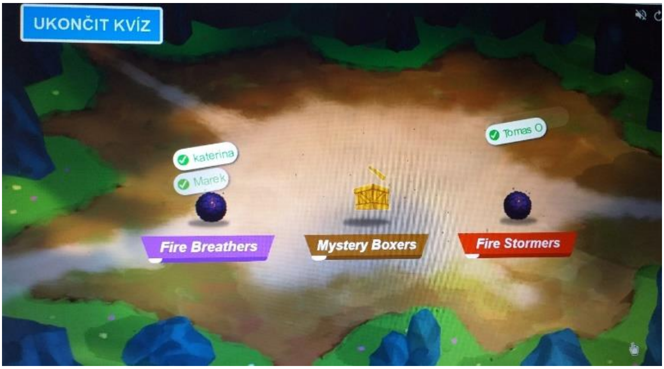
Všechny tyto cloudové aktivity, které jsou označeny symbolem - připojit zařízení, lze spustit na počítači, notebooku, tabletu či mobilním telefonu. K daným aktivitám se žáci připojují pomocí webové stránky HELLOSMART.COM a ID učitele, jak je vidět na obrázcích.

Učitel vidí připojená žákovská zařízení. Učitel žákům aktivitu spustí a žáci samostatně na svých zařízeních pracují individuálně, vlastním tempem. Po dokončení cvičení mají okamžitou zpětnou vazbu o správnosti řešení. Mezi tyto aktivity patří:

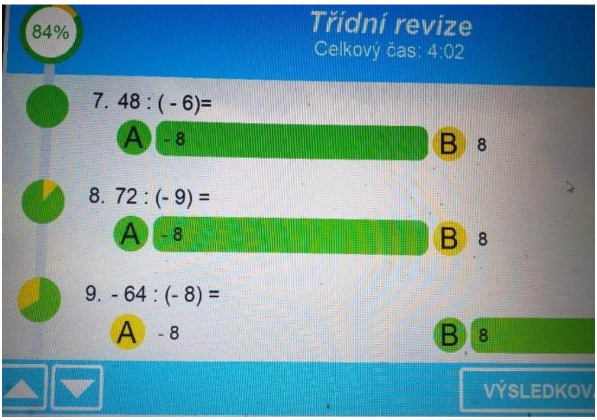
- Vyplnit mezery – studenti přetahují slova nebo čísla do prázdných míst. Tato aktivita učí dedukci, kompozici a paměť.
- Otočit – kartičky – učí paměť a slovní zásobu.
- Dejte k sobě! – vytváření správných dvojic – aktivita párování, která vyučuje korespondenci mezi jednotlivci a paměť. Tuto aktivitu v hodinách učitelé velmi využívají.
- Seřazení – studenti seřazují položky v pořadí a učí se tak o srovnání, dedukci, posloupnosti a uspořádání. Opět velmi často využívaná aktivita.
- Super řazení – studenti třídí položky do dvou kategorií. Tato aktivita učí klasifikaci a sdružování do skupin. Velmi využívaná aktivita.
- Kvíz s monstry – postupový kvíz s otázkami s výběrem více možností odpovědi a otázkami správně x špatně. Studenti pracují v týmech na jednotlivých zařízeních. Velmi oblíbená aktivita mezi žáky. Tuto aktivitu lze provozovat na tabletech, mobilních telefonech či počítačích. Žáci jsou roztříděni do skupin na základě náhodného výběru počítače. Každý žák odpovídá svým tempem a body za družstvo se sčítají. Poté se odpovědi vyhodnotí, ukážeme si správné odpovědi a vysvětlíme řešení.
- Response 2 – studenti odpovídají na otázky s více možnostmi odpovědí, otázky s výběrem z více možností, otázky typu hlasování/názor, otázky s krátkou odpovědí a otázky s odpovědí správně x špatně. Velmi výhodná aktivita k testování. Tuto aktivitu můžeme využít k anonymním odpovědím k rychlému zopakování učiva. Tato aktivita se velmi často používá k testování. Po skončení testu se žákům objeví rychlé vyhodnocení testu – na které otázky odpověděl správně, na které chybně, na které neodpovídal a vyhodnocení. Všechny tyto odpovědi jsou zaznamenány do tabulky, kterou si učitel uloží. Testy jsou rychlé a okamžitě opravené. Učitel pouze uloží výsledky do počítače. Tuto aktivitu můžeme opět provádět pomocí mobilních telefonů, počítačů či tabletů.
- Zapojte se – studenti používají svá zařízení k zasílání příspěvků nebo obrázků. Brainstormingová aktivita určena k vytváření nápadů.

Dnes se již samostatně interaktivní tabule nevyužívá. Neslouží pouze k výkladu učiva, ale využívá se hlavně spolu se žákovskými zařízeními. Na interaktivní tabuli mohli pracovat maximálně dva žáci. Důležité je zapojení všech žáků ve výuce. Mobilní telefony či tablety může každý žák využívat samostatně. Pracovat mohou na jednotlivých aktivitách samostatně, vlastním tempem. Žáci se učí práci ve skupinách, kterou budou potřebovat v kterémkoli zaměstnání – práce v týmech.

Nejvíce oblíbená aktivita u žáků je Kvíz s monstry neboli Příšerkový kvíz. Žáci jsou k dané aktivitě přihlášeni. Učitel či žáci zvolí, do kolika skupin budou rozřazeni. Každý žák řeší své otázky individuálně na svém zařízení a výsledné body se sčítají v daném týmu. Žáci na svých zařízeních vidí otázky, učitel vidí týmy a jejich úspěšnost při řešení, viz. Obrázek 4.



Obrázek 4. Prostředí učitele – Kvíz s monstry



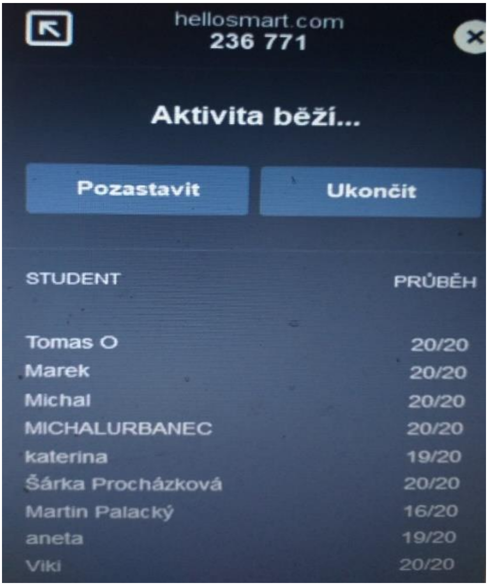
Obrázek 5. Prostředí učitele – kontrola

Po vyřešení všech úkolů všech žáků učitel se žáky projde všechny otázky a úkoly a sdělí správné řešení včetně postupu.

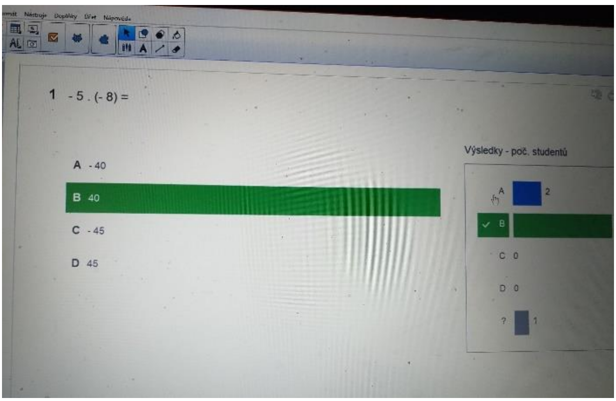
Příšerkový kvíz je u dětí velmi oblíbený.

Druhou velmi oblíbenou aktivitou je testování prostřednictvím Response 2.

Žáci opět odpovídají na otázky. Učitel na své obrazovce sleduje, jak rychle žáci odpovídají, kolik úkolů mají již splněno.



Obrázek 6. Prostředí učitele – Response 2



Obrázek 7. Prostředí učitele – Response 2 - kontrola

Po dokončení testu okamžitě vědí správné odpovědi a úspěšnost v testu. Odpovědi na jednotlivé úkoly si hned po dokončení testu učitel prochází se žáky.

Tato aktivita je velmi oblíbená i u učitelů. Testy jsou hned opraveny, výsledky můžeme uložit ve formě tabulky.

Student	Grade	# Correct	# Incorrect	# No Response	1) - 5 . (- 8) =	2) 16 : (- 4) =
MICHAL	100%	20	0	0	B	A
Marek	40%	8	12	0	B	A
Martin	20%	4	16	0	A	A
Michal	25%	5	15	0	A	A
Tomas O	60%	12	8	0	B	A
Viki	90%	18	2	0	B	A
aneta	95%	19	1	0	B	A
katerina	100%	20	0	0	B	A
Šárka	100%	20	0	0	B	A
Průměr třídy	63%				70%	90%

Obrázek 8. Prostředí učitele – Response 2 – tabulka

4 Závěr

Závěrem můžeme zhodnotit, že používání moderních on-line vzdělávacích technologií v distančním vyučování během pandemie potvrdilo jejich význam a užitečnost i na zvládnutí krizových situací. Mnohé digitální technologie, informační a komunikační systémy, které učitelé měli k dispozici a které nebyly využívány, nyní ožily a jejich uplatnění se stalo nezbytností. Učitelé, kteří tyto nástroje používali bez problémů, vzniklou situaci zvládli. Ti, kteří to dosud ignorovali, byli nuceni je využívat - "učili se za pochodu", "učili se děláním / využíváním". Erudovaní informatici, kteří tyto možnosti používali i předtím a vytvářeli vlastní didaktické aplikace, na otázku: Bylo / je tento (on-line) způsob vyučování pro Vás náročný? Odpověděli většinou: "Ne, nebyl/není".

Většina ale považovala distanční způsob vyučování za časově náročný. Učitelé přípravu elektronických učebních materiálů, on-line úkolů, testů a zkoušení označili za mimořádně náročnou a zatěžující. Školy, učitelé a ani žáci nebyli připraveni na tento druh vyučování. Na základě osobních zkušeností učitelů (respondentů průzkumu) lze říci, že chyběla organizovanost a disciplína. Učitelé přeceňovali situaci, zadávali mnoho úkolů, očekávali, že žáci nebudou podvádět a budou se průběžně připravovat. Žáci si zase mysleli, že mají prázdniny, bylo třeba je honit, aby spolupracovali. Ideálním řešením by bylo, kdyby škola měla vypracovaný nejen plán jak v případě takové situace postupovat, ale aby byla i vybavena potřebnými technologiemi a aby jejich využívání na zvýšení efektivity vyučování byla běžnou každodenní záležitostí a vnitřní potřebou. Toto řešení však v době, kdy nás šíření viru COVID-19 překvapilo, neměl nikdo a každý se snažil řešit toto po svém. Nejvíce však chyběla informační gramotnost a potřebné digitální kompetence u obou stran - učitelů i žáků/studentů.

Príspevok bol podporený projektami IGA_PdF_2019_043 s názvom „Analýza vybraných aktuálnych problémov vo výuke informaticky zameraných predmetov s akcentom na on-line technológie"; KEGA 012TTU-4/2018: Interaktívne animačno-simulačné modely vo vzdelávaní a KEGA 015TTU-4/2018 Interaktivita v elektronických didaktických aplikáciách.

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JAZYKOVÁ VÝUKA V 3D MULTIUŽIVATELSKÉM VIRTUÁLNÍM PROSTŘEDÍ

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Abstract: Výuka jazyků v online virtuálním prostředí je v současnosti jednou z nejprogresivnějších oblastí, protože na rozdíl od jiných vzdělávacích oblastí pracuje především s oblastí lidské komunikace, která nutně nevyžaduje přítomnost studenta v tradiční učebně ani práci se specifickými učebními pomůckami (jako je např. výuka fyziky apod.). Přínosem jazykového vzdělávání ve virtuálním prostředí je také možnost nezávislého prostorového a časového kontaktu mezi učícím se a např. rodilými mluvčími jazyka. Z pedagogického hlediska je však nutné prozkoumat, zda je tento způsob výuky vhodným vzdělávacím nástrojem, zda nevede k horším výsledkům učení než při použití tradičních vzdělávacích metod, a jaké jsou postoje samotných studentů k tomuto typu jazykového vzdělávání. V souvislosti s problémy ve vyučovacím procesu, které přinesla pandemie COVID-19 do výuky prakticky po celém světě v minulém roce se znásobil důraz na potřebu využívat online výuku a se stal velmi aktuálním. Metody: Na základě toho jsme realizovali srovnávací výzkum na Univerzitě Palackého na využití 3D virtuální výuky ve výuce mateřského jazyka. Byla porovnána výuka 3D virtuálním prostředí a tradiční výuka mateřského jazyka (přičemž tradiční metodou výuky se rozumí výuka ve třídě s využitím tabule, a učebnice, pracovních sešitů, elektronických učebnic a digitálních prezentací). Výsledky: Na základě výsledků našeho výzkumu bylo zjištěno, že zejména v případě literární složky výuky českého jazyka umožňuje výuka s využitím 3D vizualizace výukových objektů snazší zapamatování (ověřeno následným didaktickým testem jak v experimentální, tak i v kontrolní skupině), než v případě výuky s využitím tradičních výukových pomůcek (učebnic).

Keywords: virtuální učebna, 3D virtuální realita, víceuživatelské virtuální prostředí, online výuka jazyků

LANGUAGE LEARNING IN A 3D VIRTUAL ENVIRONMENT

Abstract: Language teaching in an online virtual environment is currently one of the most progressive areas, because unlike other educational areas, it works primarily with the area of human communication, which does not necessarily require the presence of the learner in a traditional classroom or work with specific teaching aids (such as teaching physics, etc.). Language education in a virtual environment also benefits from the possibility of spatial and temporal contact between the learner and native speakers of the language. From a pedagogical point of view, however, it is necessary to investigate whether this way of teaching is a suitable educational tool, whether it does not lead to worse learning results than using traditional educational methods, and what are the attitudes of the learners themselves towards this type of language education. In the context of the problems in the learning process brought by the COVID-19 pandemic to education virtually all over the world last year, the emphasis on the need to use online learning has multiplied and become very topical. Methods: Based on this, we have implemented a comparative research at Palacky University on the use of 3D virtual education in teaching mother tongue. 3D virtual and traditional methods of teaching mother tongue were compared (whereby traditional method of teaching is understood as classroom teaching with use of blackboards, classical textbooks, workbooks, electronic textbooks, and digital presentations). Results: Based on the results of our research, it was found that especially in the case of the literary component of Czech language teaching, teaching using 3D visualization of educational objects allows easier memorization (verified by a subsequent didactic test in both, experimental and control groups) than in the case of teaching using traditional educational tools (textbooks).

Keywords: virtual classrooms, 3D virtual reality, multiuser virtual environment, online language teaching

1 Úvod

V současné době se sektor vzdělávání potýká v důsledku celosvětové pandemie Covid-19 s výzvou k rychlému zařazování online vzdělávacích nástrojů do výuky, a to často ve formě kompletního přechodu na čistě online výuku v souvislosti s nařízenými hygienickými omezeními. Na takto rychlý organizační krok nebyly vzdělávací instituce všech stupňů škol i instituce celoživotního vzdělávání dostatečně připraveny, některé z nich se potýkají s problémy nedostatečných digitálních kompetencí učitelů či neznalostí konkrétních online vzdělávacích nástrojů, které mohou být ve výuce využity tak, aby pro žáky a studenty představovaly přínos. Kromě množství online komunikačních nástrojů (jako je ZOOM, MS Teams, Skype ad.) přichází na řadu i různé Learning Management Systémy či prostředí 3D virtuální reality.

Již před příchodem pandemie existovala zejména v USA řada škol, která vyučovala své žáky v 3D multiuživatelském virtuálním prostředí (dále jen „3DM") – např. v rozsáhlém projektu *Quest Atlantis* zaměřeném na děti mezi 9–15 lety bylo zapojeno více než 50 000 dětí, do projektů Quest Atlantis se zapojilo více než 22 zemí, v 3DM vybudovaném pomocí technologie *OpenSimulator* v Atlantě je zapojeno 35 škol s 38000 žáky a studenty, dále je to např. projekt Harvardské univerzity *The River City Project* určený žákům 6. – 9. tříd základních škol apod. K nejrozsáhlejším 3D virtuálním světům, do kterých jsou zapojeny miliony uživatelů po celém světě, patří zejména projekt Second Life (https://secondlife.com/), Sansar (https://www.sansar.com/) nebo světy postavené na zmiňované technologii OpenSim, např. Kitely (https://www.kitely.com/). Nejrozšířenějším typem vzdělávání v těchto virtuálních světech je zejména výuka jazyků a mnoho univerzit a dalších vzdělávacích institucí používá tato 3DM jakožto podporu právě pro výuku jazyků.

2 Výuka v 3D multiuživatelském virtuálním prostředí na Univerzitě Palackého v Olomouci

Na Univerzitě Palackého v Olomouci pracujeme s výukou v 3DM už více než 10 let, přičemž pro výuku v prvních letech jsme využívali volně dostupných vzdělávacích prostředí v celosvětovém projektu Second Life. Toto prostředí využívalo už od 90. let minulého století množství vzdělávacích institucí (univerzity, školy, národní organizace, nonprofitní vzdělávací organizace, knihovny, muzea). Dnes zde nalezneme zde např. virtuální verze více než 60 amerických vysokých škol (např. Oakland University, Ohio University, University of Plymouth, Coventry University, Montana State University, University of Tennessee, Ball State University, Missouri State University, Bradley University, ale také např. právnická fakulta Harvard University (jejíž online kurzy, za které je možné získat skutečné kredity, navštěvují také studenti z Číny, Jižní Koreje a dalších zemí). V českém virtuálním prostředí se zde (v tzv. československém městě Bohemia) již představily některé fakulty českých vysokých škol – Národohospodářská fakulta Vysoké školy ekonomické v Praze. Fakulta pedagogická ZČU v Plzni, Fakulta sociálních studií MU v Brně a Filozofická a Pedagogická fakulta UP v Olomouci.

V současné době se ale mnoho původních uživatelů Second Life přesouvá do jiných virtuálních světů. Většina těchto nových světů (např. OSGrid, Avination, Metropolis, Kitely ad.) je postavena na stejném principu Open Simulator, kde si účastnící mohou sami vytvářet vlastní 3D obsah a odpovídají za něho, nejsou tedy závislí na provozu a podmínkách užití do té míry jako v Second Life. Hlavním benefitem těchto světů je jejich větší dostupnost pro běžného uživatele a více místa pro vlastní tvorbu i užívání. V Second Life jsou totiž z důvodu nedostatku místa jednotlivé regiony umístěny i v několika úrovních nad sebou, v některých z ostatních světů je místa mnohem více a regiony mohou být umístěny v jedné úrovni. Významnou se stává také otázka ceny, i když i v SL jsou ceny nepříliš vysoké, je nutné za vlastní vytvořené objekty platit trvalý poplatek. Také v ostatních světech je však nutné zaplatit za určité služby.

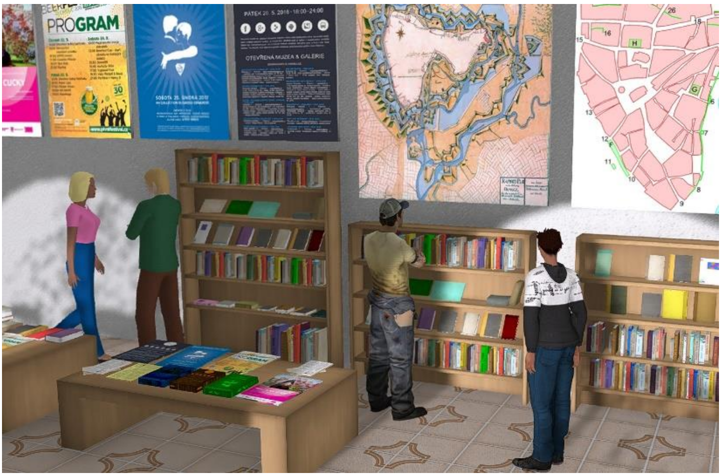
Do jednoho z výše jmenovaných prostředí (Kitely) se přesunula i Pedagogická fakulta Univerzity Palackého a začala v něm vytvářet své vlastní 3D výukové objekty, přesně na míru potřebám a tématům vlastní výuky:

Obrázek 1: Virtuální kampus Pedagogické fakulty UP v Kitely

K této skutečnosti došlo především z důvodu nedostatku místa v Second Life pro účely výuky, ale také za účelem finanční úspory. V Kitely se totiž, na rozdíl od Second Life, ve kterém se platí trvalý poplatek za region, platí pouze za čas v regionu strávený. Regiony, ve kterých právě neprobíhá žádná aktivita, jsou vypnuté.

3 Výzkumné šetření v 3D multiuživatelském virtuálním prostředí

V Kitely jsme od roku 2017 do současnosti poté realizovali výuku *předmětů Internet a multimédia ve výuce českého jazyka* a *Nová média a kyberkultura.* V rámci těchto předmětů jsme se studenty různých dvouoborových kombinací studijního programu zaměřeného na výuku českého jazyka na 2. stupni základních škol realizovali výuku jednotlivých složek mateřského jazyka (mluvnice, literatury, slohové a komunikační výchovy) tak, abychom zjistili, pro kterou složku jazykové výuky je toto prostředí nejvhodnější. V rámci této výuky jsme pak realizovali výzkumné šetření metodou pedagogického experimentu, které mělo za úkol porovnat výuku v 3DM Kitely s výukou pomocí tradičních vyučovacích metod (výklad učitele, práce s učebnicí či s elektronickou prezentací):



Obrázek 2: Ukázka z 3D virtuálního výukového prostředí Pedagogické fakulty UP pro jazykovou výuku v Kitely

3.1 Metody výzkumu

Výzkumné šetření bylo v průběhu 4 let realizováno metodou smíšeného výzkumného designu založeného na kombinaci kvantitativního a kvalitativního přístupu. Z hlediska kvantitativního výzkumu se jednalo o komparační analýzu vstupního a výstupního didaktického testu u experimentální skupiny vyučované v 3DM a kontrolní skupiny vyučované tradičním způsobem (výklad učitele s využitím učebnice). Z hlediska kvalitativního přístupu se jednalo o polostrukturované písemné dotazování zjišťující postoje studentů experimentální skupiny k výuce v 3DM, zpracované metodou zakotvené teorie (Strauss a Corbinová, 1999). Rozdělením odpovědí podle kritérií bylo získáno zpřehlednění názorů studentů a dalo se snadněji určit, kde jsou silné a slabé stránky výuky ve virtuálním prostředí a odhalit, co by mohlo dělat největší problémy při jeho využití v praxi. Polostrukturované dotazování bylo vždy realizováno až po všech proběhlých výukových jednotkách (tedy po výuce ve všech složkách mateřského jazyka).

Výuka v 3DM byla zrealizována pro 3 základní složky výuky mateřského jazyka – mluvnici, literaturu a slohovou a komunikační výchovu. Pro každou tuto složku byly vytvořeny 3D virtuální objekty pro vyučovaná témata a vytvořen vstupní a výstupní didaktický test, který byl identický pro experimentální i kontrolní skupinu. Didaktický test byl vyhodnocen statisticky podle předem stanovených kritérií, byla ověřena validita a reliabilita jednotlivých testů. Validita byla stanovena posouzením příslušného experta, reliabilita byla ověřena prostřednictvím Kuderova-Richardsonova koeficientu reliability a také metodou půlení pomocí Spearmanova-Brownova vzorce (Chráska, 2007). Po první distribuci testu pro oblast mluvnice byla vypočítána reliabilita didaktického testu prostřednictvím Kuderova-Richardsonova koeficientu reliability. Koeficient reliability může nabývat hodnot od 0 (= naprostá nepřesnost a nespolehlivost testu) po 1 (= maximální přesnost a spolehlivost testu). Pro účely pedagogického zkoumání je nutné dosáhnout hodnoty alespoň hodnoty 0,8. (Chráska, 2007), po dosazení hodnot jsme získali koeficient rentability 0,803, test bylo tedy možné považovat za dostatečně reliabilní pro testování studentů. Pro srovnání účinnosti obou výukových přístupů byl dále použit Studentův t-test, který ověřil, zda jsou rozdíly ve výsledcích statisticky významné (Chráska, 2007). Citlivost byla posuzována na základě výsledků výpočtu koeficientu ULI.

3.2 Statistické vyhodnocení dat

Výsledky testů za jednotlivé oblasti byly popsány pomocí průměrné hodnoty, směrodatné odchylky (SD) a mediánu hodnot. Kromě bodového skóre bylo vypočítáno také procento úspěšnosti v testu, kdy celkové hrubé skóre bylo vztaženo k maximálně dosažitelnému hrubému skóre za danou oblast testování. Celková úspěšnost v testu byla počítána jako souhrn výsledků v testu před výukou a po výuce. K ověření platnosti hypotéz byl použit statistický software IBM SPSS Statistics verze 22. Výsledky testů dosažené v kontrolní a experimentální skupině, resp. výsledky dosažené ve skupině mužů a žen, byly porovnány pomocí Mannova-Whitneyho U testu. Neparametrický test byl zvolen kvůli nenormální distribuci hodnot skóre. Normální distribuce byla ověřována pomocí Shapirova-Wilkova testu. Všechny testy byly dělány na hladině signifikance 0,05.

3.3 Soubor respondentů

Výzkumný soubor tvořil celkem 303 respondentů – 160 z nich se zúčastnilo virtuální výuky, 143 teoretické výuky. Soubor respondentů tvořili studenti učitelství českého jazyka a literatury na Katedře českého jazyka a literatury Univerzity Palackého v Olomouci. Průměrný věk respondentů šetření činil 21,6 (± 0,3) let. Všichni respondenti se zúčastnili kvantitativního šetření prostřednictvím didaktických testů před výukou a po výuce. Studenti zařazení do experimentální skupiny, kteří byli učeni v 3DM, byli zároveň zařazeni do kvalitativního výzkumu prostřednictvím polostrukturovaného dotazování.

Ve všech výukových jednotkách dostali respondenti stejné informace, všichni se účastnili výuky ve všech třech složkách mateřského jazyka, všichni byli přiřazeni na základě předem definovaných a popsaných kategorií ke konkrétní uživatelské úrovni pro práci s informačními technologiemi, přičemž tato kritéria byla nastavena dle mezinárodního konceptu standardizovaných počítačových dovedností ECDL (ECDL, 1999). Celkem 48,1 % studentů dosáhlo základní úrovně dle ECDL a 51,9 % úrovně mírně pokročilého uživatele dle ECDL. Kategorie pokročilý uživatel nebyla ve výzkumu zastoupena, jelikož by mohla přinést kontaminaci lepších výsledků v důsledku schopností těchto respondentů lépe zvládat prostředí virtuální reality. V důsledku toho byl ze skupiny vyřazen 1 respondent, který byl označen za pokročilého uživatele. Zároveň jsme zachovali homogenitu experimentální a kontrolní skupiny.

3.4 Výsledky

Při pedagogickém experimentu dosáhla v rámci celkového výkonu při realizaci vyučovacích jednotek lepších výsledků kontrolní skupina, která dosáhla o 8,3 % lepšího výsledku v didaktickém testu (celkový průměrný výkon experimentální skupiny činil 43,8 %, u kontrolní skupiny 48,1 %, $p = 0,006$) Před výukou byly v experimentální i kontrolní skupině zjištěny v oblasti mluvnice srovnatelné výsledky. Po výuce došlo k výraznějšímu zlepšení oproti výsledkům před výukou u kontrolní skupiny –o 18,7 %, u experimentální skupiny došlo po výuce ke zlepšení o 7,8 %. Tento rozdíl byl statisticky významný ($p < 0,0001$). V oblasti literatury došlo po výuce u obou skupin ke stejnému průměrnému zlepšení, u experimentální skupiny to bylo zlepšení o 28,5 %, u skupiny kontrolní bylo zlepšení o 29,5 %. Rozdíl mezi skupinami ve zlepšení výsledků po výuce nebyl signifikantní ($p = 0,551$). V oblasti slohu byly před výukou zjištěny u obou skupin srovnatelné výsledky, po výuce došlo k většímu zlepšení u kontrolní skupiny. Zlepšení u kontrolní skupiny bylo o 39,5 %, v experimentální skupině došlo po výuce ke zlepšení o 16,4 %. Tento rozdíl byl statisticky významný ($p < 0,0001$).

V rámci experimentu jsme rovněž pátrali po vlivu 3D vizualizace učební látky pro lepší zapamatování pojmů a jevů. V rámci didaktických testů byly vybrány pro každou složku výuky mateřského jazyka 3 otázky, k jejichž správnému zodpovězení mohla výrazně napomoci 3D vizualizace a práce s těmito 3D objekty v 3DM. U 2 otázek z testu mluvnice byl prokázán statisticky signifikantní rozdíl ($p = 0,022$ a $p = 0,010$) v tom smyslu, že průměrný výsledek byl oproti našemu předpokladu lepší u kontrolní skupiny ve srovnání s experimentální skupinou. U otázek z literatury byl zjištěn signifikantně lepší výsledek (tj. vyšší průměrná hodnota bodového skóre) u experimentální skupiny ($p = 0,039$). Dále zde byl prokázán signifikantní rozdíl mezi experimentální a kontrolní skupinou ve výsledcích po výuce u otázky č. 3a ($p = 0,003$) a otázky č. 3b ($p < 0,0001$). U experimentální skupiny byla prokázána vyšší průměrná hodnota bodového skóre, tj. lepší výsledek než u skupiny kontrolní. U otázek ze slohové a komunikační výchovy byl zjištěn u otázky č. 3. signifikantně lepší výsledek u kontrolní skupiny ($p = 0,004$).

V kvalitativní části výzkumného šetření jsme v rámci polostrukturovaného dotazování respondentů experimentální skupiny zjistili, že k nejvýznamnějším faktorům, které ovlivňují pozitivní hodnocení výuky v 3DM ze strany respondentů, je zejména oblast motivace pro zapojení do učebního procesu, přičemž 57,82 % reakcí bylo pozitivních, nejčastěji z důvodu nové zkušenosti či zapojení vícero smyslu při získávání nových informací, dále oblast sociální interakce, přičemž 55 % výsledků bylo pozitivních zejména ve smyslu podobnosti s reálným mezilidským kontaktem a možnosti využití hlasového chatu k přirozené mezilidské komunikaci. 68,13 % respondentů pak jako pozitivní označilo také příjemný pocit perspektivy v 3DM, které poskytuje názornější zpodobnění konkrétního učiva a rozšířené možnosti oproti realitě.

K nejvýznamnějším negativním faktorům pak patřily zejména potíže s ovládáním avatara (54,38 %), nedostatek pocitu vlastní identity (52,71 %), zejména v důsledku pocitu umělosti a nepřirozenosti světa, neztotožnění se s avatarem a virtuálním prostředím, nedostatečná konsistentnost s reálným světem (51,25 %), zejména v důsledku obtížnosti s ovládáním pohybu kamery, nereálné možnosti pohybu apod.

4 Diskuze

Výsledky našeho výzkumného šetření z didaktického hlediska neprokázaly významně vyšší úspěšnost studentů experimentální skupiny. Důvodem však mohla být i novost prostředí 3DM, ve kterém se pohybovali, tudíž část jejich pozornosti byla soustředěna zejména na schopnost ovládat avatara, pohybovat se v prostředí a také prozkoumávat jednotlivé detaily prostředí. Zatímco v případě kontrolní skupiny, která byla učena tradiční metodou, na kterou jsou po léta zvyklí, k tomuto mentálnímu rozptýlení nedocházelo. Proto by byl do budoucna potřebný výzkum zaměřený na dlouhodobější (např. roční) výuku v 3DM, při níž by již studenti s jistotou zvládali pohyb v prostředí, aby bylo možné s jistotou vyloučit, že horší výsledky nezpůsobuje prostředí samo, ale novost jeho pobytu v něm a nutnost zaměřit část své pozornosti na ovládání pohybu v prostředí.

V případě literární složky výuky mateřského jazyka se jednoznačně (statisticky signifikantně) potvrdila naše hypotéza, že vizualizace učiva umocněná manipulací s objekty v 3DM (experimentální skupina) povede k lepšímu zapamatování jevů a pojmů, nežli v případě, že student pouze pasivně sedí a poslouchá výklad učitele (kontrolní skupina). Za hlavní důvod považujeme skutečnost, že při výuce literatury byli studenti v 3D přítomni všichni současně a při manipulaci s 3D objekty se museli vzájemně domlouvat na spolupráci, kdo a kam bude 3D objekty přesouvat. Ostatní sledovali tuto práci. V případě tradiční výuky byli studenti pouze seznámeni s tématem výuky, tzn. zde se zapojovala pouze jejich sluchová a vizuální složka vnímání, nikoliv kinestetická, příp. emocionální (vizuální zážitek při manipulaci s postavami, nutnost domlouvat se na postupu apod.). Nicméně efekt pohybu s 3D objekty se již neprojevil v případě mluvnické výuky, při níž dosáhli lepších výsledků studenti kontrolní skupiny. Důvodem mohl být i fakt, že v tomto případě byl zvolen přístup individuální práce v prostředí, studenti se na manipulaci s 3D objekty nemuseli domlouvat s ostatními, pohybovali se volně po prostoru a neměli jasně stanovené, kdo a kdy bude s objekty manipulovat.

Při výzkumu i interpretaci uvedených výsledků vycházíme z předpokladu, že zapojením vícero smyslových vjemů a emocionální složky dochází k lepšímu zapamatování poznatků. Podle Daleova (Dale, 1946) kužele zkušenosti by si měl jedinec zapamatovat až 90 % toho, co dělá (tedy učí se zkušeností). Do tohoto oddílu kužele zkušenosti spadá i účast na virtuální výuce v podobě virtuální simulace skutečnosti. Podobně Kalhous a Obst (Kalhous a Obst, 2009) uvádějí, že čím více smyslů je do poznávání zapojeno, tím více poznatků by si měl učící se subjekt zapamatovat. To se nám potvrdilo ve výuce literatury, nikoliv však ve výuce mluvnice či slohu. Jedním z faktorů, které zde mohou působit, je již zmiňovaná novost virtuálního prostředí a obtíže při pohybu v prostředí u studentů se základní úrovní počítačových dovedností.

3DM výuka je vhodné pro výuku těch témat, ve kterých je možné simulovat realitu, a tudíž propojit teoretické poznatky s praxí. Čím více se názorná výuka podobá realitě, tím větší procento poznatků je student schopen si zapamatovat, ale také je následně aplikovat, přemýšlet o nich a zasazovat je do celkového kontextu, což přehledně demonstruje Daleův Kužel zkušeností (Dale, 1946).

V tomto případě lze učinit závěr, že pokud probíhá výuka v 3DM, je vhodnější využít metodu vzájemné spolupráce, neboť v případě, kdy byla manipulace s 3D objekty řízena vyučujícím a studenti se museli domluvit na postupu, jak a kam budou s objekty manipulovat, dosáhli následně lepších výsledků, než v případě, kdy byli ponechání při řešení sami sobě a v jejich práci pak mohlo docházet k dílčím problémům, o kterých vyučující či ostatní studenti ani nevěděli. Doporučujeme tedy, aby výuka v 3DM byla postavena zejména na řízené výuce a kolaborativním přístupu, ponechání studenta samotného při řešení úkolů se v tomto případě spíše míjí účinkem.

Svou roli ve výsledcích mohla ale sehrát i úroveň počítačových dovedností studentů a předchozí zkušenosti v práci ve 3DM, z toho důvodu doporučujeme pro výuku v těchto prostředích věnovat dostatečný čas proškolení pro práci v tomto prostředí, příp. zařazení nenáročných úkolů v tomto prostředí, a teprve poté, kdy se cítí studenti v pohybu v prostředí jistí, realizovat vlastní výuku.

Z hlediska jazykové výuky můžeme na základě našich výsledků výzkumu doporučit využití zejména pro oblast literatury, kde 3DM najde uplatnění v tématech, která poskytují možnost dramatizace, zážitkového učení, zapojení a kooperaci skupiny. Právě zážitková pedagogika se snaží získávat nové poznatky prostřednictvím zpracovávání probíhajících zážitků při různém stupni jejich uvědomění si prožívajícím (Plháková, 2003). Podobný názor nalezneme i u Říhy (Říha, 2006), který kolaborativní vzdělávání podporované počítačem doporučuje jako vhodný vzdělávací nástroj pro získávání znalostí a zdůrazňuje mimo jiné také jeho využití při vzdělávání účastníků, kteří jsou od sebe fyzicky vzdáleni.

Co se týče postojů studentů k výuce v 3DM, zhruba přes polovina respondentů si toto prostředí ztotožňuje s pozitivními aspekty, což znamená, že téměř polovina vyhodnotila toto prostředí některým z výše uvedených negativním aspektům. K podobným výsledkům došel ve svých výzkumech Second Life např. S. Hornik (Hornik, 2010), který v rámci realizace výuky finančního managementu na University of Central Florida prováděl longitudinální studii na základě analýzy dat a zpětné vazby od studentů formou rozhovoru v letech 2007–2010. Pracoval s různě velkými skupinami (200 až 800 studentů) a zjistil, že pouze 1/3 studentů pracuje v 3DM proto, že se jim výuka v tomto prostředí líbí, zbývající 2/3 se staví k 3DM negativně, nebo v něm pracují pouze proto, že je to součást úkolu, který jim byl v rámci výuky zadán. Nicméně jeho analýza dat prokázala, že čím déle studenti v SL pracovali, tím rostl jejich pocit, že je SL pro ně efektivním učebním nástrojem. V roce 2007, kdy Hornik začal používat SL pro výuku, pouze 17,3 % studentů uvádělo, že jim SL pomohl pochopit základní pojmy z finančního účetnictví, zatímco v roce 2009, po systematické 3leté výuce, to bylo již 40,7 %.

5 Závěr

3DM představují v rámci online vzdělávacích nástrojů zajímavý aktivizační prvek, znamenají obohacení výukového procesu o aspekt sociální interakce v online prostoru v průběhu výuky, vyjádření aspektů nonverbální komunikace (proxemika, gestika apod.), umožnění prvků interaktivity ve smyslu manipulace s objekty a komunitní spolupráce, umožnění situačního učení simulací reálných situací a událostí. V jistém směru také redefinují dosavadní chápání principu názornosti, neboť umožňují realizovat názorně demonstrační metody (pokusy), které jsou situačně zakotvené 3D virtuální simulací reality. K jejich limitům patří zejména časová náročnost ve smyslu přípravy výuky a také nutnost dobrých digitálních kompetencí jak ze strany učitele, tak studenta. Mohou však při vhodném nasazení do výuky znamenat přínosný aktivizační a motivační prvek sloužící k lepšímu zapamatování zejm. ve výukových tématech, při kterých jsou využívány prvky zážitkového učení, dramatizace, hraní rolí a také kooperaci výukové skupiny.

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AN ALTERNATIVE METHOD OF MODELLING IRREVERSIBLE DEFORMATIONS OF HYPERELASTIC MATERIALS

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Abstract: At present, multiplicative plasticity models are used to model irreversible deformations of hyperelastic materials. The underlying theory assumes that after plastic deformations, the body's intermediate configuration consists of an assembly of isolated and locally stress-free neighbourhoods, over which no plastic deformation gradient exists that meets the conditions of compatibility. Consequently, the deformation gradient is not integrable, and the body moves from its initial configuration to its intermediate configuration without a plastic displacement field. Such treatment of the body is neither mathematically nor physically justified, and the related material models can hardly be considered continuum-based. In this paper, we show that the plastic flow rule causes the incompatibility of the plastic deformation gradient. We have changed the flow rule so that it is objective and meets the compatibility conditions locally and have modified the models accordingly, critically analysing the obtained results.

Keywords: nonlinear continuum theory for finite deformations of elastoplastic media, objective and thermodynamically consistent formulation, multiplicative plasticity, hyperelastic materials, compatible flow rule.

1 Introduction

Hyperelastic materials, such as natural and synthetic rubber, polymers, vulcanized elastomers, plastics, biomaterials and many others, are nonlinear elastic materials. The characteristic feature of hyperelastic materials is that they can withstand large elastic strains without undergoing irreversible deformations or being fractured. The materials are often considered to be isotropic, and their constitutive equations are derived from strain-energy density functions [1-3].

The theory of multiplicative plasticity is used at present to model irreversible deformations in hyperelastic materials within the framework of finite-strain elastoplasticity. The theory uses the multiplicative split of the deformation gradient

$$\mathbf{F} = \mathbf{F}^{el} \bullet \mathbf{F}^{pl}, \tag{1}$$

into an elastic $\mathbf{F}^{el}$ and a plastic $\mathbf{F}^{pl}$ part. The theory assumes that after plastic deformation, a stress-free or locally unstressed intermediate configuration of the deforming body consists of an assembly of isolated local neighbourhoods, which cannot be reassembled together to get the overall stress-free configuration. Consequently, the theory treats the intermediate configuration differently from the initial and current configurations [1, 2]. In the former case, it uses the theory of crystal plasticity, while in the latter, it uses the continuum theory to describe the plastic behaviour of the body. As a result, the theory assumes that the plastic deformation gradient $\mathbf{F}^{pl}$ in the multiplicative split of the deformation gradient is not integrable, and no plastic motion exists either that maps each material particle from the plasticizing region of the body's initial configuration into the plasticizing region of the body's intermediate configuration [1].

Écsi and Élesztős [4-6] presented the modified nonlinear continuum theory for finite deformations of elastoplastic media. The theory preserves the physics of elastoplastic deformations and provides a universal framework for developing objective and thermodynamically consistent material models. The theory was further improved when it was discovered that not the stress-free intermediate configuration causes the incompatibility of the elastic and the plastic tensor factors in the multiplicative decomposition of the deformation gradient but the plastic flow rule, which will be shown later.

The aim of this paper is to present an alternative method of modelling irreversible deformations of hyperelastic materials. A modified plastic flow rule has been proposed, which is objective and meets the compatibility conditions locally. The model is demonstrated in the numerical experiment where uniaxial tensile testing of a rubberlike material using the modified Mooney-Rivlin material model has been studied. In the paper, a few early analysis results are presented and briefly discussed.

2 An alternative method of modelling irreversible deformations of hyperelastic materials

The proper kinematics of finite elastoplastic deformation on the condition that the body first undergoes plastic deformation and then elastic deformation at its all constituents is depicted in Figure 1. However, the contemporary theory of multiplicative plasticity assumes that the plastic factor of the deformation gradient is incompatible [1, 2]. Therefore, the tensor is not integrable, and no plastic motion exists either that maps every material point from the plasticizing region of the initial volume ${}^{0}\Gamma$ into the corresponding region of the body's intermediate volume ${}^{i}\Gamma$ when plastic deformations take place (Figure 1).

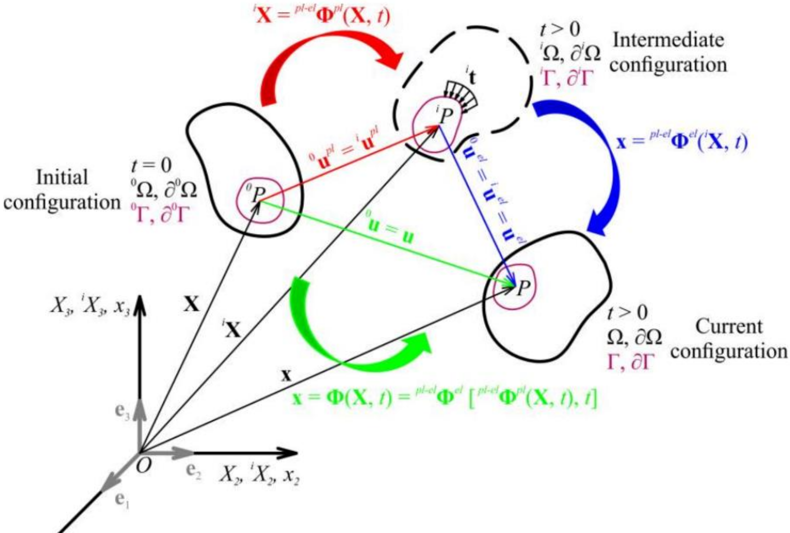

Figure 1: The proper kinematics of finite elastoplastic deformation

The incompatible plastic flow rule is a severe problem because it causes the body to move from its initial configuration into its intermediate configuration without the plastic displacement field ${}^{0}\mathbf{u}^{pl}(\mathbf{X}, t)$. Such behaviour is not justified physically; it violates the deformation kinematics and affects both small strain and finite strain theories of plasticity.

The sufficient and necessary condition of integrability can be expressed by the Stokes' theorem [7] in the form [8]

$$\oint_{{}^0C} \mathbf{A}\bullet d\mathbf{X} = \oint_{{}^0C} \nabla_0\mathbf{a}\bullet d\mathbf{X} = \int_{S_0} \mathbf{N}\bullet\left(\nabla_0\times\mathbf{A}\right)\cdot dS_0 = \int_{S_0} \mathbf{N}\bullet\left[\nabla_0\times\left(\nabla_0\mathbf{a}\right)\right]\cdot dS_0 = \mathbf{0}, \quad (2)$$

which implies

$$\nabla_0\times\mathbf{A} = \mathbf{0},\ \text{or}\ \nabla_0\times\mathbf{A} = \varepsilon_{ijk}\cdot\frac{\partial A_{mj}}{\partial X_i}\cdot\mathbf{e}_k\otimes\mathbf{e}_m = \varepsilon_{ijk}\cdot\frac{\partial a_m}{\partial X_j\cdot\partial X_i}\cdot\mathbf{e}_k\otimes\mathbf{e}_m = \mathbf{0}, \quad (3)$$

as the conditions of compatibility. Here, $\mathbf{A} = \mathbf{A}(\mathbf{X},\ t) = \nabla_0\mathbf{a}(\mathbf{X},\ t) = = \partial\mathbf{a}(\mathbf{X},\ t)/\partial\mathbf{X}$ is a second-order tensor field defined as a material gradient of a vector field $\mathbf{a}(\mathbf{X},\ t)$, ${}^0C$ is a closed curve, a perimeter of an arbitrary simply connected area S_0 located on any cross-sectional area of the body, created by cutting the body into half by an imaginary cutting plane. $\mathbf{N}$ is the outward surface unit normal vector to S_0. The alternative forms of the Stokes' theorem imply similar compatibility conditions in all configurations of the body.

Écsi et al. [8] have shown that the deformation gradient, its elastic part and plastic part, and the displacement fields' respective gradients are integrable tensors. As a result, the assumption that the plastic deformation gradient is an incompatible tensor, on which the whole theory of contemporary multiplicative plasticity models are based [1, 2], is neither mathematically nor physically justified. However, the assertion is incorrect if one takes a deeper look at the plastic flow rule. At present, it is expressed in the following form [2]

$${}^i\mathbf{d}^{pl} = \dot{\lambda}\cdot\frac{\partial\Psi(\boldsymbol{\tau})}{\partial\boldsymbol{\tau}}. \quad (4)$$

Here, $\dot{\lambda}$ is the plastic multiplier, $\Psi(\boldsymbol{\tau})$ the yield surface definition in the Kirchhoff stress space $\boldsymbol{\tau}$ and $\partial\Psi(\boldsymbol{\tau})/\partial\boldsymbol{\tau}$ the yield surface normal. ${}^i\mathbf{d}^{pl}$ denotes the symmetric spatial plastic strain rate tensor, which is identical with the spatial gradient of the plastic velocity gradient ${}^i\mathbf{L}^{pl} = {}^i\mathbf{d}^{pl} + {}^i\mathbf{w}^{pl} = \mathrm{sym}\left({}^i\mathbf{L}^{pl}\right) + \mathrm{ant}\left({}^i\mathbf{L}^{pl}\right)$ since the plastic spin tensor is zero ${}^i\mathbf{w}^{pl} = \mathbf{0}$. It can be verified that the plastic flow rule defined by Eqn. (4), in general, does not meet the conditions of compatibility

$$\nabla_i \times {}^i\mathbf{L}^{pl} = \varepsilon_{ijk} \cdot \frac{\partial\left(\dot{\lambda} \cdot \partial\Psi(\boldsymbol{\tau}) / \partial\boldsymbol{\tau}\right)_{mj}}{\partial\, {}^i X_i} \cdot \mathbf{e}_k \otimes \mathbf{e}_m \neq \mathbf{0}. \tag{5}$$

Here, ${}^i X_i$ where $i = 1,\ 2,\ 3$ are the corresponding Lagrangian coordinates (Figure 1). Therefore, the plastic flow rule and not the stress-free intermediate configuration causes the incompatibility of the elastic and plastic tensor factors in the multiplicative decomposition and the deformation gradient when plastic deformation occurs in the material.

2.1 The locally compatible plastic flow rule

The problem of the incompatible plastic flow rule can be fixed locally by splitting the velocity field into elastic and plastic parts as

$${}^0\dot{\mathbf{u}} = {}^0\dot{\mathbf{u}}^{el} + {}^0\dot{\mathbf{u}}^{pl} = \left(1 - {}^0k\right) \cdot {}^0\dot{\mathbf{u}} + {}^0k \cdot {}^0\dot{\mathbf{u}}, \tag{6}$$

and introducing the plastic flow rule in the following form

$$\frac{\partial\, {}^0\dot{\mathbf{u}}^{pl}}{\partial \mathbf{X}} = {}^0k \cdot \frac{\partial\, {}^0\dot{\mathbf{u}}}{\partial \mathbf{X}}. \tag{7}$$

Here ${}^0k = const \in \langle 0,\ 1 \rangle$ is the plastic multiplier. The flow rule is reasonable since, according to Newton's first law, the material particle does not change the direction of its motion when the stress state reaches the yield limit unless there is an extra force acting on the particle. Moreover, since discrete optimization is used to calculate the multiplier in computational plasticity, the fact that the multiplier value is constant is also acceptable, although, in reality, it is a function of the particle's position vector.

2.2 The constitutive equation of the modified Mooney-Rivlin material model

Considering the modified nonlinear continuum theory for finite deformations of elastoplastic media [4-6] and the compatible plastic flow rule above, while assuming the condition that the body first undergoes elastic and then plastic deformations at its all constituents, the elastic part of the deformation gradient can be expressed in the intermediate configuration of the modelled body as

$$\mathbf{F}^{el}\left(\mathbf{X},\ t\right) = \mathbf{F}\left(\mathbf{X},\ t\right) - \int_0^t \frac{\partial\, {}^0\dot{\mathbf{u}}^{pl}}{\partial \mathbf{X}} \cdot dt. \tag{8}$$

The material gradient of the Lagrangian plastic displacement field ${}^{0}\dot{\mathbf{u}}^{pl}$ can then be determined using implicit numerical time integration in the following incremental form

$$\frac{\partial\, {}^{n+1,0}\mathbf{u}^{pl}}{\partial \mathbf{X}} = \Delta t \cdot \frac{\partial\, {}^{n+1,0}\dot{\mathbf{u}}^{pl}}{\partial \mathbf{X}} + \frac{\partial\, {}^{n,0}\mathbf{u}^{pl}}{\partial \mathbf{X}} = \Delta t \cdot {}^{0}k \cdot \frac{\partial\, {}^{n+1,0}\dot{\mathbf{u}}}{\partial \mathbf{X}} + \frac{\partial\, {}^{n,0}\mathbf{u}^{pl}}{\partial \mathbf{X}}. \tag{9}$$

Here, the left superscripts ${}^{n+1}(\bullet)$, ${}^{n}(\bullet)$ denote the variable $(\bullet)$ values at time steps $n+1$ and n, respectively, corresponding to discrete times ${}^{n+1}t$ and ${}^{n}t$, where $\Delta t = {}^{n+1}t - {}^{n}t$ is the time step size.

The strain-energy density function of the Mooney-Rivlin material model uses the invariants of the elastic isochoric left Cauchy-Green deformation tensor $\mathbf{B}^{el}_{iso}$ while utilizes the multiplicative split of the elastic deformation gradient $\mathbf{F}^{el}$ into an isochoric part $\mathbf{F}^{el}_{iso}$ and a volumetric part $\mathbf{F}^{el}_{vol}$. The elastic isochoric left Cauchy-Green deformation tensor then takes the form [2, 3]

$$\mathbf{B}^{el}_{iso} = \mathbf{F}^{el}_{iso} \bullet \left(\mathbf{F}^{el}_{iso}\right)^{T} = \det\left(\mathbf{F}^{el}\right)^{-\frac{2}{3}} \cdot \mathbf{B}^{el}. \tag{10}$$

The strain-energy density function of the modified Mooney-Rivlin material can then be expressed in the intermediate configuration as [2, 3]

$$\overline{\Psi}^{*el}\left(I_1^{*el},\, I_2^{*el},\, J^{el}\right) = C_{10} \cdot \left(I_1^{*el} - 3\right) + C_{01} \cdot \left(I_2^{*el} - 3\right) + \frac{1}{d} \cdot \left(J^{el} - 1\right)^2, \tag{11}$$

where

$$I_1^{*el} = I_1^{*el}\left(\mathbf{B}^{el}_{iso}\right) = tr\left(\mathbf{B}^{el}_{iso}\right), \tag{12}$$

$$I_2^{*el} = I_2^{*el}\left(\mathbf{B}^{el}_{iso}\right) = \frac{1}{2} \cdot \left[\left[tr\left(\mathbf{B}^{el}_{iso}\right)\right]^2 - tr\left[\left(\mathbf{B}^{el}_{iso}\right)^2\right]\right], \tag{13}$$

and $J^{el} = \det\left(\mathbf{F}^{el}\right)$ is the Jacobian of the elastic deformation. Here, C_{10} and C_{01} are material parameters, and $K = 2/d$ is the bulk modulus. The corresponding stress constitutive function as a Kirchhoff stress measure then takes the following form [2, 3]

$$\begin{aligned} {}^{i}\boldsymbol{\tau}^{el} = \frac{\partial \overline{\Psi}^{*el}}{\partial \mathbf{F}^{el}} \bullet \left(\mathbf{F}^{el}\right)^{T} &= 2 \cdot \left(C_{10} + C_{01} \cdot I_1^{*el}\right) \cdot dev\left[\mathbf{B}^{el}_{iso}\right] - \\ &- 2 \cdot C_{01} \cdot dev\left[\left(\mathbf{B}^{el}_{iso}\right)^2\right] + \frac{2}{d} \cdot J^{el} \cdot \left(J^{el} - 1\right) \cdot \mathbf{I}. \end{aligned} \tag{14}$$

Here, $dev\left[\mathbf{B}_{iso}^{el}\right]$ and $dev\left[\left(\mathbf{B}_{iso}^{el}\right)^2\right]$ denote the deviatoric parts of tensors $\mathbf{B}_{iso}^{el}$ and $\left(\mathbf{B}_{iso}^{el}\right)^2$, respectively.

The constitutive equation can then be transformed into any configurations and stress space using appropriate stress transformation. In the 2nd Piola-Kirchhoff stress space, the constitutive equation takes the following form:

$$\mathbf{S}^{el} = \left(\mathbf{F}^{el}\right)^{-1} \bullet {}^{i}\boldsymbol{\tau}^{el} \bullet \left(\mathbf{F}^{el}\right)^{-T}. \tag{15}$$

To take into account the material or internal damping, we have extended the model by a viscous part

$$\mathbf{S} = \mathbf{S}^{el} + \mathbf{S}^{vis} = \left(\mathbf{F}^{el}\right)^{-1} \bullet {}^{i}\boldsymbol{\tau}^{el} \bullet \left(\mathbf{F}^{el}\right)^{-T} + {}^{mat}\mathbb{C}^{vis} : {}^{*}\dot{\mathbf{E}}^{el}, \tag{16}$$

using the material elastic strain rate tensor ${}^{*}\dot{\mathbf{E}}^{el}$ [6, 9]

$${}^{*}\dot{\mathbf{E}}^{el} = \frac{1}{2} \cdot \left[\left(\dot{\mathbf{F}}^{el}\right)^{T} \bullet \mathbf{F}^{el} + \left(\mathbf{F}^{el}\right)^{T} \bullet \dot{\mathbf{F}}^{el}\right], \tag{17}$$

and the fourth-order material viscosity tensor ${}^{mat}\mathbb{C}^{vis}$, whose definition is similar to the fourth-order material elasticity tensor

$${}^{mat}\mathbb{C}^{vis} = 2 \cdot G^{vis} \bullet \mathbb{I} + \lambda^{vis} \cdot \mathbf{I} \otimes \mathbf{I}, \tag{18}$$

$$G^{vis} = \frac{E^{vis}}{2 \cdot \left(1 + \upsilon^{vis}\right)}; \quad \lambda^{vis} = \frac{\upsilon^{vis} \cdot E^{vis}}{\left(1 + \upsilon^{vis}\right) \cdot \left(1 - 2 \cdot \upsilon^{vis}\right)}. \tag{19}$$

Here G^{vis} is the viscous shear modulus ; λ^{vis} is the viscous first Lamé constant; $\mathbb{I}$ and $\mathbf{I}$ are the fourth- and second-order identity tensors. The parameter E^{vis} stands for the viscous Young's modulus and υ^{vis} for the viscous Poisson's ratio.

The final form of the constitutive equation of the modified hyperelastic-plastic Mooney-Rivlin material model used in our finite element analyses takes the following form in the Kirchhoff stress space corresponding to the current configuration [5, 9]

$$\boldsymbol{\tau} = \mathbf{F} \bullet \mathbf{S} \bullet \mathbf{F}^{T} = \mathbf{F} \bullet \left[\left(\mathbf{F}^{el}\right)^{-1} \bullet {}^{i}\boldsymbol{\tau}^{el} \bullet \left(\mathbf{F}^{el}\right)^{-T} + {}^{mat}\mathbb{C}^{vis} : {}^{*}\dot{\mathbf{E}}^{el}\right] \bullet \mathbf{F}^{T}. \tag{20}$$

The Cauchy stress can then be expressed as $\boldsymbol{\sigma} = \boldsymbol{\tau} / J$ using the well-known transformation, where $J = \det\left(\mathbf{F}\right)$ is the Jacobian of the deformation.

2.3 The definition of the reference yield surface

A proper continuum theory of finite deformations of elastoplastic media allows for the formulation of the material model in all stress spaces and configurations of the body. As a result, the yield surface also has definitions in all stress spaces, from which one has to be a reference [4]. In this work, we have used the Von-Mises material model with isotropic hardening in the Kirchhoff stress space to describe the plastic behaviour of our material

$$ {}^{\tau}\psi = {}^{\tau}\sigma_{eq}\left(\boldsymbol{\tau}\right) - {}^{\tau}\sigma_{y}\left(e^{pl}\right) \leq 0. \tag{21}$$

Here the equivalent Kirchhoff stress ${}^{\tau}\sigma_{eq}\left(\boldsymbol{\tau}\right)$ is defined as

$$ {}^{\tau}\sigma_{eq}\left(\boldsymbol{\tau}\right) = \sqrt{\frac{3}{2}\cdot\sum\boldsymbol{\tau}:\sum\boldsymbol{\tau}}; \qquad \sum\boldsymbol{\tau} = \boldsymbol{\tau} - \frac{tr\left(\boldsymbol{\tau}\right)}{3}\cdot\mathbf{I}. \tag{22}$$

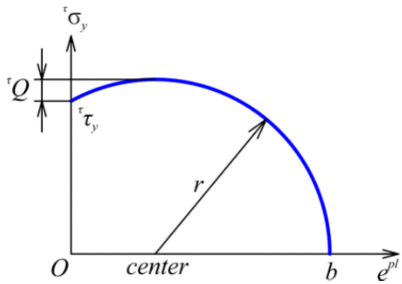

Figure 2: The yield stress versus uniaxial plastic strain curve of the material

Since in the case of hyperplastic materials, the determination of the yield stress versus uniaxial plastic strain curve of the material poses a problem, we assumed the curve to be a function of the accumulated plastic strain e^{pl} in the following form (Figure 2)

$$ \begin{aligned} &{}^{\tau}\sigma_{y}\left(e^{pl}\right) = \sqrt{r^{2} - \left(a\cdot e^{pl} - center\right)^{2}}; \quad r = {}^{\tau}\tau_{y} + {}^{\tau}Q; \\ &center = \sqrt{r^{2} - {}^{\tau}\tau_{y}^{2}}; \quad a = \frac{center + r}{b}. \end{aligned} \tag{23}$$

Here ${}^{\tau}\tau_{y}$ is the constant yield stress of the material, and ${}^{\tau}Q$ is the maximum hardening stress. In the numerical analysis, the material hardening/softening is controlled by the accumulated plastic strain e^{pl}.

The parameter b denotes the maximum value of the accumulated plastic strain at which the material loses its integrity, i.e. where the yield stress reduces to zero. The other material parameters can easily be identified from Figure 2.

The accumulated plastic strain in our model has been determined by time integration of the accumulated plastic strain rate

$$\dot{e}^{pl} = \sqrt{\frac{2}{3} \cdot \mathbf{d}^{pl} : \mathbf{d}^{pl}}; \qquad e^{pl} = \int_0^t \dot{e}^{pl} \cdot dt, \tag{24}$$

using the spatial plastic strain rate tensor in the form

$$\mathbf{d}^{pl} = \frac{1}{2} \cdot {}^0k \cdot \left[\frac{\partial \dot{\mathbf{u}}}{\partial \mathbf{x}} + \left(\frac{\partial \dot{\mathbf{u}}}{\partial \mathbf{x}} \right)^T \right]. \tag{25}$$

3 Numerical analysis and its results

In the numerical analysis plastic behaviour of a natural rubber specimen, dimensions $0.0068\ \mathrm{m} \times 0.0014\ \mathrm{m} \times 0.03\ \mathrm{m}$ has been studied. The specimen was loaded in tension along its longitudinal axis using $v = 0.02\ m.s^{-1}$ prescribed axial velocity at the specimen moving end. The moving end was also guided in the transverse direction while the specimen second end was fixed. Figure 3 depicts the spatially discretized body of the specimen used in the finite element analysis. The specimen was initially at rest. The analysis was run as dynamic until it failed to converge using implicit time integration and a $0.0005\ s$ time step size. The material properties of the rubber specimen are outlined in Table 1.

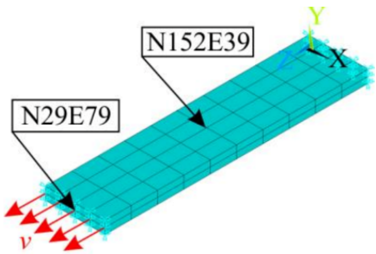

Figure 3: The spatially discretized specimen used in the finite element analysis

Table 1: The material properties of the specimen

$\rho_0\ [kg \cdot m^{-3}]$	1 100
$C_{10}\ [Pa]$	2 906.3
$C_{01}\ [Pa]$	30 635.3
$d\ [Pa^{-1}]$	$6.0027632e^{-7}$
$E^{vis}\ [Pa \cdot s]$	1 000
$\upsilon^{vis}\ [-]$	0.49
${}^{\tau}\tau_y\ [Pa]$	250 000
${}^{\tau}Q\ [Pa]$	50 000
$b\ [-]$	2.0

The following figures show a few selected results coming from the numerical experiment. These are the axial displacement distribution over the body, the accumulated plastic strain distribution and the von Mises stress distribution as a Cauchy's stress measure and the time history curves of the same variables at selected nodes (N) of the element (E).

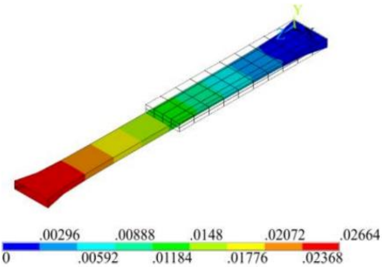

Figure 4: Axial displacement distribution *[m]* at the end of the analysis

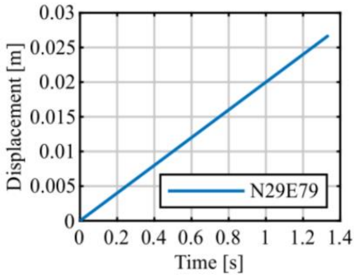

Figure 5: Axial displacement time-history curve at node *N29E79*

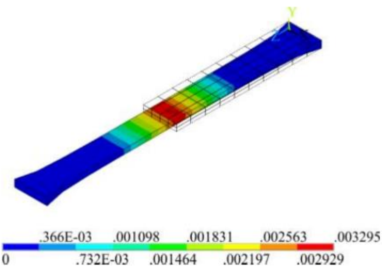

Figure 6: Accumulated plastic strain distribution *[-]* at the end of the analysis

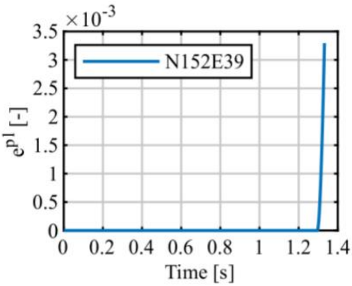

Figure 7: Accumulated plastic strain time-history curve at node *N152E39*

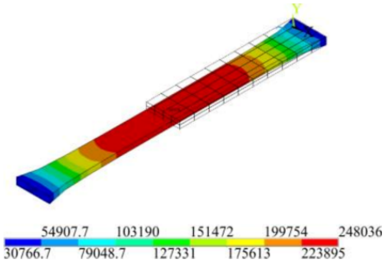

Figure 8: von Mises stress distribution *[Pa]* at the end of the analysis

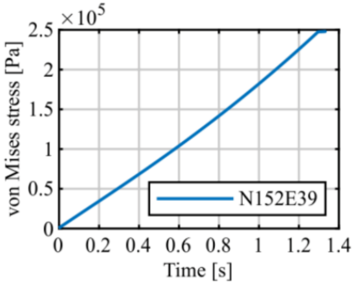

Figure 9: von Mises stress time-history curve at node *N152E39*

As shown in Figures 4 and 5, the maximum axial displacement is 0.027 m at the specimen moving end when the analysis ceased to convergence. The corresponding maximum elongation is 90 %. The maximum accumulated plastic strain, which is the measure of irreversible deformations and controls the isotropic hardening, is approximately 0.33 % at the end of the analysis. The von Mises stress increases at a higher rate in elastic loading than in plastic lading until it decreases when the material softens at the end of the analysis.

4 Conclusion

In this paper, there has been presented an alternative method of modelling irreversible deformations of hyperelastic materials. The related material model uses a plastic flow rule that meets the compatibility conditions locally and the objectivity requirements. The model was demonstrated in a numerical experiment using the modified Mooney-Rivlin material model, where tensile testing of a rubber-like specimen was studied. The analysis results are informative only. The proper verification of the material model requires further numerical analyses and thorough material testing.

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THERMAL EXPANSION OF ILLITIC CLAY RADOBICA

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Abstract: Brick clay from a locality Radobica, Central Slovakia (39 % of quartz, 46 % of illite, 12.5 % of Na-feldspar, and 2.5 % of unidentified phase) was investigated for its possible reuse. The dilatometric measurements of clay were performed during heating as well as at room temperature on samples preheated at temperatures from 100 °C to 1100 °C. At the lowest temperatures, only a small expansion was observed. Dehydroxylation of illite (between 450 °C and 700 °C) was accompanied by the expansion. The sample has a relatively high amount of quartz that passes through the $\alpha \rightarrow \beta$ transition which exhibited itself as a steep expansion. Sintering and vitrification lead to the steep contraction. The course of the dilatometric curve of the fired sample is linear up to 500 °C with CLTE of 6.4×10^{-6} 1/K. After it, a regular thermal expansion continues. Partially fired samples showed that firing up to 500 °C almost did not influence the dimensions of the sample.

Keywords: illitic clay; thermal expansion; sintering; ceramics

1 Introduction

Illitic clays are essential ingredients for building ceramics [1]. The natural additive minerals in these clays are quartz and feldspar. Other additives, e.g. carbonates, iron oxides, and sulfides are also often present. In addition, clays usually contain some organic material. The structure and properties of the ceramic product made from illitic clay are consolidated during the firing, in which physical and chemical processes occur in individual mineralogic phases [2, 3, 4] and between them, see Table 1. The properties of the ceramic body largely depend on these processes.

Table 1 – processes in illitic clay

Temperature (°C)	event	references
20 – 300	the loss of the residues of the physically bound water from pores	
350 – 400	removing of the interlayer water in illite	[5]
450 – 700	removing of the structurally bound water (dehydroxylation) in illite	[6, 7]
around 573	$\alpha \rightarrow \beta$ transition of quartz	
750 – 1100	sintering and vitrification	[6, 8, 9, 10]

These processes are reflected in the changes of properties of the fired samples including thermal expansion [6, 7]. When the clay contains calcite, its decomposition is observed between 700 °C and 900 °C and results in intensive contraction and mass loss. The influence of calcite on the thermophysical properties of ceramics was studied in [8].

The high-temperature reactions, in which dehydroxylated phyllosilicates change into spinel and mullite, cause intensive contraction in the case of the kaolinitic mixtures. The same is valid for illitic mixtures, where, in addition to that, intensive vitrification is observed [5, 6, 9]. These high-temperature processes are irreversible, therefore the contraction is preserved in the cooled samples.

Reversible transformation of quartz at ~573 °C (Tab. 1) plays an important role in mechanical strength and elastic properties due to the creation of the microcracks if the firing temperature was high enough to develop a glassy phase [11, 12].

The material investigated here is the clay from the locality Radobica, Central Slovakia. The clay was exploited for brick manufacturing in the past. Its re-exploiting can be attractive in a new ceramic mixture with a fly-ash from a nearby coal combustion power plant. The goal of this paper is to study the thermal expansion of this clay as a function of the firing temperature.

2 Experimental

The clay for preparing the samples was excavated from a depth of more than 1.2 m because at lower depths the samples contained a large amount of organic mass and sample properties varied significantly. The clay was ground and mixed with distilled water to obtain a plastic mass with a water content of 25 mass%. Cylindrical samples with a diameter of 11 mm were prepared with a laboratory extruder. After open-air free drying, the samples contained ~2 mass% of the physically bound water.

Thermal expansion of the unfired samples was measured using the push-rod horizontal dilatometer [13] from 20 °C to 1100 °C at the heating rate of 5 °C/min

The dimensional changes of the samples fired at 100, 200,…, 1100 °C without a dwelling at the highest temperature, were measured at room temperature. The temperature of 1100 °C was chosen because it is the presumptive highest firing temperature used in the industrial production of clay bricks and tiles. A self-generated atmosphere was used during the thermodilatometry and firing.

3 Results and discussion

The XRD analysis was carried out at room temperature for Radobica clay green and fired in our previous work [11]. The green clay contained 39 mass% of quartz, 46 mass% of illite, 12.5 mass% of Na-feldspar, and 2.5 mass% of unidentified phases. Taking into account that the color of the fired samples was red, the unidentified minerals could be ferrous oxides which are very often present in brick clays. After firing at 1000 °C, the main crystalline phases were quartz (48 mass%), Na-feldspar (13 mass%), hematite (3 mass%), and amorphous phase (36 mas%).

The composition and microstructure of the clay change during heating. In general, results of differential thermal analysis, thermogravimetry, and thermodilatometry revealed the processes which take place in the investigated clay [11]. The used temperature interval (20 °C to 1100 °C) can be divided into three subintervals: 20 °C – 400 °C, in which a release of the physically bound water and burning of the organic impurities take place; 400 °C – 700 °C, in which dehydroxylation of clay minerals and $\alpha \rightarrow \beta$ transition of quartz take place; and 700 °C – 1100 °C, in which sintering, vitrification, and high-temperature reactions take place.

The relative thermal expansion of the unfired sample during its heating is shown in Fig. 1. At the lowest temperatures (20 °C → 100 °C) only a small expansion was observed. This is a region in which a regular thermal expansion and release of the physically bound water, which causes a contraction, take place. Dehydroxylation of illite (between 450°C and 700 °C) is accompanied by expansion of the sample dimensions [7, 9, 10]. The sample has a relatively high amount of quartz that passes through the $\alpha \rightarrow \beta$ transition which proves itself as a steep expansion. The result is the maximum of the linear thermal expansion coefficient (CLTE) around 573 °C, Fig. 1. The next processes, sintering, and vitrification lead to the steep contraction.

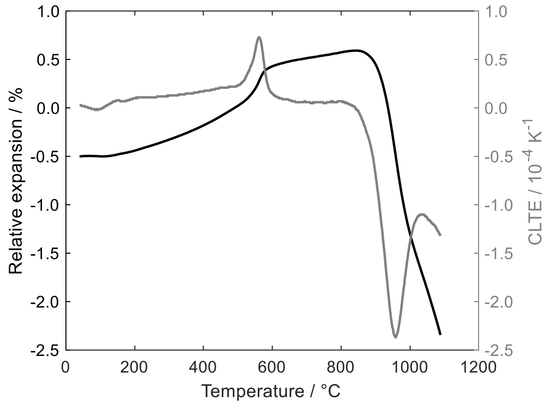

Figure 1: Thermodilatometric curve (black line) and CLTE (gray line) of the unfired sample during heating to 1100 °C at 5 °C/min

The relative expansion of the sample measured on the sample from the previous firing is shown in Fig. 2. The course of the relationship is approximately linear up to 500 °C with CLTE of 6.4×10^{-6} 1/K. This value is from the relatively large interval for clay building ceramics, e.g. 12×10^{-6} 1/K [14], (4 – 8)×10^{-6} 1/K [15], (10 – 20)×10^{-6} 1/K [16]. Samples with a significant amount of quartz show a step in their thermodilatometric curves around the $\alpha \rightarrow \beta$ transition of quartz. After it, a regular thermal expansion continues because no change in the structure, except softening the sample above 800 °C, takes place. The pressing mechanical force, which is necessary for the work of the push-rod dilatometer, bent the thermodilatometric curve down above 900 °C. In fact, the sample dimensions continue to expand [13].

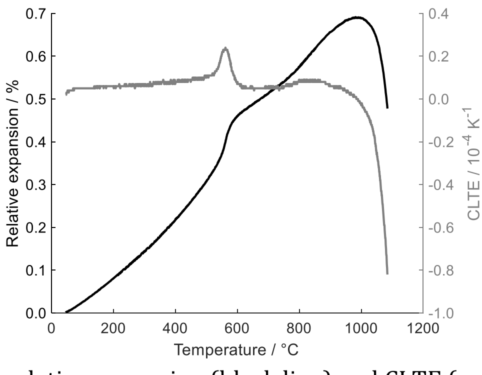

Figure 2: The relative expansion (black line) and CLTE (gray line) of the clay fired at 1100 °C

The relative expansion measured at room temperature after partial firings is in Fig. 3. The firings up to 500 °C, i.e. up to the start of dehydroxylation, almost did not influence sample dimensions. The structure and microstructure are not impacted at such low temperatures. Dehydroxylation causes an expansion [7, 9, 10] measured during heating with the help of thermodilatometry. This expansion is partially irreversible and was registered on the cooled samples. The sintering, vitrification, and high-temperature reactions change the microstructure of illitic clay substantially at temperatures above 800 °C. At these temperatures, the contraction of samples was observed.

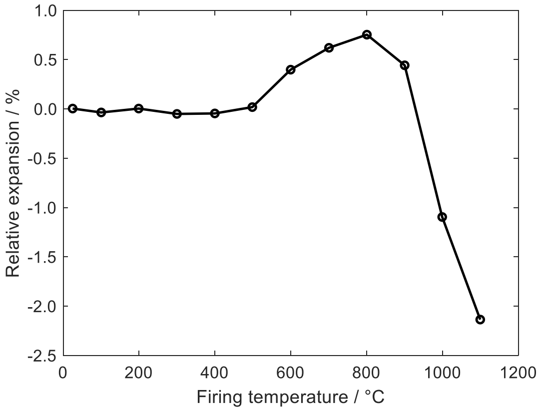

Figure 3: Relative expansion of the clay sample after firing at different temperatures

3 Conclusions

The clay from the Radobica deposit containing 39 mass% of quartz, 46 mass% of illite, 12.5 mass% of Na-feldspar, and 2.5 mass% of unidentified phases was investigated with the help of dilatometry. The release of the physically bound water, dehydroxylation of illite, sintering, and vitrification are the main processes which take place during heating. These processes influence the sample dimensions.

Unfired samples:

- At the lowest temperatures, only a small expansion is observed. This is a region in which a regular thermal expansion and release of the physically bound water, which causes a contraction, take place.
- Dehydroxylation of illite (between 450 °C and 700 °C) is accompanied by an expansion of the sample dimensions.

- The sample has a relatively high amount of quartz that passes through the $\alpha \rightarrow \beta$ transition which proves itself as a steep expansion.
- Sintering and vitrification lead to steep contraction.

Fired samples:

- The course of the dilatometric curve of the fired sample is approximately linear up to 500 °C with CLTE 6.4×10^{-6} 1/K.
- The samples had a significant amount of quartz which caused a step in their thermodilatometric curves around the $\alpha \rightarrow \beta$ transition of quartz. After it, a regular thermal expansion continued because no change in the structure occurred, except for the softening of the sample above 800 °C.

Partially fired samples:

- The firings up to 500 °C almost did not influence the dimensions of the sample.
- Dehydroxylation causes an expansion. This expansion is partially irreversible and was registered on the cooled samples.
- The sintering, vitrification, and high-temperature reactions change the microstructure of illitic clay substantially at temperatures above 800 °C. At these temperatures, the contraction of samples was observed.

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VÝUČBA CHÉMIE ONLINE: MOŽNOSTI VZDELÁVANIA ŽIAKOV POČAS PANDÉMIE COVID-19

Melánia FESZTEROVÁ, SK

Abstrakt: Štatistiky odpadov poskytujú informácie o tom, ktoré odpady znečisťujú životné prostredie, v akom množstve a kde, ale neuvádzajú, čo človeka z takéhoto prostredia ohrozuje a ako sa môže brániť. Príspevok prezentuje dôležitosť a výhody vzdelávania žiakov základných škôl v prírodovednom predmete (chémia) s pomocou e-learningového kurzu počas pandémie COVID-19. E-learningový kurz *„Modernizácia vzdelávania a interdisciplinárny prístup v kategórii odpad a odpadové hospodárstvo“* je umiestnený na webovej stránke Univerzity Konštantína Filozofa v Nitre. Pozostáva z desiatich tém. Každá téma obsahuje metodický list pre učiteľa a pracovný list pre žiaka. Ako príklad e-learningového kurzu sme vybrali tému s názvom *„Kam s odpadom z elektrických a elektronických zariadení a prečo?“*. Pri alarmujúcom náraste množstva a druhov elektroodpadov je nevyhnutné plynulo vzdelávať a vychovávať žiakov k sledovaniu kontaminácie životného prostredia uvedenými odpadmi a tým aj k ochrane zdravia. E-learningové vzdelávanie žiakov 7. ročníka základných škôl sleduje environmentálne, didaktické a pozorovacie ciele. Zvolená téma kurzu využíva prednášky a metódy zážitkového učenia na dosiahnutie environmentálnych cieľov. Následne metóda otázok a odpovedí a neštruktúrované pozorovanie boli zvolené tak, aby sa dosiahli ďalšie ciele a úlohy. Nami prezentovaná téma je zameraná na dôležitosť zberu elektroodpadu, jeho separáciu, identifikáciu piktogramov a spôsoby klasifikácie látok, ktoré tvoria elektroodpad. E-learning je jednou z foriem dištančného vzdelávania. Uvedená vedomostná základňa je otvorená pre nové metódy a postupy. Navyše umožňuje neustále pripájanie aktuálnych materiálov, informácií, platných predpisov a nariadení.

Kľúčové slová: e-learning, dištančné vzdelávanie, elektroodpad, COVID-19.

TEACHING CHEMISTRY ONLINE: OPTIONS FOR EDUCATING PUPILS DURING COVID-19

Abstract: Statistics of waste provide information on which wastes pollute the environment, in what amounts and where, but do not say what threatens a person from the environment and how they can defend themselves. This paper presents the importance and benefits of primary school pupils' education in the natural science discipline (chemistry) with the help of the e-learning course during the COVID-19. E-learning course "*Modernization of Education and Interdisciplinary Approach in the Category Waste and Waste Management*" is located on the website of Constantine the Philosopher University in Nitra. It consists of ten topics. Each topic contains the methodological sheet for the teacher and the worksheet for the pupil. As an example of an e-learning course, we chose the topic "*Where to with waste from electrical and electronic equipment and why?* ". With the alarming increase in the amount and type of electrical waste, it is necessary to continuously educate and train pupils to monitor the contamination of the environment with this waste and thus to protect health. Therefore, the e-learning education of 7th-grade primary school pupils pursues the environmental, didactic and observation goals. The selected topic of the course uses lectures and experiential learning methods to meet environmental goals. Subsequently, the question-and-answer method and unstructured observation have been chosen to meet other objectives and tasks. This topic focuses *on collecting electrical waste importance, its separation, identification of pictograms, and ways to classify substances that form electrical waste.* E-learning is one of the forms of distance education. This knowledge base is open to the implementation of new methods and procedures. In addition, it allows the constant connection of current materials, information, applicable rules and regulations.

Keywords: e-learning, distance education, electrowaste, COVID-19.

1 ÚVOD

Znalosti a inovácie, ako aj informačné a komunikačné technológie (IKT) mali výrazný vplyv na mnohé hospodárske odvetvia, ako sú zdravotníctvo, financie a doprava [1 – 2]. A ako je to so vzdelávaním? Prioritným cieľom pedagógov na základných školách je zvýšenie kvality a efektívnosti vzdelávania školopovinnej mládeže [3 – 4]. Výzvou pre túto oblasť je pokračovať s rozširovaním pomocou nových foriem vzdelávania [2, 5]. Pedagógovia na základných školách zriedkavo využívajú e-learningové vzdelávanie ako edukačný prostriedok počas výchovno-vzdelávacieho procesu. Vo väčšine prípadov prítomnosť internetových technológií vo vzdelávaní sa obmedzuje na vyhľadávanie informácií a len zriedkavo aj na komunikáciu. Jednou z príčin môže byť nedostatok e-learningových kurzov v danej oblasti a absencia vedomostí z problematiky využitia e-learningu. Z uvedeného dôvodu musíme zdôrazniť, že dôležitá je nielen dostupnosť informácií pomocou e-learningových kurzov, ale aj schopnosť využiť nadobudnuté vedomosti v praxi [6 – 8]. Formy využívania e-learningových kurzov sú spojené s tým, či používateľ má počítačové zručnosti.

V príspevku je prezentovaný význam, dôležitosť a opodstatnenosť vzdelávania žiakov základnej školy v prírodovedných predmetoch zameraných na environmentálnu oblasť s pomocou e-learningového kurzu E-learningový kurz *„Modernizácia vzdelávania a interdisciplinárny prístup v kategórii odpad a odpadové hospodárstvo"* je zameraný na elektroodpady a ich chemické zloženie z pohľadu výchovnovzdelávacej práce a vo vzťahu jeho aplikácie do praxe. Vzdelávanie a odborná príprava zamerané na zloženie odpadov sú nástrojom systematického formovania a rozvíjania odborných vedomostí a zručností žiakov. Ako ukážku z e-learningového kurzu sme vybrali tému 4 s názvom *„Kam s odpadom z elektrických a elektronických zariadení a prečo?"*. Úlohou je: overiť vedomosti žiakov, či vedia čo zaraďujeme medzi odpad z elektrických a elektronických zariadení; vysvetliť žiakom ako sa separuje elektroodpad a uviesť dôvody na základe ktorých sa triedi; zistiť, či žiaci vedia, ako sa s elektroodpadom manipuluje a ktoré chemické látky obsahuje a možnosti ich ďalšieho využitia.

2 METODOLÓGIA

Vybraná téma e-learningového kurzu s názvom *„Kam s odpadom z elektrických a elektronických zariadení a prečo?"* je zameraná na tému elektroodpadov a ich triedenie [9]. Otázka znie prečo práve vzdelávanie v oblasti odpadov z elektrických a elektronických zariadení a prečo formou e-learningu? Odpoveďou sú štúdie mnohých autorov, ktorí publikovali výsledky z oblasti výchovy a vzdelávania s podporou IKT [10 – 12]. Ako uvádzajú autori Larsen, Vincent-Lancrin (2006) vzdelanie je predpoklad znalostnej ekonomiky: výroba a využívanie nových vedomostí si vyžadujú viac vzdelanej populácie a pracovnej sily [2]. Práve IKT sú veľmi silným nástrojom na šírenie vedomostí a informácií a sú základným aspektom vzdelávacieho procesu [2, 4, 8]. Následne IKT prinášajú inovatívne postupy. Vedecký výskum v mnohých oblastiach bol tiež revolúciou v nových možnostiach, ktoré ponúkajú IKT, vrátane digitalizácie informácií a nových možností nahrávania, simulácie a spracovania údajov [13].

E-learningový kurz sa nachádza na webovej stránke Univerzity Konštantína Filozofa v Nitre na portáli „amos.ukf.sk" v prostredí LMS Moodle*.* E-learningový kurz tvorí 10 tém. Vybraná 4. téma na dosiahnutie environmentálnych cieľov využíva metódu prednášok (výklad, fotografie z prostredia) a zážitkového učenia. Na dosiahnutie ďalších cieľov (didaktický cieľ a cieľ pozorovania) boli zvolené metódy otázok a odpovedí a neštrukturalizovaného pozorovania. *4. téma* e-learningového kurzu je tvorená *Metodickým listom pre učiteľov* a *Pracovným listom pre žiakov.*

Obsa*h Metodického listu pre učiteľov* uvádza:

- dôvody, prečo je nutné odpad z elektrických a elektronických zariadení separovať osobitne;
- spôsoby správnej manipulácie s odpadom z elektrických a elektronických zariadení;
- odpadové komodity, ktoré sa triedia a sú súčasťou v elektrických a elektronických zariadeniach;
- možností separácie a ďalšieho využitia chemických látok (prvkov, zlúčenín), ktoré elektroodpad obsahuje.

Metodický list pre učiteľov opisuje aj negatívne vplyvy elektroodpadov na prostredie a tým aj na zdravie populácie.

E-learningové vzdelávanie žiakov 7. ročníka základnej školy s pomocou pracovného listu (*Pracovný list pre žiakov*) sleduje *environmentálny, didaktický a cieľ pozorovania*. V uvedených cieľoch sme sa zamerali na žiakmi nadobúdané *vedomosti a rozvíjané spôsobilosti a zručnosti*. Z hľadiska *nadobúdaných vedomostí žiak vie: poukázať na dôležitosť zberu elektroodpadu; identifikovať piktogramy určené pre oddelený zber; roztriediť látky, ktoré patria do elektroodpadu a uviesť príklady elektroodpadov*. Pri orientácii *na rozvíjané spôsobilosti a zručnosti žiak vie*: *manipulovať s odpadmi; riešiť problémy súvisiace s elektroodpadom a kriticky myslieť; aplikovať separáciu odpadov v praxi a navrhnúť alternatívne postupy.*

3 VÝSLEDKY

Vzhľadom na proces vytvárania efektívneho systému výchovy a vzdelávania v uvedenej téme sa snažíme o využitie prierezových vzťahov pri riešení vybranej problematiky a následnú konsolidáciu a prehlbovanie znalostí z prírodovedných predmetov [14], predovšetkým z chémie [9]. Sledujeme vzťah a záujem žiakov o tému zberu *odpadu z elektrických a elektronických zariadení.*

Vzhľadom na rozvoj kompetencií a zručností je naším zámerom, aby žiaci boli schopní: *správne manipulovať s odpadom z elektrických a elektronických zariadení; aplikovať triedenie a zber elektroodpadu do praxe; riešiť problémy súvisiace s elektroodpadom a kriticky myslieť; navrhnúť model ako znížiť množstvo elektroodpadu (súťaže zamerané na ochranu životného prostredia); navrhovať alternatívne postupy v súvislosti s elektroodpadom.* Dôraz je kladený na prehlbovanie vedomostí ako kľúčovú hnaciu silu, ktorá úzko súvisí s hospodárskym rozvojom, ale je tiež výzvou pre sektor vzdelávania [15]. Správne triedenie elektroodpadu je dôležitým faktorom pri znižovaní množstva využívaných surovín prostredníctvom recyklačných programov a úsilia o implementáciu obehového hospodárstva [16 – 17].

3.1 Metodický list pre učiteľov s témou "KAM S ODPADOM Z ELEKTRICKÝCH A ELEKTRONICKÝCH ZARIADENÍ A PREČO?"

Metodický list pre učiteľov obsahuje: ciele (názov tematického celku, žiakom nadobúdané a rozvíjané vedomosti, požiadavky na vstupné vedomosti a zručnosti, riešený didaktický problém, vyučovacie metódy a formy, prípravu učiteľa, pomôcky a diagnostiku dosiahnutia vzdelávacích cieľov); úlohy pre žiakov; organizáciu práce a pomôcky; niektoré informácie pre učiteľa týkajúce sa elektroodpadov.

Úlohy pre žiakov:

1. Overiť vedomosti žiakov o odpadoch z elektrických a elektronických zariadení a čo k nim zaraďujeme.
2. Vysvetliť žiakom ako sa separuje elektroodpad a uviesť dôvody na základe, ktorých sa separuje.
3. Zistiť, či žiaci vedia, ako sa s elektroodpadom správne manipuluje.
4. Preveriť, či žiaci poznajú, ktoré chemické látky môžu obsahovať odpady z elektrických a elektronických zariadení a prečo sú nebezpečné pre životné prostredie.

5. Zorganizovať plagátovú výstavu prác žiakov s témou „*Kam s odpadom z elektrických a elektronických zariadení a prečo?*“.
6. Zmapovať v blízkosti školy (bydliska) zberné nádoby na použité batérie.
7. Uviesť spôsoby, ako by bolo možné znižovať množstvo elektroodpadu.

Organizácia práce je rozdelená do 3 etáp a 4 časových úsekov. Obsahuje motiváciu a rozdelenie úloh počas vyučovacej hodiny, činnosť mimo povinnej výučby a riešenie problému po vyučovaní.

V časti „*Niektoré informácie k úlohám*“ sú rozšírené informácie a poznatky pre učiteľov k jednotlivým úlohám. V *4. téme* táto časť obsahuje spracované nasledovné oblasti:

Elektroodpad − odpad z elektrických a elektronických zariadení.

Chemické látky, ktoré sa nachádzajú v odpade z elektrických a elektronických zariadení.

Miesta zberu odpadu z elektrických a elektronických zariadení.

3.1.1 Elektroodpad - odpad z elektrických a elektronických zariadení

Elektroodpad je odpad ako každý iný, ktorého sa chceme zbaviť, mali by sme sa ho zbaviť alebo sa ho musíme zbaviť. Dôvodov je niekoľko: *je nefunkčný, starý, nevyhovuje už našim požiadavkám.* Patria sem zariadenia, ktoré prestanú plniť svoju funkciu, stratia svoju špecifickú vlastnosť určenia a opotrebujú sa. Končia svoj životný cyklus a stávajú sa odpadom, v tomto prípade elektroodpadom.

Úloha pre žiakov: Na tvrdú podložku si žiaci nakreslia tabuľku. Do pripravenej tabuľky zaznačia, ktoré zariadenia po skončení ich funkčnosti by zaradili do elektroodpadu a ktoré nie. Pomôckou pri práci je Tabuľka 1.

Tabuľka 1: Čo zaraďujeme do odpadu z elektrických a elektronických zariadení a čo nie

Do elektroodpadu patria	Do elektroodpadu nepatria
-veľké domáce spotrebiče (chladničky, televízory, práčky); -výpočtová technika (počítače, notebooky); telekomunikačné zariadenia (telefóny, mobilné telefóny, slúchadlá);	-triedené zložky (papier, sklo, plasty, kovy, viacvrstvové kombinované materiály); -komunálny odpad; -iný odpad (papier, sklo, plasty).

-osvetľovacie zariadenia (žiarovky, žiarivky); -malé domáce spotrebiče (rýchlovarné kanvice, holiace strojčeky, fény, elektrické zubné kefky, zubné sprchy), vysávače, hračky; -zariadenia určené na športové a rekreačné účely; -prístroje na monitorovanie a kontrolu (kamery), zariadenia na prehrávanie zvuku alebo obrazu (projektory), hudobné zariadenia; -tonery z tlačiarní, tlačiarne, kopírky, monitory.	

Pedagóg oboznámi žiakov s nasledujúcimi pojmami: *elektroodpad, nebezpečné látky, rizikové prvky, kyselina, recyklácia.*

1.3.2 Chemické látky, ktoré sa nachádzajú v odpade z elektrických a elektronických zariadení

Elektroodpad je nebezpečný odpad, ktorý obsahuje široké spektrum rôznych chemických látok (prvkov, zlúčenín) (Tabuľka 2). Obsahuje rizikové prvky (Pb, Sn, Hg) a iné chemické látky anorganického pôvodu. Tak isto môže obsahovať aj organické chemické látky ako sú napr. freóny. Z uvedeného dôvodu musí byť elektroodpad recyklovaný v špeciálnych linkách, ktoré sú na ich recykláciu upravené.

Úloha pre žiakov: Žiaci pracujú v skupinách. Zapíšu si, ktoré chemické látky (prvky, zlúčeniny) sú obsiahnuté v elektroodpadoch a ako a s nimi správne manipuluje. Uvedú dôvody, prečo sú chemické látky nebezpečné pre životné prostredie a tým aj pre zdravie človeka [18]. Diskutujú o informáciách, ktoré sú uvedené na obaloch elektrických a elektronických zariadení (piktogramy) a aký je ich význam.

Tabuľka 2: Nebezpečné chemické látky v elektroodpadoch

Žiarivka je zariadenie, nízkotlakový výbojkový zdroj svetla, napájaný elektrickou energiou. Pozostáva zo sklenenej trubky, ktorá je vo vnútri pokrytá látkou luminofórom, štartéra a výbojky (ortuťová, halogenidová, sodíková, xenónová). Svetlo v žiarivke vzniká ultrafialovým žiarením ortuťového výboja, ktorý luminofór premení na svetlo. *Žiarovka* je elektrický tepelný zdroj svetla, ktoré vznikne rozžeravením vlákna žiarovky prechodom elektrického prúdu. Toto vlákno je uložené v sklennej bubline, ktorá je vyplnená vákuom alebo nezlučivým plynom (zmes argónu alebo kryptónu s dusíkom). Spodnú časť žiarovky tvorí objímka, najpoužívanejšia je závitová, ktorou sa žiarovka pripája do zariadenia a teda do obvodu. ***Žiarivky*** aj ***žiarovky*** sú zaradené medzi nebezpečný odpad. Každá žiarivka obsahuje pary Hg, ktoré sú toxické nielen pre človeka, ale aj pre životné prostredie. Pri rozbití žiarivky Hg môže unikať do prostredia.
Televízory a niektoré ***mobilné telefóny*** tiež obsahujú tenké žiarivkové trubice. Preto je dôležité dávať pozor, aby sa takýto telefón, resp. TV prijímač nerozbil, aby nepraskol a aby sa Hg, ktorá sa nachádza vo vnútri nedostala do prostredia.
Batérie (veľké aj malé prenosné) sa nesmú dávať do zmesového odpadu. Zaraďujeme ich medzi nebezpečné odpady, pretože obsahujú toxické látky [19. Súčasne obsahujú látky, ktoré sa dajú recyklovať.
Autobatérie Obsahujú H_2SO_4, ktorá je žieravina. Leptá a dráždi pokožku, dýchacie orgány a sliznicu, spôsobuje ťažké poleptanie. Obsahujú aj Pb [19].

Pri nákupe elektrozariadenia, na obale výrobku (príbalovom letáku) je vyobrazený grafický znak označujúci elektrické a elektronické zariadenie vrátané batérií, žiaroviek a žiariviek *určené na oddelený zber* po ukončení ich funkčnosti. Tieto zariadenia patria medzi nebezpečné odpady, preto sa nesmú vhadzovať do zberných nádob, ale odovzdávajú sa na *zberných dvoroch*.

3.1.3 Miesta zberu odpadu z elektrických a elektronických zariadení

Elektroodpad sa zbiera na zbernom dvore a následne sa odovzdáva firmám, ktoré majú autorizáciu a sú určené na spracovanie elektroodpadu. *Elektroodpad z domácností* je možné odovzdať aj na miestach ako*:* spätný zber v predajniach a na zberných miestach (veľmi malý elektroodpad) v rámci oddeleného zberu zložiek komunálneho odpadu z domácností, vrátane tých, ktoré obsahujú škodlivé látky, ktorý je organizovaný v jednotlivých obciach.

Pedagóg vysvetlí žiakom čo sa rozumie pod pojmom „*elektroodpad z domácností*“. *Elektroodpad z domácností* je odpad, ktorý vzniká v domácnostiach, na chatách, v záhradách a v garážach. Elektroodpad vzniká aj v rámci zamestnania. Táto komodita nepatrí medzi bežné druhy komunálneho odpadu, ktoré vznikajú denne. Nepatrí ani do zmesového komunálneho odpadu alebo objemného odpadu.

Pedagóg oboznámi žiakov s pojmami: *skládka elektroodpadov a zdroje odpadov*.

3.2 Pracovný list pre žiakov s témou „Kam s odpadom z elektrických a elektronických zariadení a prečo?"

Pracovný list pre žiakov je tvorený všeobecnou časťou (motivačná) a úlohami (A – D).

Úlohu A tvoria nasledovné položky: Preverenie vedomostí žiakov a príprava mapových podkladov obce (okolia školy, sídliska, bydliska); spracovanie informácií z literárnych zdrojov (z publikácií, časopisov, zborníkov) o odpadoch z elektrických a elektronických zariadení.

Úlohu B tvoria nasledovné položky: Žiaci, resp. každá skupina žiakov si na základe tabuľky 1 pripraví vlastnú tabuľku Ž1, do ktorej zaznačia, ktoré zariadenia po skočení ich funkčnosti by zaradili do elektroodpadu a ktoré nie. Do tabuľky Ž1 si poznačia aj tie odpady, ktoré nepatria medzi elektroodpady. Po vyplnení tabuľky diskutujú so spolužiakmi v skupine o elektroodpadoch. V rámci diskusie vymenujú všetky dôvody, prečo jednotlivé odpady patria/nepatria do elektroodpadov. Následne preveria, aké majú vedomosti o ďalšom spracovaní a využití odpadov z elektrických a elektronických zariadení.

Tabuľka Ž1: Čo zaraďujeme do odpadu z elektrických a elektronických zariadení a čo nie

Do elektroodpadu patria	**Do elektroodpadu nepatria**

Žiaci z literárnych zdrojov spracujú informácie o tom ako sa správne manipuluje s elektroodpadom.

Odpovedajú na otázku, *„Aké nebezpečné chemické látky (prvky, zlúčeniny) elektroodpady môžu obsahovať?"*. Svoje odpovede zapíšu do spoločnej tabuľky Ž2.

Tabuľka Ž2: Nebezpečné chemické látky (prvky, zlúčeniny) v elektroodpadoch

Žiarivky aj žiarovky	
Televízory a niektoré mobilné telefóny	
Batérie (veľké aj malé prenosné)	
Autobatérie	

Žiaci následne vyhľadajú vo svojom okolí miesta, kde sa nachádzajú nádoby na zber použitých batérií a poznačia si ich do pripravených mapových podkladov obce (okolia školy, sídliska, bydliska).

Úlohu C tvoria nasledovné položky: Žiaci informujú ďalšie skupiny, čo zistili v teréne ohľadne elektroodpadov. Spolu vytvoria kompletnú mapu obce s miestami, kde sú umiestnené nádoby na zber použitých batérií. Pripravia tabuľku so zistenými údajmi o tom, ktoré elektroodpady sa sústreďujú na zbernom dvore a čo nepatrí k elektroodpadom. Navrhnú možnosti ako predchádzať vzniku elektroodpadov, resp. ako znižovať množstvo elektroodpadov. Návrhy spíšu na veľký plagát. Poukážu na tie chemické látky nachádzajúce sa v elektroodpadoch, ktoré negatívne vplývajú na zdravie populácie a možnosti ako predchádzať ich hromadeniu.

Zo získaných informácii žiaci pripravia plagátovú výstavu s témou „*Kam s odpadom z elektrických a elektronických zariadení a prečo?*“. Plagátovú výstavu rozšíria o postupy spracovania a možnosti ďalšieho využitia chemických látok obsiahnutých v elektroodpadoch.

Prediskutujú najvhodnejšie umiestnenie nádoby na zber použitých batérií v školských priestoroch.

Úlohu D tvoria kontrolné otázky, na ktoré žiaci odpovedajú v rámci opakovania prebranej témy.

4 Záver

Aktuálne informácie o triedení elektroodpadov ukazujú, že táto vzdelávacia činnosť nie je v školách uspokojivá. Preto je potrebné zamerať dlhodobú pozornosť nielen na zvyšovanie teoretických vedomostí o elektroodpadoch, ale aj na ich ďalšie možnosti využitia, príp. využiteľnosti chemických látok, z ktorých sú zložené, alebo sú ich súčasťou. Prezentovaná téma e-learningového kurzu „*Kam s odpadom z elektrických a elektronických zariadení a prečo?*“ bola pripravená s cieľom osvojovania si nových poznatkov a s možnosťou ich ďalšieho využitia v praxi. Takáto znalostná základňa je otvorená pre nové metódy a postupy a v prípade e-learningového kurzu aj o možnosť plynulého doplňovania nových informácií a materiálov. Uvedený vývoj si vyžaduje aj nové prístupy ako zo strany pedagógov tak aj žiakov [12, 20 – 21]. V opísanej téme „*Kam s odpadom z elektrických a elektronických zariadení a prečo?*” sme zacielili naše úsilie na znižovanie množstva odpadov z elektrických a elektronických zariadení, ktoré vznikajú v domácnostiach a na školách; na odstránenie negatívnych vplyvov elektroodpadov na okolie a na problémy s ich odbúraním v prostredí. Každý z nás je povinný manipulovať s elektroodpadom spôsobom, ktorý neohrozuje zdravie ľudí a nepoškodzuje životné prostredie. Orientovali sme sa na zníženie rizika súvisiaceho s ohrozením zložiek životného prostredia (vody, ovzdušia, pôdy, horninového prostredia, rastlín a živočíchov) a nepriaznivého vplyvu na krajinu.

Je dôležité si *uvedomiť*, že vytriedený elektroodpad môže byť v určitých výrobných procesoch surovinou. Správne vytriedený elektroodpad je opätovne spracovaný a využitý. Môže sa použiť na výrobu nových výrobkov. Práve triedením s následnou recykláciou sa šetria prírodné zdroje a zásoby nerastných surovín [18]. Pokiaľ ide o výchovu a vzdelávanie zamerané na elektroodpad, existuje viacero možností ako zaujať žiakov a viesť ich tak k ochrane nielen životného prostredia, ale aj vlastného zdravia. Je dôležité, aby sme predovšetkým motivovali žiakov k triedeniu elektroodpadov a využitie IKT formou e-learningových kurzov má k tomu všetky predpoklady. Riaďme sa heslom: Dajme odpadu nový život!

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DZIAŁANIA NAUCZYCIELA A JEGO WIZERUNEK W OCZACHUCZNIÓW

Elżbieta Sałata, Karolina Szczęsna, PL

Streszczenie: Celem prezentowanych badań jest próba określenia jakie działania nauczyciela sprawiają, że jest on odbierany pozytywnie przez uczniów. Podstawą empiryczną prezentowanych analiz są badania empiryczne przeprowadzone na grupie uczniów klas wczesnoszkolnych. Przedmiotem analiz są opinie uczniów na temat nauczyciela, jego działań i posiadanych przez niego cech. Przedstawione wyniki pozwolą na ustalenie poprzez jakie działania nauczyciel może stać się widziany pozytywnie, a także czego powinien się wystrzegać w swojej pracy.

Słowa kluczowe: nauczyciel, uczniowie, wizerunek, działania.

TEACHER'S ACTIONS AND HIS IMAGE IN THE EYES OF STUDENTS

Abstract: The aim of the presented research is to try to determine what activities of the teacher make him / her perceived positively by students. The empirical basis of the presented analyzes is empirical research carried out on a group of early school students. The subject of the analysis are students' opinions about the teacher, his activities and the characteristics he possesses. The presented results will allow determining through what activities the teacher can be perceived positively, and what he should avoid in his work.

Keywords: teacher, pupils, image, activities.

1 WPROWADZENIE

Podczas pobytu dziecka w przedszkolu często nauczyciel staje się autorytetem, a zarazem najważniejszą osobą w jego życiu. Nasuwa się więc pytanie czy nauczyciel zdaje sobie sprawę z tego jak ogromna rola na nim spoczywa, czy jest świadomy jak szybko może stracić ten autorytet? Zawód ten przez wieki uważany był za jeden z najbardziej prestiżowych. Niestety, być może przez rewolucję technologiczną, której nagły wzrost można zaobserwować w ostatnich dekadach, zawód ten powoli traci swój prestiż. Według Zofii Żukowskiej – polskiej pedagog [1]: „nauczyciel to zawód i powołanie, to zdolności wrodzone i wyuczone, to odpowiedni zbiór cech osobowości temperamentu, to umiejętność poświęcania się dla dobra innych osób, to miłość do dzieci”.

Inną definicję nauczyciela ukazują Zbigniew Kwieciński i Bogusław Śliwierski [2], którzy nauczyciela traktują jako „towarzysza” podczas rozwoju dziecka. Nauczyciel według autorów ma pomagać podopiecznemu w rozwiązywaniu pojawiających się na jego drodze problemów. Ma też wpływać na osobowość i umiejętności dziecka, jednak nie jest gwarantem rozwoju zachowań jedynie pozytywnych u wychowanka. Na kształtowanie się obrazu nauczyciela w oczach dziecka niezaprzeczalnie wpływają działania nauczyciela, jak również posiadane przez niego cechy osobowości czy kompetencje [3]. Zwłaszcza dzieci w okresie przedszkolnym czy wczesnoszkolnym oceniają nauczyciela głównie patrząc na jego wygląd, cechy oraz podejście do dzieci. Dopiero w starszych klasach szkoły podstawowej, czy szkole średniej uczniowie bardziej cenią posiadane przez nauczyciela kompetencje i sposób przekazu wiedzy. Celem publikacji jest określenie działań nauczyciela sprawiających, że jest on odbierany pozytywnie przez uczniów.

1.1 Funkcje i zadania nauczycieli

W zawodzie nauczyciela istotnym elementem są wypełniane przez niego funkcje czy zadania jakie powinien pełnić. Niewątpliwie są one wyznacznikiem wizerunku nauczyciela w oczach nie tylko dzieci, ale też ich rodziców oraz innych nauczycieli. Próbę wyliczenia funkcji nauczyciela podejmuje Karolina Appelt [4]. Autorka wymienia następujące funkcje jakie pełni nauczyciel zarówno przedszkola jak i szkoły:

- funkcja dydaktyczna – jest związana z przekazywaniem podopiecznym wiedzy,
- funkcja wychowawcza – nauczyciel ma oprócz nauczania także wychowywać, czyli przekazywać pewne uniwersalne wartości, kształtować osobowość wychowanka,
- funkcja opiekuńcza – wsparcie, zapewnienie uczniom bezpieczeństwa, troska oraz zapewnienie warunków do optymalnego rozwoju.

K. Appelt zaznacza, iż funkcje te powinny się wzajemnie przenikać, a niewypełnienie którejkolwiek z powyższych funkcji powoduje, że efektywność działań nauczyciela spada. Na szczeblu edukacji przedszkolnej najważniejszą rolę pełni funkcja opiekuńcza. Natomiast dla dzieci starszych kluczową jest funkcja dydaktyczna, gdyż uczniowie ci nastawieni są przede wszystkim na przekaz wiedzy ze strony nauczyciela.

Omawiając funkcje, jakie pełni nauczyciel w swojej pracy, warto także wspomnieć o zadaniach jakie na nim spoczywają [5]. Stanowią one razem z funkcjami istotny element pracy nauczyciela, a co za tym idzie wpływają na kształtowanie się wizerunku nauczyciela w oczach dzieci. Jolanta Szempruch [6] zadaniami nauczyciela nazywa czynności, poprzez realizacje których nauczyciel wypełnia określone założenia. Jako kluczowe zadanie nauczyciela badaczka wymienia nauczanie. Natomiast kolejnymi, ale również ważnymi, zadaniami nauczyciela są:

- formowanie umiejętności społecznych,
- budzenie do samodoskonalenia,
- wyznaczanie ścieżki życiowej podopiecznym,
- współpraca ze środowiskiem lokalnym,
- ustawiczne relacje między nauczycielem, a rodzicami.

J. Szempruch oprócz powyższych zadań nauczyciela, wskazuje kolejne, nowe zadanie, które w ostatnich czasach wysuwa się na pierwszy plan, a mianowicie działania innowacyjne i kreatywne. Realizacja tego zadania ma sprostać współcześnie dynamicznie zmieniającej się rzeczywistości edukacyjnej. Wypełnienie tych wszystkich zadań sprawia, że nauczyciel będzie pozytywnie widziany przez innych oraz przyczyni się do sukcesów podopiecznych.

Sally Brown i Phil Race [7] za dwa główne zadania stawiane nauczycielowi uważają określony sposób nauczania oraz wychowanie człowieka do życia w społeczeństwie. Sposób nauczania wiąże się z profesjonalizmem. Nauczyciel powinien być profesjonalistą w swej pracy, winien działać tak, by stale się doskonalić [8]. Autorki nadmieniają, iż jakość wykonywanych przez nauczyciela zadań zależy w znacznym stopniu od jego samooceny. S. Brown i P. Race stwierdzają, że wyższa samoocena przyczynia się do większych sukcesów edukacyjnych uczniów. Z kolei Caroline Gipps, Bet McCallum, Eleanore Hargreaves, [9] za najważniejsze zadanie nauczyciela we współczesnym świecie uważają umiejętność stawiania uczniowi pytań pobudzających go do myślenia oraz zachęcających do sprawdzenia swoich pomysłów. Pytania te to m.in.: „Co mógłbyś teraz zrobić?", „Co się stanie jeżeli zrobisz to w taki sposób?". Zadanie to ma sprawić, że uczeń w przyszłości będzie sam poszukiwał rozwiązań, gdy napotka na swojej drodze jakieś przeszkody, stanie się odważny. Będzie chętny do realizacji swoich planów i marzeń. Na przestrzeni ostatnich latach prowadzonych było wiele badań na temat nauczyciela i jego opinii wśród uczniów. Jak się okazuje nie ma jednoznacznej odpowiedzi co robić, aby stać się wzorowym nauczycielem, którego wszyscy uczniowie będą darzyć jednakową

sympatią i szacunkiem. Dzieje się tak być może dlatego, że współczesny świat coraz szybciej się rozwija, pojawiają się coraz to nowe wzorce, a młodzież często utożsamia się z osobami, które są autorytetami na portalach społecznościowych czy blogach.
Martyna Probachta i Karolina Sławińska [10] podejmują próbę zaprezentowania sylwetki wymarzonego nauczyciela powołując się na własne badania przeprowadzone wśród dzieci klas II oraz VI. Autorki dokonując analizy rysunków dzieci 8-letnich, przedstawiających wymarzonego nauczyciela stwierdzają, że dobry nauczyciel jest zawsze przedstawiany jako wesoły. Często dzieci zwracają uwagę czy nauczyciel ma poczucie humoru i potrafi żartować. Autorki pytając dzieci uczęszczające do klasy VI, o ich wymarzonego nauczyciela usłyszały, że ma on być pogodny.
Anna Klim-Klimaszewska również w swoich badaniach przedstawia działania nauczyciela sprawiające, że staje się on lubiany przez uczniów [11]. Autorka koncentruje się na sześciolatkach. Dzieci te zwracają uwagę na wygląd swojej pani. Przy ocenie biorą też pod uwagę czy pani jest „dobra", cierpliwa oraz czy jest wesoła i często się śmieje.

Warto więc się zastanowić co można nazwać obrazem czy wizerunkiem nauczyciela. Stanisław Korczyński [12] określa tak wszystkie jednostronne poglądy danej jednostki na temat nauczyciela, które tworzą się mimo pewnej zmienności zachowywania się nauczyciela. Jak twierdzi autor, wizerunek ten wykształca się przez relacje panujące w społeczeństwie.

2 ZAŁOŻENIA METODOLOGICZNE I CHARAKTERYSTYKA BADANEJ PRÓBY

Celem podjętych badań było ustalenie co przyczynia się do formowania się obrazu nauczyciela w oczach uczniów. Priorytetem było poznanie jakie działania nauczyciela sprawiają, że jest on lubiany przez uczniów, a także wskazanie jakie czynniki wpływają na kształtowanie się negatywnego obrazu nauczyciela w oczach dzieci. W badaniach skupiono się na grupie dzieci klas I-III, ponieważ dla tej grupy nauczyciel odgrywa istotną role w procesie nauczania.
W związku z powyższym celem sformułowano następujące pytania badawcze:

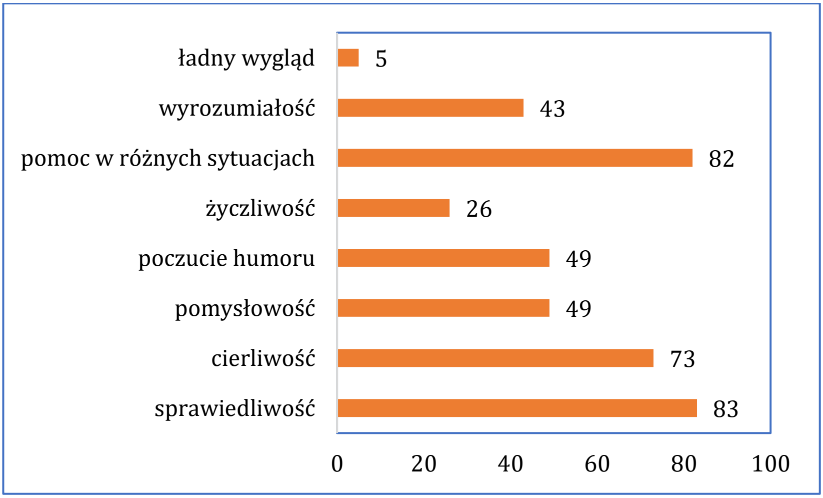
1. Jaki obraz nauczyciela funkcjonuje w oczach dzieci klas I-III?
2. Jakie działania nauczyciela wpływają na jego pozytywny wizerunek w oczach dzieci?
3. Czy wszystkie dzieci postrzegają swojego nauczyciela pozytywnie?
4. Czy aparycja nauczyciela wpływa na postrzeganie go przez uczniów?
5. Czy osiągnięcia w nauce dziecka przyczyniają się do tworzenia pozytywnego obrazu nauczyciela?
6. Jakie cechy nauczyciela są cenione przez uczniów?

Metodą badawczą, którą zastosowano w niniejszej pracy była metoda sondażu diagnostycznego. Metoda ta zobrazowała jak postrzegany jest nauczyciel przez dzieci klas I-III oraz ukazała jakie działania nauczyciela kształtują jego wizerunek. Analizie badawczej poddane zostały wypełnione przez uczniów online kwestionariusze ankiety własnej konstrukcji. Przeprowadzone badania miały charakter ilościowy. W badaniach wzięło udział 105 uczniów, w tym 39 uczniów klasy pierwszej, 17 klasy drugiej oraz 49 klasy trzeciej szkół podstawowych. Do badań przystąpili uczniowie Szkoły Podstawowej im. Kornela Makuszyńskiego w Natolinie, Publicznej Szkoły Podstawowej im. Żołnierzy Armii Krajowej 72 Pułku Piechoty w Mniszku oraz Publicznej Szkoły Podstawowej im. Marii Konopnickiej w Mazowszanach. Do badań przystąpiło 50 dziewcząt oraz 55 chłopców.

3 Badania własne

Pierwszy problemem badawczy dotyczył tego jaki obraz nauczyciela funkcjonuje w oczach dzieci klas I-III. Dzieci odpowiadały na pytanie czy lubią swojego nauczyciela. Zadowalające jest, że aż 99% badanych stwierdza, że swojego nauczyciela darzy sympatią. Tylko jeden z uczniów oznajmia, że nie lubi swojego nauczyciela. Takie wypowiedzi mają znaczący wpływ na obraz nauczyciela jaki funkcjonuje w oczach uczniów. Uczeń, który odpowiedział, że nie lubi swojego nauczyciela miał również za zadanie wyjaśnić co jest tego powodem. Oto co napisał: „Pani krzyczy, mało się uśmiecha”.
Odpowiedzi na następne pytanie badawcze dotyczyły działań nauczyciela sprawiających, że jest on lubiany przez uczniów. Najpierw zapytano jakie zachowania nauczyciela wpływają na jego wizerunek w oczach uczniów. Respondenci mieli wybrać dwa określenia z czterech podanych oraz dopisać swoje propozycje.

W ocenie dzieci klas wczesnoszkolnych ich nauczyciel jest najczęściej pomocny – 95 wyborów oraz wesoły – 93 wybory. Te właśnie działania przyczyniają się do tego, że nauczyciel jest lubiany przez uczniów. Zastanawiający jest fakt, że aż czworo badanych potwierdziło, że ich nauczyciel jest czasami krzykliwy. Dodatkowo dzieci zaznaczały odpowiedź, że ich nauczyciel jest troskliwy, cierpliwy i wolno się denerwuje. Pocieszający jest fakt, że określenia te są pozytywne, a pogodne usposobienie i dobry humor u nauczyciela sprawia, że jest on dobrze oceniany przez uczniów.
Kolejny problem badawczy był pytaniem najistotniejszym, gdyż miał pokazać jakie działania nauczyciela sprawiają, że jest on darzony sympatią przez podopiecznych. Badani uczniowie mieli do wybory kilka odpowiedzi. Mogli zaznaczyć trzy odpowiedzi spośród siedmiu oraz napisać własne propozycje. Odpowiedzi przedstawia poniższy wykres.



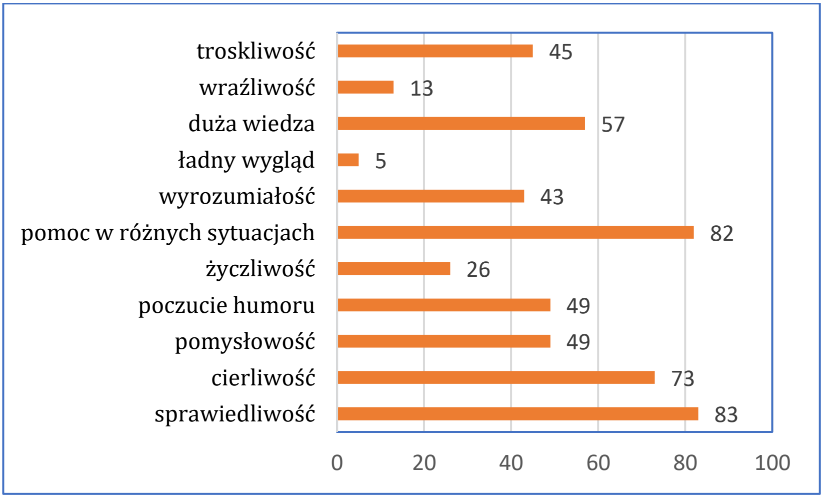
Wykres nr 1. Działania nauczyciela sprawiające, że uczniowie go lubią
Źródło: Badania własne

Dobre tłumaczenie (75 wyborów) treści niezrozumiałych okazało się działaniem, które najbardziej przyczynia się do tego, że dzieci darzą sympatią swojego nauczyciela. Również ważnym poczynaniem nauczyciela, które pomaga w zyskiwaniu sympatii u wychowanków jest prowadzenie ciekawych lekcji – 74 głosy. Uczniowie klas wczesnoszkolnych licznie wybrali też pomoc nauczyciela gdy zachodzi taka potrzeba (73 wybory) jako działanie wpływające pozytywnie na wizerunek nauczyciela. Sprawiedliwe ocenianie (44) stanowiło wszystkich zaznaczanych odpowiedzi jest więc to też kolejna czynność, która wpływa na sympatię u wychowanków. Po 22 razy badani deklarowali, że poczucie humoru i częsty uśmiech oraz zabieranie na wycieczki i spacery również skutkuje pozytywnym podejściem do nauczyciela. Jedno dziecko oznajmiło, że życzliwość względem dzieci stanowi właśnie działanie, które sprawia, że uczniowie lubią nauczyciela. Działania te są więc głównymi wytycznymi do tego jak ma postępować nauczyciel względem dzieci tak, aby być przez nie lubianym. Nauczyciele powinni więc zwracać uwagę na swoje czyny oraz podejście do uczniów, a wtedy prawdopodobnie staną się lubiani, a może nawet zyskają miano autorytetu.

Analizując prowadzone dotychczas przez innych badaczy badania na temat wizerunku nauczyciela można stwierdzić, że wygląd nauczyciela również ma znaczenie w ocenie obrazu nauczyciela w oczach uczniów. W niniejszej pracy również postawiono takie pytanie badawcze. Respondentów zapytano czy wygląd swojego nauczyciela ma wpływ na jego postrzeganie. Okazało się, że prawie 1/5 ankietowanych (20 uczniów) sądzi, że aparycja nauczyciela wpływa na jego wizerunek. Pozostałe 4/5 badanych - 85 dzieci oznajmia, że wygląd nauczyciela nie przyczynia się na jego postrzeganie przez innych. Nasuwa się wniosek, że nauczyciele powinni dbać o swój wygląd i ubiór, gdyż niektóre dzieci zwracają uwagę na te elementy.

Również często wysokie osiągniecia w nauce sprawiają, że nauczyciel darzony jest większą sympatią. Z tym twierdzeniem łączył się kolejny problem badawczy. Zapytano więc uczniów jak oceniają swoje osiągnięcia w nauce tak, aby zbadać czy wyniki w edukacji wpływają na wizerunek nauczyciela. 84,8 % ankietowanych (89) swoje osiągnięcia w nauce ocenia jako dobre. 16 uczniów czyli 15,2 % uważa, że wyniki w nauce uzyskuje średnie. Żadne z dzieci nie sądzi, że jego wyniki w nauce są złe. Prowadzone badania korespondują z badaniami prowadzonymi przez Bożenę Żuk. Autorka [13] na podstawie prowadzonych badań wśród uczniów klas I-III wylicza co sprawia, że nauczyciel jest dobrze widziany przez uczniów. Najważniejszym czynnikiem okazało się prowadzenie uczniów do sukcesów edukacyjnych oraz wysokie wyniki uzyskiwane przez badanych. Wyniki przedstawione na diagramie powinny więc przyczyniać się do postrzegania nauczyciela przez uczniów klas I-III pozytywnie.

Ostatni problem badawczy dotyczył cech najbardziej cenionych u nauczyciela. Respondenci wybrać mogli pięć najbardziej pożądanych cech oraz dopisać własne propozycje. Odpowiedzi te miały ukazać jakimi cechami powinien odznaczać się nauczyciel, aby był postrzegany pozytywnie.



Wykres nr 2. Najważniejsze cechy u nauczyciela
Źródło: Badania własne

Analizując powyższy wykres zauważyć można zróżnicowanie odpowiedzi. Cechy, które są najbardziej cenione u nauczyciela przez dzieci to sprawiedliwość (83 odpowiedzi) i pomoc w różnych sytuacjach (82 odpowiedzi). Kolejno badani wybierali cierpliwość (73 odpowiedzi). Aż 57 uczniów uważa, że wiedza posiadana przez nauczyciela jest istotna. Kluczowe dla ankietowanych cechy, którymi powinien odznaczać się nauczyciel (powyżej 40 wyborów) to pomysłowość, poczucie humoru, troskliwość, a także wyrozumiałość. Mniej cenioną cechą jest życzliwość – 26 odpowiedzi. Cechą, która jest najmniej znacząca w zawodzie nauczyciela okazał się ładny wygląd (5 wyborów). Wyniki są więc podobne do tych przedstawionych przez innych badaczy w poprzedniej części pracy. Takimi badaniami zajmowała się też m.in. Małgorzata Głoskowska-Sołdatow [14]. Autorka zaznaczała, podobnie jak powyższy wykres, że sprawiedliwość i wyrozumiałość uczniowie u nauczyciela cenią najbardziej.

Reasumując stwierdzić można, że aparycja nauczyciela ma znaczenie tylko dla niewielkiej grupy uczniów. Dla dzieci liczą się głównie posiadane cechy nauczyciela takie jak sprawiedliwość, pomoc czy cierpliwość. Cechy te sprawiają, że nauczyciel staje się pozytywnie widziany przez uczniów, a to przyczynia się do całościowego pozytywnego postrzegania nauczyciela.

4 ZAKOŃCZENIE

Podsumowując powyższe rozważania zawód nauczyciela to nie tylko powołanie, ale i wielki obowiązek oraz odpowiedzialność. Nauczyciel ma przede wszystkim nauczać, ale również wychowywać. Nauczyciel poprzez swoje działania kształtuje swój wizerunek w oczach innych. Kluczowe są cechy posiadane przez nauczyciela, które wpływają w znacznym stopniu na proces nauczania-uczenia się i jego efekty. Artykuł ten miał pomóc ustalić jakie działania nauczyciela sprawiają, że jest on mniej lub bardziej lubiany przez uczniów.

Zaprezentowane w niniejszym artykule dane nie pozwalają na uogólnienia, jednakże mogą stanowić podstawę dla pogłębionych analiz tego zjawiska na reprezentatywnej populacji. Można natomiast wysnuć wniosek dotyczące badanej grupy. W wyniku przeprowadzonych badań okazało się, że istnieje szereg czynników sprawiających, że nauczyciel jest postrzegany raczej pozytywnie. Okazało się, że wizerunek nauczyciela kształtują posiadane cechy, działania, które realizuje podczas swojej pracy oraz poprzez podejście do ucznia. Pomoc dzieciom oraz wesołe usposobienie nauczyciela sprawia, że jest on pozytywnie postrzegany. Także dobre tłumaczenie niezrozumiałych treści okazało się działaniem, które najbardziej przyczynia się do tego, że dzieci darzą sympatią swojego nauczyciela. Kolejnym działaniem, które wpływa na wizerunek nauczyciela w oczach podopiecznych jest prowadzenie ciekawych lekcji. Wymienione działania, a także posiadanie cech takich jak sprawiedliwość i cierpliwość pomaga w kształtowaniu pozytywnego obrazu nauczyciela w oczach najmłodszych. Warto więc uważać na to w jaki sposób podchodzi się do ucznia oraz jago problemów, gdyż szybko można stracić w oczach uczniów. Zaprezentowana problematyka badań nie jest wyczerpująca, gdyż prawdopodobne jest, że wynik badań mógłby być inny w zależności od liczebności grupy badawczej oraz jej wieku. Możliwe, ze uczniowie klas starszych inaczej ocenili by swojego nauczyciela. Warto nieustannie obserwować czy postrzeganie nauczyciela przez dzieci zmienia się i jakie są tego przyczyny.

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VYUŽÍVANIE INTERAKTÍVNYCH DIDAKTICKÝCH APLIKÁCIÍ VO VÝUČBE

Ildikó PŠENÁKOVÁ, Milan ŠTRBO, SK

Abstrakt: Tvorba interaktívnych učebných materiálov a ich následné využívanie v pedagogickej praxi nie je jednoduchá úloha. Mnohí učitelia nevyužívajú interaktívnu tabuľu len preto, lebo je nedostatok dostupných interaktívnych vzdelávacích materiálov a oni nie sú schopní si vytvoriť sami. V rámci projektu KEGA sme realizovali prieskum, ktorý mal za úlohu zmapovať situáciu v používaní interaktívnej tabule a využívania interaktívnych didaktických aplikácií vo vyučovacom procese na základných a stredných školách na Slovensku. V článku prinášame niektoré jeho výsledky.

Kľúčové slová: interaktivita, učebný materiál, interaktívna tabuľa, dotazník, prieskum

USE OF INTERACTIVE DIDACTIC APPLICATIONS IN TEACHING

Abstract: The creation of interactive teaching materials and their subsequent use in pedagogical practice is not an easy task. Many teachers do not use the interactive whiteboard simply because there is a lack of available interactive educational materials, and they are unable to create them themselves. As part of the KEGA project, we conducted a survey, which aimed to map the situation in the use of interactive whiteboards and the use of interactive didactic applications in the teaching process at primary and secondary schools in Slovakia. In this article we present some of its results.

Keywords: interactivity, teaching materials, interactive whiteboard, questionnaire, survey

1 Úvod

Tvorba interaktívnych učebných materiálov, didaktických aplikácií a vedomostných testov aj napriek tomu, že na ich prípravu sú pre pedagógov k dispozícii rôzne podporné programové balíky, nie je jednoduchá úloha. Mnohí učitelia nevyužívajú interaktívnu tabuľu len preto, lebo je nedostatok dostupných interaktívnych vzdelávacích materiálov a oni nie sú schopní vytvoriť kvalitný, didakticky aj metodicky správny interaktívny materiál [1].

V rámci projektu KEGA č. 015TTU-4/2018, ktorého riešenie bolo naplánované na tri roky, ale vzhľadom na vzniknutú pandemickú situáciu v roku 2020 bol ukončený až v roku 2021, sme realizovali prieskum, ktorý mal za úlohu zmapovať situáciu v používaní interaktívnej tabule a využívania interaktívnych didaktických aplikácií vo vyučovacom procese.

Nakoľko využívanie interaktívnych pomôcok závisí predovšetkým od pedagóga, zamerali sme sa preto na získanie informácií hlavne od učiteľov základných a stredných škôl na Slovensku.

2 Prieskum využívania interaktívnych didaktických aplikácií

Prieskum bol realizovaný v priebehu rokov 2018-2019. Zber údajov sa uskutočnil podľa plánu projektu v rámci Trnavského a Nitrianskeho kraja, a vďaka kolektívu riešiteľov bol rozšírený aj v Žilinskom kraji Slovenskej republiky.

2.1 Cieľ a zameranie prieskumu

Hlavným cieľom prieskumu bolo zistiť súčasný stav využívania interaktívnych tabúľ a interaktívnych (elektronických) didaktických aplikácií na základných a stredných školách.

Zamerali sme sa aj na zistenie, z akých vyučovacích predmetov alebo tematických celkov učiva chýbajú učiteľom vhodné interaktívne materiály, ktoré by mohli využívať vo vzdelávaní. Tieto výsledky nám mali pomôcť pri výbere náplne vytváraných interaktívnych materiálov, čo bolo tiež jednou z úloh projektu.

2.2 Metóda prieskumu – dotazník

Na splnenie cieľa prieskumu sme ako výskumnú metódu zvolili dotazník. Dotazník, ako výskumný nástroj, patrí medzi najčastejšie používané výskumné metódy. Používa sa predovšetkým v spoločenských vedách na hromadné a hlavne rýchle zisťovanie faktov, postojov, názorov, hodnôt, preferencií, motívov, záujmov, potrieb a iného.

Dotazník bol vypracovaný v elektronickej podobe, nakoľko rozšírenie počítačov a moderných technológií a celosvetový prístup na internet, uľahčuje a zjednodušuje dostupnosť respondentov. Okrem toho dotazník v elektronickej podobe je možné posielať napríklad aj pomocou e-mailu, čo je veľkou výhodou pre výskumníka, pretože mu šetrí čas a taktiež je výhodou, že on samotný nemusí byť prítomný pri vypĺňaní dotazníka. Elektronická podoba dotazníka umožňuje aj rýchlejšie a ľahšie vyhodnotiť a zhrnúť jeho výsledky. V súčasnosti sa väčšina dotazníkových výskumov realizuje prostredníctvom elektronických dotazníkov [2].

Dotazník vytvorený v rámci projektu bol realizovaný ako webový dotazník. Podstatnou výhodou webového dotazníka je, že je synchrónny, čo znamená, že odpovede respondentov sa priamo prenášajú do databázy, ktorú vytvoril výskumník. Webový dotazník môže vyplniť každý, kto sa na webovú stránku dostane.

Za účelom získania údajov do nášho prieskumu bol dotazník vytvorený prostredníctvom internetovej stránky https://docs.google.com/forms. Odkaz na dotazník bol rozposlaný prostredníctvom e-mailov na jednotlivé školy, čo predstavovalo najjednoduchší spôsob ako zozbierať čo najviac údajov, ale bol šírený aj pomocou sociálnych sietí.

Dotazník bol anonymný a obsahoval deväť otázok, pričom nie na všetky bolo povinné odpovedať. Obsahoval otvorené otázky s nutnosťou dopísať odpoveď, zatvorené otázky, ktoré mali vopred stanovené alternatívy odpovedí a polouzavreté, ktoré ponúkali respondentovi vybrať odpovede alebo/aj dopísať vlastnú odpoveď. Dotazník obsahoval aj priestor na prípadné pripomienky a komentáre zúčastnených respondentov.

3 Vyhodnotenie odpovedí na otázky dotazníka

Dotazník vyplnilo 148 respondentov, z ktorých sme vo vyhodnotení použili 110, nakoľko ostatné neobsahovali všetky relevantné odpovede, alebo boli vyplnené nezodpovedne. Výsledky elektronického dotazníka nie sú hodnotené podľa veku či pohlavia učiteľov.

Prvou otvorenou otázkou: „Aká je Vaša aprobácia?“ sme zisťovali kombináciu predmetov, ktoré zúčastnení učitelia študovali. Otázka nebola povinná, preto nie všetci respondenti na ňu odpovedali (Tabuľka 1). Ako dobre vieme, nie na každom predmete sa dá pracovať s interaktívnou tabuľou, aj keď vieme si predstaviť, že aj teória z telesnej výchovy sa dá vyučovať pomocou interaktívnych elektronických materiálov, ale nie je to práve vhodný spôsob výučby telocviku na základných a stredných školách. Výsledok bol pre nás zaujímavý v porovnaní s výsledkami iných otázok dotazníka.

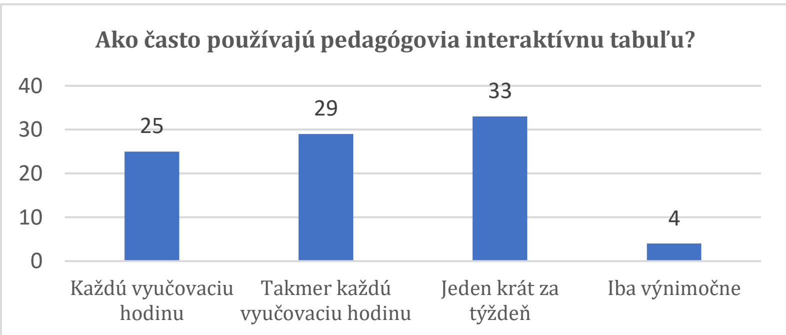
Nie je neznámym faktom, že pedagógovia vo svojom vyučovacom procese často nevyužívajú skutočný potenciál interaktívnej tabule, alebo ju používajú len ako premietacie plátno [3]. Na otázku: „*Využívate na Vami vyučovaných predmetoch interaktívnu tabuľu (inak ako len* *premietacie plátno)?"* odpovedalo 82 % respondentov kladne, na základe čoho môžeme konštatovať, že naše školstvo sa modernizuje a učitelia skvalitňujú spôsoby sprostredkovania učebnej látky žiakom.

Tabuľka 1: Aprobácia pedagógov zúčastnených prieskumu

Otázka: ***Aká je vaša aprobácia?***			
Odpoveď	*Počet*	*Odpoveď*	*Počet*
Slovenský jazyk	7	História, dejepis	5
Cudzie jazyky	32	Náboženstvo, etická výchova	2
Matematika	10	Telesná výchova	3
Fyzika	5	Hudobná výchova	5
Informatika	26	Výtvarná výchova	1
Biológia	5	Odborné predmety	7
Chémia	3	1. stupeň základnej školy	30
Geografia	1		

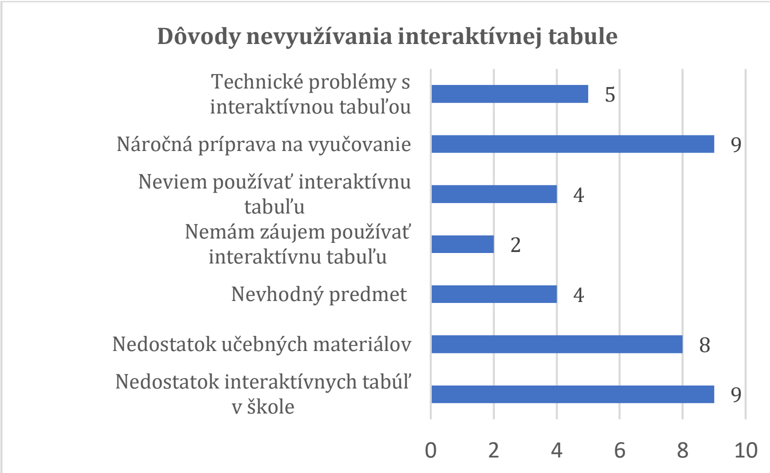
Po kladnej odpovedi na predchádzajúcu otázku sme chceli vedieť: *„Ak áno, ako často?"* Boli ponúknuté štyri možné odpovede, pričom tri boli uzavreté a jedna otvorená. Odpovede na otvorenú otázku sme opäť kategorizovali z dôvodu podobnosti odpovedí.

Na základe odpovedí sme mohli konštatovať, že interaktívnu tabulu využívajú učitelia na svojich vyučovacích hodinách v dostatočnej miere.



Graf 1: Používanie interaktívnej tabule z časového hľadiska

Zaujímali nás aj dôvody, prečo pedagógovia nevyužívajú interaktívnu tabuľu počas vyučovania. Respondenti si mohli vyberať z ponúknutých odpovedí alebo napísať vlastnú (Graf 2). Žiaľ, z odpovedí vyplynulo aj to, že na niektorých školách je ešte stále nedostatok interaktívnych tabúľ.

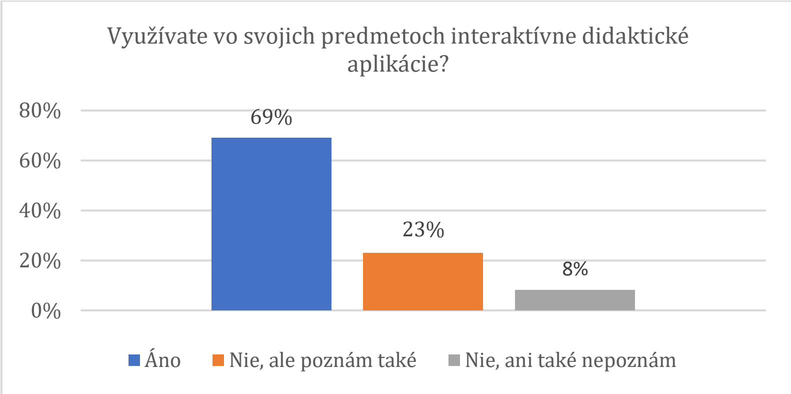


Graf 2: Problémy pri práci s interaktívnou tabuľou

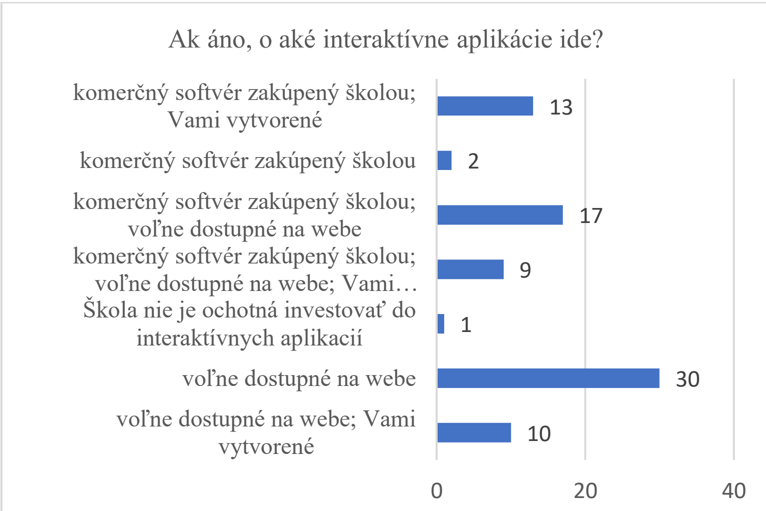
Na základe získaných údajov z dotazníka sme zistili, že tí ktorí nevyužívajú interaktívnu tabuľu (aj inak ako len premietacie plátno) boli prevažne učitelia prvého stupňa základných škôl a ako dôvod uviedli zložitú prípravu učebného materiálu na vyučovaciu hodinu. Problémy týkajúce sa tvorby učebného materiálu a nedostatku vhodného učebného materiálu uvádzajú aj učitelia humanitných vied ako je slovenského alebo cudzieho jazyka.

Na druhej strane z odpovedí respondentov na otázku „*Využívate vo svojich predmetoch interaktívne didaktické aplikácie?*“ (Graf 3) môžeme konštatovať, že interaktívne didaktické aplikácie sa postupne dostávajú do povedomia učiteľov a stávajú sa súčasťou vyučovacieho procesu.

Zisťovali sme aj to, konkrétne aké a z akých zdrojov využívajú interaktívne didaktické aplikácie učitelia. Z odpovedi vyplýva (Graf 4), že väčšina učiteľov je odkázaná na používanie aplikácií na webových stránkach alebo na používaní komerčného softvéru zakúpeného školou. Len málo učiteľov si interaktívne aplikácie vytvára. Je pravdepodobné, že dôvodom môže byť samotná náročnosť prípravy a tvorby interaktívnych didaktických aplikácií. Respondenti nemuseli odpovedať na túto otázku, v prípade odpovede si však mohli vybrať z viacerých odpovedí. Na grafe 4 sme znázornili ich kombinácie.



Graf 3 : Využívanie interaktívnych didaktických aplikácií



Graf 4: Typy používaných interaktívnych aplikácií

Na otázku: *„Zvýšilo používanie interaktívnych aplikácií atraktivitu Vášho predmetu u žiakov*?" až 83 % respondentov odpovedalo kladne, čo potvrdzuje efektivitu využívania interaktívnej didaktickej aplikácie počas vyučovania a jej pozitívny vplyv na atraktivitu predmetu z pohľadu žiakov.

Odpovede na otázku, ktorá sa týkala vytvárania pedagógmi vlastných interaktívnych aplikácií alebo interaktívneho učebného materiálu nás nepotešili, ale v podstate sa potvrdil náš predpoklad, pretože len 35 %

pedagógov odpovedalo kladne, zvyšných 65 % si ešte nevytvárali učebný materiál vhodný na prácu na interaktívnej tabuli.

Otázka, na základe ktorej sme chceli získať a zostaviť zoznam tematických celkov, z ktorých chýba interaktívny učebný materiál, nesplnila svoj účel bezvýhradne. Dôvodom bolo, že učitelia väčšinou neuvádzali tematický celok učiva alebo konkrétnu tému, alebo uviedli len predmet, v ktorom by uvítali takýto materiál. V odpovediach je badateľná korelácia s predmetovou aprobáciou pedagógov, ktorí sa zúčastnili prieskumu. Je evidentné, že každý pedagóg uviedol ním vyučovaný predmet. Zároveň z odpovedí je viditeľné aj to, že v podstate dostupné interaktívne aplikácie chýbajú prakticky z každého predmetu, v ktorých je dôležitá názornosť a precvičovanie.

4 Výsledky prieskumu

Uskutočneným dotazníkovým prieskumom sme získali údaje, ktoré vykazujú aktívne používanie interaktívnych tabúľ a interaktívnych didaktických aplikácií pedagógmi, počas jednotlivých vyučovacích hodín. Toto pozitívne zistenie poukazuje na aktívnu modernizáciu školstva, čo sa týka úspešného zavádzania, ale hlavne využívania informačno–komunikačných technológií vo vyučovacom procese.

Zistili sme, že učitelia stále v niektorých prípadoch ešte pozorujú nedostatočné vybavenie základných škôl interaktívnymi pomôckami, čo má za následok neplnohodnotné využívanie interaktívnej techniky.

Na základe odpovedí učiteľov sme zistili aj to, že nie každá škola kupuje pre svojich pedagógov aj interaktívny softvér k interaktívnej tabuli a nie všetci učitelia sú schopní vytvárať interaktívny didaktický materiál sami. V týchto prípadoch veľká väčšina učiteľov využíva interaktívne didaktické aplikácie, ktoré sú voľne dostupné na internete.

Rovnako výsledky prieskumu ukázali, že učitelia privítajú interaktívny učebný materiál a interaktívne aplikácie prakticky v každom vyučovacom predmete.

5 Záver

Technická úroveň vybavenia na našich základných a stredných školách sa zlepšuje, preto si myslíme, že je dôležité, aby sa technické prostriedky a zariadenia správne a v dostatočnej miere využívali. K tomu sú potrební v prvom rade vhodne vzdelaní pedagógovia, ktorí s nimi vedia pracovať a sú dostatočne motivovaní na ich využívanie v pedagogickom procese.

Výsledky z dotazníka jednoznačne ukazujú, že učitelia z praxe majú záujem o tvorbu interaktívnych elektronických vzdelávacích materiálov.

Ak budúci pedagógovia už počas svojho štúdia získajú vedomosti z oblasti ako tvoriť a využívať interaktívne učebné materiály a osvoja si zručnosti práce s interaktívnou tabuľou, stanú sa z nich plnohodnotní učitelia, ktorí tieto nadobudnuté kompetencie budú využívať vo svojej praxi, čo je naším cieľom.

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SUMMARY OF FOREIGN RESEARCH FOR THE USE OF INTERACTIVE WHITEBOARDS (IWBS)

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Abstract: Electronic interactive whiteboards are an effective way to introduce electronic content and multimedia materials into the learning process. It provides great opportunities to use the visibility of the material, quick search for additional information (with direct access to the Internet), creative approach to foreign language classes. There are also various online whiteboards available for remote learning that allow digital collaboration imitating the interactive whiteboard in the classroom. The aim of this article was to provide an overview of foreign research on the use of IWBs in the teaching process.

Keywords: Interactive whiteboards (IWBs), teaching process.

1 Introduction

Interactive whiteboards (IWBs) are being integrated into many classrooms these days. Nowadays we can say that these Interactive whiteboards are commonly used in a mass scale around the globe. Common themes on whiteboards include effects on perception, motivation, attention, behaviour, level of interaction between student, teacher, and IWB, learning, pedagogy, and achievement. There is a sense that this tool may offer considerable potential to enhance student learning. Promoters of the tool provide case studies of the novelty and support that can be achieved through the clever use of the tool. Early evidence suggests that IWBs can have a positive effect on teaching and learning, however, much of this evidence is not supported, or based on case studies making it difficult to generalize. Many people, including teachers, parents, experts, researchers, etc., also suggests that IWBs are used to reinforce current didactic teaching practices, as teachers can easily use them as a blackboard replacement on a global scale. Speaking of use of IWBs, there is clearly a expectation of how will teachers, students, parents and public react to this kind of tool. For more than 100 years of using basic chalk boards, and being used to this type of boards, today we can meet with different opinions from many perspectives. There are still people preferring chalk boards, with attitude that IWBs have negative impact on education processes and students. We are talking about students mainly from primary and high school where attitudes to using this kind of tool may vary. Although public and representatives of education expect that IWBs may be beneficial, it's not always like that. We can expect positive or either negative responses from different sides of view from now to upcoming years. Those responses may help with further producing of IWBs and their improvements to prevent future negative responses or even complete elimination of them.

2 IWBs vs. Traditional blackboards in Education system

Interactive whiteboards are gradually replacing traditional blackboards and whiteboards in classrooms all across the world. Their benefits are efficient not just for students, but also for teachers. More teachers have dropped the chalk to teach with a mouse, stylus, and a swipe of their index finger on touch screens of whiteboards. With interactive whiteboards, it has become possible to incorporate high-definition images, video and graphics into lessons. This has made it easier for difficult concepts to be explained to students in a visual manner, keeping them more engaged in class sessions. Static chalkboards and paper-based lessons don't connect with students in the digital age [1]. Teachers forced to rely on chalk to reach students are doomed to fail. Forcing lessons into lectures or on chalkboards in the classroom will lead students to tune out before the class starts. The multimedia stimuli presented to students learning from an interactive whiteboard are on a different level to those in a classroom relying on a traditional blackboard [2].

2.1 Presenting content and displaying student projects

With interactive whiteboards, student projects can be displayed on a big screen for receiving and review by the class. This has a positive effect on the psyche of the student body, creating a sense of community, competition and engagement [1]. With traditional blackboards, a separate arrangement for projection systems and projection screens must be made to display information of this kind. Even with an overhead projector it is hard to make a truly engaging atmosphere [3]. The whiteboard shouldn't replace teaching or lecture time in the classroom. Instead, it should enhance the lesson and provide opportunities for students to better engage with the information. The teacher has to prepare additional materials that can be used with the smart technology before class starts – such as short videos, infographics, or problems the students can work on using the whiteboard [4].

2.2 Improved collaboration and interaction among students

The best interactive whiteboard solutions, make collaboration among classroom participants simpler than ever before. They allow annotations, manipulation of content, surveys, connection through smartphones and so much more. A traditional blackboard limits collaboration as only one individual can realistically use the board effectively at any given time [5]. It is also difficult to make annotations or add new content without wiping off the old content. A blackboard or static whiteboard can be a very good basic sketch pad, but without the ability to share information, and really interact with the content, far from reaching the IWB [6]. With the smartboard technology as the center of the lesson, students can better collaborate in the classroom. The digital technology unlocks the internet as they work, allowing students to connect the lesson to technology they use every day [7].

2.3 Highlights of important information from the lesson

Smart technology can be used to highlight essential information as students work through a lesson. Before the lesson begins, the sections that will be covered during the class can be outlined. As each section begins, we can break down the key topics, definitions, and critical data for students on the whiteboard [7]. This can also include graphics and videos in addition to text. This will help students not only with note taking, but also to review future topics you will be covering [1].

2.4 Answering student questions

Engaging the students using the interactive whiteboard and questions from the class. We can look up for additional information or data using smart technologies. Question can be written on the whiteboard and then the teacher can work through the answers with the students. Let them see how the teacher answer the question or pull in additional data. When the teacher is finished, the results of the questions can be saved and sent to the student via an email for later reference [5].

For teachers and students, the interactive white board is a powerful benefit to the classroom. It opens up the students to collaboration and closer interaction to the lessons. For schools struggling to connect students to classroom lessons, or keep students engaged, smart technology like interactive whiteboards is an ideal solution. An interactive whiteboard in the classroom provides students with the technology they know and understand. It enhances collaboration and invites interaction with the lesson. Afterwards, students can see how the technology they use connects to the lessons they learn in school.

2.5 How IWBs work

Every interactive whiteboard system requires three basic components: a computer, projector and the interactive whiteboard. To use it, the projector is connected to both the computer and IWB so that the document or media opened on the computer is displayed for the audience on the screen. In contrast to previous conventional computer and projector setups, the user controls the IWB directly from the surface of the screen either by using the special pens accompanied with the board or with the touch of a finger. In this way, the user can interact with the IWB so as to more readily engage the audience. While most IWBs only allow for one input or finger/pen to be used at a time, the new models recently released in 2012 can allow up to four users to simultaneously select, write or draw on the board. In terms of ease of use, interactive whiteboards are designed so that novice users, who are familiar with computer software, can use it with minimal training. Then, as experience grows, the user can utilize the related software, usually offered by the manufacturer of the IWB to carry out more advanced and flexible operations. Most IWB manufacturers also provide the user access to an online community wherein complete lessons, ranging by grade and subject can be searched and downloaded. Among those lessons, some offer professionally designed content with sophisticated multimedia and interactive capabilities that can be purchased from publishers, magazines and other content providers.

2.6 Additional hardware

The majority of IWB manufacturers also develop supplementary hardware to accompany IWB products. Some of the additional hardware can be a Learner Response System or LRS. This device is an electronic remote or clicker used by an audience as a means to directly respond to a particular lesson or presentation. While the specific features of this tool vary from model to model, most units contain a USB receiver that sets up a radio frequency in the room with a range of approximately (30m) as well as an LCD screen that allows the user to edit and change their response. The types of responses that can be requested include true or false, yes or no, numeric, opinion or word answers and complete mathematical or scientific equations. When an instructor or teacher requests feedback, the audience enters their response on the clicker. Once submission is complete the results are stored within the accompanying software, which, the instructor can present on the interactive whiteboard with each entry listed or anonymously.

3 Research 1: Teacher beliefs of the use of IWB

According to large-scale study [8], the researchers have studied nine teachers from seven schools as part of this large-scale analysis. The teachers were chosen on the basis that in national tests in 2005 their classes had shown progress between the baseline and posttest outcomes. This enabled the evaluators to observe classrooms where the use of IWBs had become fully embedded in teaching and learning through use for more than two years. Over the period of the evaluation, the use of IWBs across the curriculum had increased [9]. A huge majority of interviewed teachers felt they had adopted new teaching practices as a result of having an IWB. In the observed classrooms many teachers had made radical changes to their lesson planning, creating or accessing their own resources, and storing them in either personal or shared areas on the school's server. Research findings from classroom observations showed that IWBs aid the teaching of difficult, abstract and complex ideas, that the ambience of classrooms in which IWBs are used is more cooperative and "sharing," and that there are very positive effects on the attention, attitude, and motivation of students in classes with IWBs [10]. Authors stressed how IWBs introduce more possibilities for positive interactivity between the teacher and the learners, which is an essential pedagogical component.

Teachers reported using the IWBs in approximately two-thirds of the mathematics lessons in 2003 and nearly three-quarters of these lessons in 2004. Overall, the interviewed teachers were extremely positive about the impact of IWBs on their teaching and thought that using the IWBs in lessons improved students' motivation to learn. A consistent proportion of teachers (85%) believed that IWBs would lead to improvements in students' attainment [8].

In another research which took place in Turkey, the teachers were given questions about pros and cons of using IWB's. The research consisted of 10 teachers from different branches. As a general evaluation, it is seen that all of the teachers stated that technology is a sine qua non for the education field [10]. In addition, all teachers think that smart boards will attract students' attention thanks to the visuals. Teachers also think that the blackboard, which is an important part of the traditional classroom environment, will be replaced by the smart board in the future [1]. Some of the most frequent answers are that teachers find the smart board seminars given to them very theoretical. Teachers who felt support at this point stated that they should be given more help through seminars in areas where they are inadequate. In addition, teachers want the seminars to be practice-oriented.

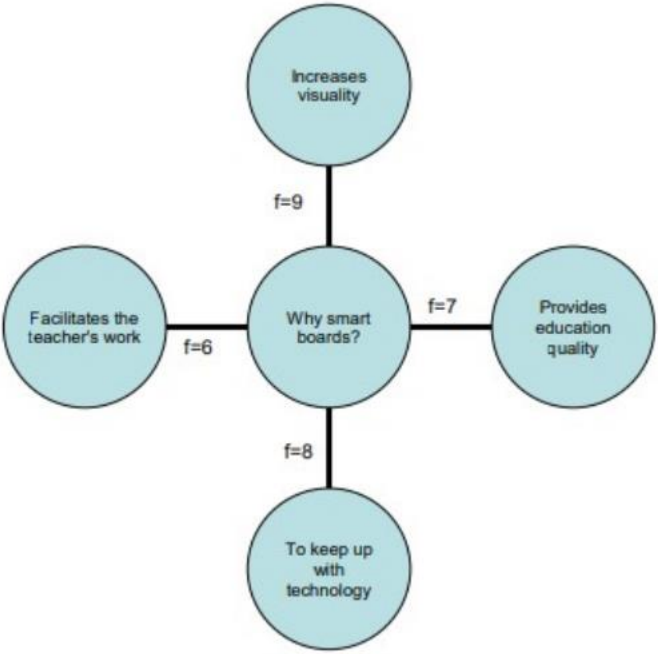

Figure 1 Teachers' views on why they need a smart board

When Figure 1 is examined, it is seen that most of the teachers stated that they need a smart board to keep up with the technology. On the other hand, almost all teachers stated that smart boards increased the visualization, and therefore, a useful material. Seven teachers stated that the smart board would improve the quality of education and six teachers would reduce their workload. In addition, it can be said that all teachers think that smart boards will replace blackboards soon [10].

According to the research, the teachers indicated that smart board has a potential to increase student success, but some teachers stated that the smart boards were not enough to achieve success alone. As an important finding, some teachers believe that smart boards will increase student interest and motivation [3]. In addition, seven teachers believe that this material will increase student participation. All of the teachers stated that technology is required in education as in every field. Some of the teachers pointed out that education influences the technology, and that the technology has been developing thanks to the education [11]. On the other hand, some of the teachers stated that technology is needed for effective teaching as well as updating the education system.

3.1 Summary of research 1

Based on the data acquired from several studies, it was observed that nearly all of the teachers had positive opinions about smart boards. It is pleasing that teachers have positive perspectives towards technological materials. Teachers stated that the use of smart boards in classrooms would increase the motivation of students and increase their involvement and participation. Another result of the studies is that teachers need support for the use of smart boards. On the other hand, some teachers' comments about their colleagues show that the level of technology use for elder teachers is low. Indeed, some studies have shown that older teachers are resistant to technology. Şahin collected data from 512 teachers, and according to the results, teachers have partially agreed that the use of materials in classrooms will help preventing the disciplinary problems and help facilitating classroom management. Similarly, in this study, teachers think that the use of smart boards in classrooms will ease classroom management. Finally, teachers' opinions on the relationship between education and technology have also provided some evidences about teachers' view on smart boards. First of all, teachers' positive outlook on the use of technology in the educational environment can be interpreted as an indicator of their positive attitude and belief towards smart boards. Considering the effect of teachers' beliefs on their teaching, it can be said that the results will have positive effects on teaching activities.

3 Research 2: Observation of students

Students have been more curious, interested, and inspired as a result of the widespread use of Interactive Whiteboards around the world. The new modern age demands change, and in addition to conventional schooling, they need digital materials and additional skills, since it is often easier to obtain additional details related to a specific curriculum. Students spend a lot of time using their computers or surfing the internet. If the teachers raise their interest in the topic instead of offering them material which is boring and difficult to understand, the teachers could search the topic on the internet and this way they can develop their knowledge and make the lesson more enjoyable [12].

In study of the uptake of IWBs in a secondary school, Glover and Miller [7] proposed that IWBs offered considerable benefits to learning. They reported that students were more likely to engage in learning due to the surprise element that was offered through the IWB, the large visual cues offered through the IWB presentation format, and the quicker pace of lessons. In exploring the impact of IWBs on students' thinking, Wall (2005) reported that, among other things, students indicated that there was considerable motivational effect of the IWBs to the extent that IWBs could change students' perceptions of subject areas. Research has shown that IWBs may offer potential links between learning styles of students and the learning environment offered through the IWB format. In their review of the literature on IWBs, a range of curriculum areas was reported as having adopted the IWB as part of their pedagogy and links to learning styles [7]. However, in another study it was reported that some students did not like the openness of their responses as they were available to public scrutiny and students felt threatened by that openness and hence less likely to participate. However, other students reported that the use of technology helped to create a community within the classroom where they could expose their difficulties to the group and seek the support of others in solving problems. It was also found that as the number of hours of IWB exposure increases, students' awareness of the distinctiveness of IWB technology increases. The use of IWB as an instructional tool has a beneficial effect on student engagement in classroom lessons and led to improved student behaviour. Teachers and students believe that IWB had a high impact on revitalizing the classroom [5].

According to large-scale study, the observed lessons in USA containing the IWB tool, contained more whole-class teaching and less group work. The lessons involving IWBs had significantly more open questions, answers from students, probes, evaluation, and general discussion. Most of these differences were only observed after the IWBs had been in use for a year. The IWB use also contributed to a faster pace in the lessons (measured as increase in the total number of interactions between the teacher and students in these classes). In terms of the impact on students' attainment, however, the IWBs appeared to have a negligible effect. . Compared with other schools nationally, the students in the IWB pilot schools performed better on national tests in mathematics in 2003 [8].

The second large study of primary education in literacy, science, and mathematics was conducted by. The study concerned 4,116 students from Year 3 to Year 6 (aged between 7 and 11) in 172 classes in 97 primary schools, and 3,156 students in Years 1 and 2 (between 5 and 7 years old) in 160 classes in 96 primary schools, in 20 local authorities in England. It was found that IWBs benefited averagely attaining students and high-attaining students in that they made greater progress with higher exposure to IWBs in mathematics, whereas IWBs had little effect upon the progress in mathematics of low-attaining students. In evaluating their findings, the researchers concluded that the use of an IWB increases the level of children's engagement with learning activities [6].

5 Conclusion

Almost every effect of the IWBs on the lessons is considered positive. Raising participation, drawing attention, providing enthusiasm, raising the pace of the lesson, facilitating the lecture, motivating students, visualizing the lesson, saving time, focusing students‟ attention are the positive effects of IWBs on the lesson. Students' ideas about the interactive whiteboard are basically positive, they like using it, discovering the opportunities it provides, it motivates them, and it has a great influence on their interests.

In summary, the use of IWBs in the education process, has been generally seen with positive attitudes and responses, prevailing amongst the negative ones. But the most important goal in the interactive learning environment is to retain students' attention and help them understand the material, making the material interesting and exciting for them so that it will be their curiosity that forces them to acquire knowledge instead of the burden of requirements in boring and unentertaining environment.

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DESIGN AND CREATION OF ELECTRONIC TEACHING AID FOR EFFECTIVENESS AND ATTRACTIVENESS OF EDUCATION INCREASING

Peter KOVÁČIK, SK

Abstract: The article analyses requirements of new methods of student education at level of secondary school with professional electrical and electronic focus. It describes creation of new teaching aid that incites fantasy, concentration and motivation to create interesting things by self competence of students oriented to electrical field of study. At the same time it orientates students towards unconventional way of thinking and non orthodox solutions. Teaching aid exploits digital form that is attractive for young people with aspiration to focus attention of students to studied professional knowledge..

Keywords: teaching aid, electronics, digitizing, quality of education.

1 Introduction

At present, a digitizing is applied at school accordingly. Standard blackboard and chalk (standard teaching aids) were replaced by interactive boards and data projectors. Thanks to present software of computers, it is possible to join into one presentation: text, pictures, different animations, video and sound that creates more interesting and attractive material for students. Electronic aids replace some standard aids in successive steps.

Student can't see physically many actions at electrical engineering and electronics. This is reason why it is very important so as students create correct idea about behaviour of studied electronic components. Designed electronic teaching aid is able to simulate characteristics of electronic components and to display characteristics visually by display. Taught topic is then more understandable at lesson, thanks to this educational aid. On the base of object teaching, it is possible to visualise characteristics of electronic component to student, to allow better understanding and to help for knowledge using in practice.

The requirement of unconventional, attractive solution

Basic aim of designed teaching aid is to create such electronic instrument that is able, at arbitrary part of its transfer characteristics, to change its amplification – that means profile of volt – ampere characteristics. The purpose is to create such instrument that transforms input voltage to output voltage by transfer characteristics created by author (Fig.1).

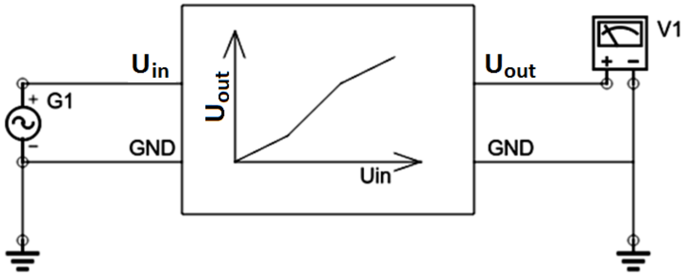

Fig.1 Principle of designed electronic teaching aid

The instrument changes input signal to output signal by transfer characteristics. Output signal is conveyed into measuring instrument V1 – imaging display. The instrument is possible to create by two principles: analogue and digital. Each of principles has its advantages and disadvantages.

Analogue principle is usually realized by computing amplifiers. Signal is transferred from input to output nearly without time delay and without massive distortion – what is the advantage. The disadvantage is relatively complex and extensive scheme, limited number of points on transfer characteristics where profile of characteristics is changed (Fig. 2).

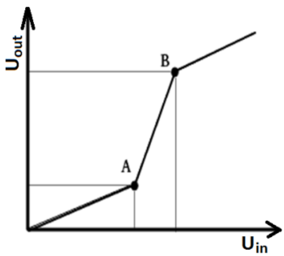

Fig.2 The principle of transfer characteristics profile design for teaching aid

Digital teaching aid changes analogue input signal to digital. Digital signal is changed by characteristics saved in memory of teaching aid to adequate value. Obtained digital output value is consequently changed to analogue form by digital analogue converter.

A digitizing has its disadvantages: Analogue signal has to be sampled. Each sample has to have determined its corresponding numerical value (quantization) by its analogue amplitude. Non linear distortion and time delay is originated by these processes and is corresponding to term of separate activities (transfer of data between converter and microprocessor, time of conversion at analogue-digital and digital-analogue converter, time of microcontroller activity). The digital teaching aid has big advantage on the other hand – transfer characteristic is possible to create by requirement, without any restrictions. A restriction by number of points on transfer characteristics does not exist, as it is at analogue principle.

The decision of device creation resulted into digital principle, from point of view of actual but mainly future trend. Dominant occasion was – non limited possibilities of transfer characteristics profile creation by principle shown in Fig.2. The teaching aid was designed in form of modules to take lucidity for students (main transformer, power source, analogue-digital and digital-analogue converter, microcontroller, display) shown in Fig.3.

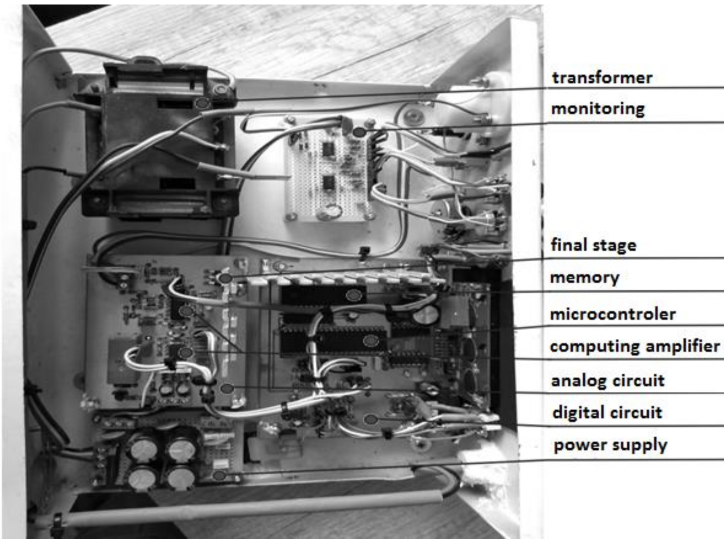

Fig.3 Designed electronic instrument as teaching aid

The transfer characteristic is created by software to take general purpose, as it was upper mentioned. Advantage is also possibility to use software and program language used at lessons at school – students are allowed to create transform characteristics by job or by their requirements. Thereafter, students can verify product of their knowledge and accuracy of their work by teaching aid. It faces towards increasing of students creativity including accent to preciseness of their activity based on natural competition. Examples of displays showing software creation for teaching aid are in Fig.4.

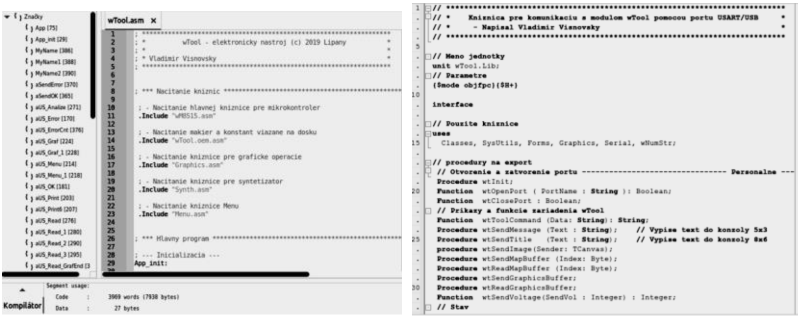

Fig.4 Examples of displays – software creation for teaching aid

There is possibility to display other parameters, because values of parameters are known from software exactly (Fig.5), in addition to programmed characteristic imaging.

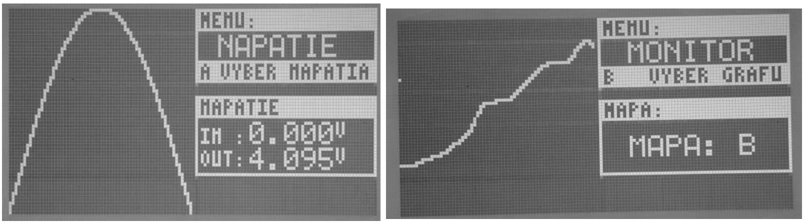

Fig.5 Graphical imaging of transfer characteristics including possibilities to display other parameters

Data, that is possible to display on small display screen of teaching aid (Fig.6), is possible to use as a signal for bigger display systems.

Fig.6 Front panel of designed teaching aid including built-in display

The environment, that makes it possible to create characteristics more quickly and comfortable, was created for simplification of student activity and for approaching to equipment of higher programming languages (Fig7).

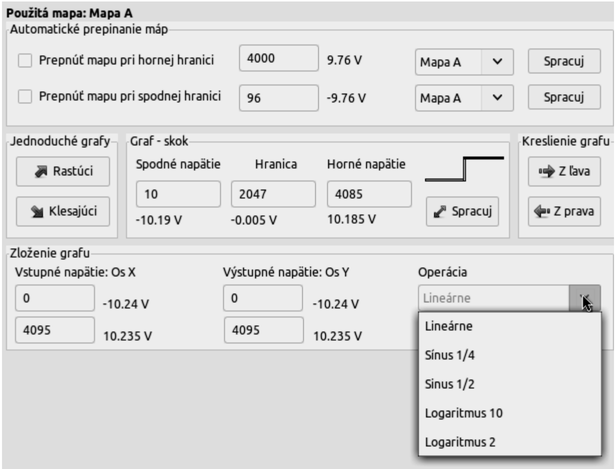

Fig.7 Environment for comfortable design of characteristics

Designed teaching aid makes it possible to motivate students towards activity at taught subject at which teaching aid is used. Its potentialities are much larger and depend on creativity of educated students as well as mastery of an educator. An educator should continuously to incite fantasy and creativity of students during education of electronic and informatics subjects.

Effectiveness of education depends on active interest of students on topic under study. Effectiveness is directly dependent on intensity of recognition, observation, reflection and possibility to verify studied topic practically. Suggested electronic teaching aid makes it possible what was mentioned above and leads students to the high activity at all educational activities – students have to know content of studied topic to have ability, by their knowledge, to design and to realize volt ampere characteristics of particular component or electronic circle. Presented technique is attractive for students in term of possibility to demonstrate their knowledge and skills practically. Such approach incite to students to practical activity and interaction as well as good competition. Mentioned behaviour is important for their future practice.

Conclusion

The article describes design of teaching aid that uses digital concept of characteristics creation, for example of electronic components. Teaching aid forms possibilities to apply inventive potential of students during educational process and to obtain professional knowledge at school or after-school activity. Teaching aid provides possibility to study deeply and to evolve knowledge at studied sphere of electronics and informatics.

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MATEMATICKÉ APLIKAČNÉ ÚLOHY V ODBORNEJ PRÍPRAVE ŠTUDENTOV SLOVENSKEJ POĽNOHOSPODÁRSKEJ UNIVERZITY V NITRE

Dana ORSZÁGHOVÁ, SK

Abstrakt: Ciele matematického vzdelávania v ekonomických a technických študijných programoch na Slovenskej poľnohospodárskej univerzite v Nitre sú stanovené tak, aby študenti vedeli matematické metódy použiť v riešení aplikačných úloh. Hlavným cieľom článku je prezentovať ukážky úloh, v ktorých sa matematický postup používa na riešenie úloh v aplikačnom kontexte profesijného uplatnenia absolventov a analyzovať úspešnosť študentov v riešení úloh. Údaje na analýzu boli získané zo seminárnych prác, priebežných a skúškových testov z matematiky v 1. ročníku bakalárskeho stupňa štúdia. Na vyhodnotenie dát boli použité metódy matematickej štatistiky. Riešením aplikačných úloh na prednáškach a cvičeniach získajú študenti predstavu o použití matematických metód a význame ich štúdia, čím sa zlepšia aj podmienky na správne pochopenie teoretického základu matematiky.

Kľúčové slová: vzdelávanie, výučba matematiky, aplikačné úlohy.

MATHEMATICAL APPLIED TASKS IN THE PROFESSIONAL TRAINING OF STUDENTS OF THE SLOVAK UNIVERSITY OF AGRICULTURE IN NITRA

Abstract: The goals of mathematical education in economic and technical study programs at the Slovak University of Agriculture in Nitra are set so that students know how to use mathematical methods in solving application problems. The main goal of the article is to present examples of problems in which mathematical procedures are used to solve tasks in the application context of the professional field of graduates and to analyse the success of students in solving applied problems. Data for analysis were obtained from seminar projects, mid-term tests and exam tests in mathematics in the 1st study year of bachelor's degree. Mathematical statistics methods were used to evaluate the data. By solving application examples in lectures and exercises, students gain an idea of the possibility of using mathematical methods and the importance of their study, which will improve the conditions for a proper understanding of the theoretical basis of mathematics.

Keywords: education, mathematics teaching, applied tasks.

1 Úvod

Študenti na Fakulte ekonomiky a manažmentu (FEM) Slovenskej poľnohospodárskej univerzity (SPU) v Nitre získavajú matematické vedomosti z povinných a voliteľných predmetov, pričom matematické a štatistické metódy sa používajú vo výučbe odborných predmetov v aplikovanej podobe. Diskusia o význame a cieľoch matematického vzdelávania reflektuje na požiadavku kvality vysokoškolského vzdelávania. Je spojená s novými trendmi uplatnenia nástrojov IT v procese vzdelávania a v rôznych oblastiach praktického života, čo súvisí aj s uplatnením absolventov univerzity v ich budúcej profesii.

Kvalitné vzdelávanie vyžaduje erudovaných učiteľov, preto ich príprava musí obsahovať metodologický základ a následne praktickú účasť vo vzdelávacom procese, kde sa prejavia požiadavky na uplatnenie rôznych didaktických aspektov vyučovania [1]. Didaktické aspekty implementácie IKT do vyučovania matematiky zahŕňajú aj vzájomnú interakciu medzi počítačom a používateľom, ktorá umožňuje pracovať samostatne a ponúka možnosti pre hľadanie súvislostí a postupov riešenia úlohy [9].

Informačné technológie sú prostriedkom pre dištančnú formu štúdia, kde je dôraz zameraný na samostatné štúdium [10]. Moderné nástroje informačných technológií vytvárajú podmienky pre zmeny v edukačnom procese a mnohé výskumné štúdie sa zaoberajú možnosťami zvýšenia efektívnosti procesu učenia a učenia sa pomocou technológií [4], [11].

V aplikačných úlohách zameraných na ekonómiu sú základom štúdia teoretické metódy, ktoré riešia finančné rozhodovanie, proces minimalizácie nákladov, maximalizáciu zisku, rozpočtové analýzy, optimalizáciu spotreby, modelovanie a prognózy. Matematické metódy a výpočty sú obsiahnuté aj v rámci predmetov zameraných na štúdium a riešenie úloh z finančnej a poistnej matematiky [3]. Použitie matematických programov, online kalkulačiek a interaktívnych nástrojov je súčasťou vyučovania predmetov na vysokých školách [5].

V príspevku sme sa sústredili na úspešnosť študentov v riešení aplikačných úloh v téme diferenciálny počet funkcie s jednou reálnou premennou a dvoma reálnymi premennými a výsledné hodnotenie na skúškach z povinných matematických predmetov.

2 Študijné zdroje k predmetom Matematika IA a Matematika IB

V ekonomických študijných programoch na bakalárskom stupni štúdia na Fakulte ekonomiky a manažmentu sú zaradené v prvom ročníku dva povinné predmety: Matematika IA a Matematika IB. V Tabuľke 1 sú sumarizované informácie o rozsahu hodín výučby a študijný priemer za celý ročník v akademickom roku 2020/2021.

Tabuľka 1: Povinné predmety v 1. ročníku bakalárskeho štúdia na FEM

Predmet 2020/2021	Semester	Rozsah prednáška/cvičenie	Študijný priemer
Matematika IA	zimný	2/2	2,51
Matematika IB	letný	3/2	1,78

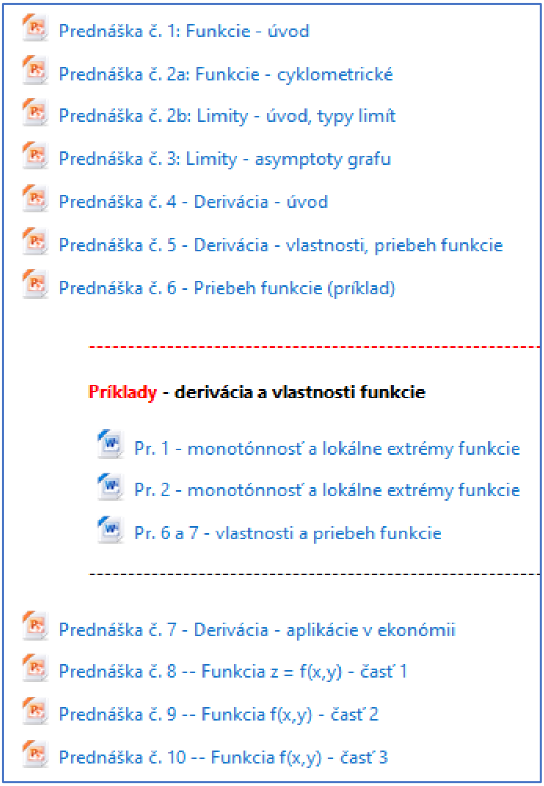
Uvedené povinné predmety garantuje a vyučuje Katedra matematiky, ktorá pripravila aj aktuálnu študijnú literatúru v podobe tlačených učebníc, ktoré obsahujú študijnú látku z matematiky pre všetky fakulty SPU [6], [7]. K hlavným témam vyučovania matematiky patria diferenciálny a integrálny počet, lineárna algebra a úvod do pravdepodobnosti. Okrem teoretického základu k preberaným matematickým metódam obsahujú učebnice úlohy, ktoré študenti riešia v testoch na skúške z matematiky.

Mnohé zmeny v metódach a formách výučby matematiky boli podnietené rozvojom nových nástrojov IT, ktoré umožňujú dištančné vzdelávanie v novej podobe. Uplatňovanie e-learningu on-line a off-line poskytlo možnosti na prednášky a cvičenia vo virtuálnom priestore s priamou účasťou pedagógov a študentov, alebo vo forme videa so spätnou väzbou prostredníctvom úloh a individuálnych projektov.

Nástroje IT sú neoceniteľnou pomôckou pri súčasnom trende znižovania výmery hodín matematiky. To spôsobuje, že pedagógovia nemajú dostatok vyučovacieho času na vysvetlenie teoretického základu, na ktorý nadväzujú aplikácie. Od študentov sa vyžaduje vysoká aktivita v samostatnom štúdiu matematiky, ktoré je podporené cielene vytvorenými elektronickými študijnými materiálmi, aby neprichádzalo k formálnemu získavaniu vedomostí. Okrem tlačených vzdelávacích zdrojov majú študenti SPU v Nitre prístup k študijným materiálom v elektronickej verzii v prostredí LMS MOODLE [2]:

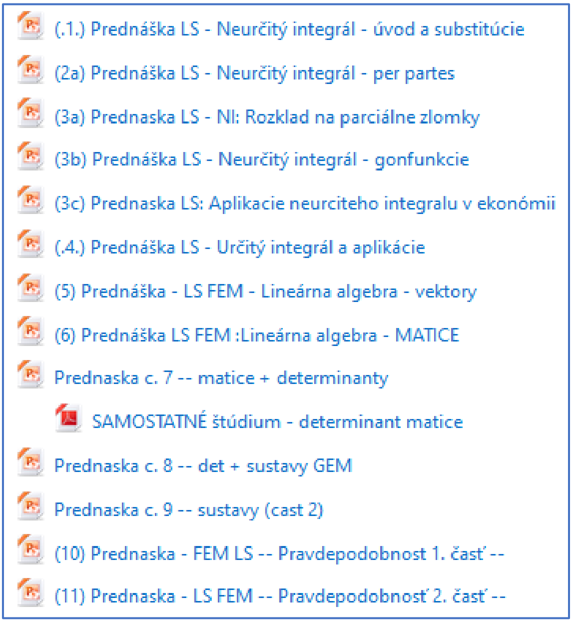
- k predmetu Matematika IA kurz „Cvičenia z matematiky ZS“,
- k predmetu Matematika IB kurz „Cvičenia z matematiky LS“.

Na Obrázku 1 a Obrázku 2 sú uvedené ukážky zoznamu prednášok z uvedených kurzov. Prednášky sú doplnené súborom vzorových príkladov a zadaní úloh na samostatné štúdium.



Obrázok 1: Obsah prednášok v kurze „Cvičenia z matematiky ZS“

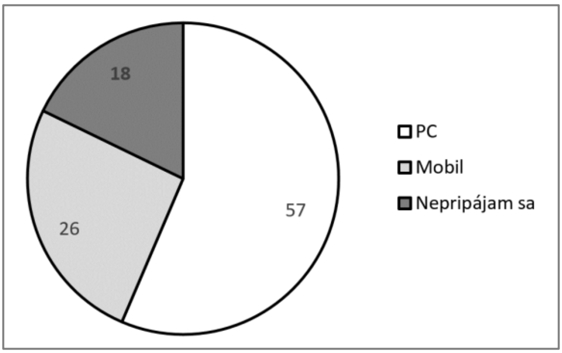
K preberaným témam študenti povinne odovzdali v elektronickej podobe súbory vypracovaných úloh, ktoré boli základom hodnotenia získaných vedomostí počas semestra v roku 2020/2021. Pedagógovia z Katedry matematiky pripravili k typovým úlohám prezentácie v PowerPointe, ktoré obsahovali podrobný postup s komentárom k riešeniu úlohy. Do preberanej látky boli zaradené aj aplikačné úlohy, ktoré prezentujú konkrétne použitie matematických metód. V zimnom semestri prvého ročníka prebieha proces adaptácie študentov na vysokoškolské štúdium, preto je potrebné aktivovať motiváciu študentov zo stredných škôl do štúdia exaktnej matematiky.



Obrázok 2: Obsah prednášok v kurze „Cvičenia z matematiky LS"

V roku 2020 sme uskutočnili dotazníkový prieskum, v ktorom bola otázka: Pripájate sa na niektoré elektronické aplikácie z matematiky?

a) áno, na počítači, b) áno, na mobile, c) nepripájam sa.



Obrázok 3: Odpovede o pripájaní sa na matematické aplikácie
Zdroj: [8]

Odpovede študentov v grafickej podobe sú na Obrázku 3. Z odpovedí vyplýva, že na získavanie vedomostí z matematiky používajú študenti aj dostupné elektronické matematické aplikácie. Respondenti mohli označiť viac odpovedí, pričom vidíme, že prevláda pripájanie na počítači.

3 Analýza študijných výsledkov z matematiky

3.1 Ukážky aplikačných úloh z diferenciálneho počtu v predmete Matematika IA

Riešením aplikačných úloh získajú študenti predstavu, ako a kde môžu uplatniť vedomosti z matematiky.

Príklad 1:

Máme zistiť rozmery obdĺžnikového dvora s čo najväčším obsahom, ak na jeho ohradenie máme 60 m pletiva a vieme, že jednu stranu ohrady tvorí stena budovy.

Príklad 2:

Firma CBA analýzou nákladov zistila, že pri produkcii x hektolitrov (hl) oleja má celkový zisk vyjadrený vzťahom

$$CZ(x) = -36{,}7x^2 + 1466x - 1000.$$

Súčasná úroveň produkcie je x = 10 hl oleja na deň. Pomocou derivácie máme zistiť, či je ekonomicky výhodné zvýšiť produkciu oleja.

Príklad 3:

Funkcia celkových nákladov má vyjadrenie

$$CN(x) = \frac{x^3}{3} - x^2 + 1000,$$

kde x je úroveň produkcie v tisíckach. Zistite, pre akú úroveň produkcie budú celkové náklady minimálne a veľkosť nákladov uveďte.

Príklad 4:

Funkcia celkového príjmu pre určitý produkt je

$$R(x) = 100x - x^2,$$

kde x označuje počet predaných kusov. Aký je marginálny príjem pri predaji 40 kusov? Výsledky interpretujte.

Príklad 5:

Producent vyrába jeden produkt pre odberateľov dvoch druhov. Pre odberateľov 1. druhu vyrába x jednotiek produktu a odberatelia platia cenu $50 - 5x$ dolárov za produkt. Pre odberateľov 2. druhu produkuje y jednotiek produktu a títo odberatelia platia cenu $100 - 10y$ dolárov za produkt. Producentove náklady na vyrobenie $(x + y)$ kusov produktu sú $90 + 20(x + y)$ dolárov. Aby producent dosiahol maximálny zisk, koľko produktov má vyrobiť pre jednotlivých odberateľov?

Príklad 6:

Mesačnú produkciu firmy môžeme vyjadriť nasledovnou funkciou:

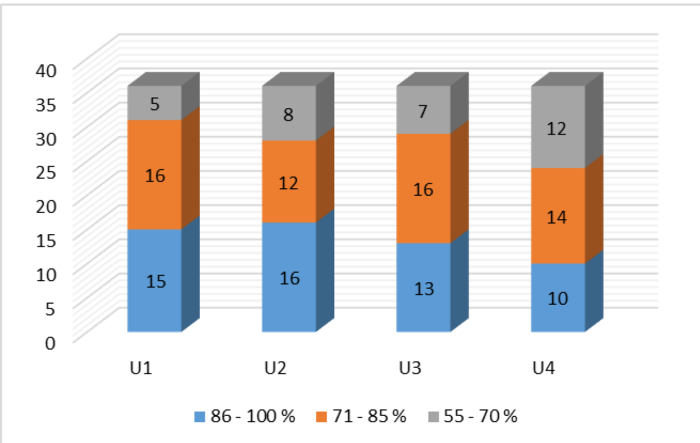
$$Q = 100 \cdot K - K^2 + 150 \cdot L - 0{,}5L^2,$$

kde premenná K znamená výrobný faktor kapitál, premenná L znamená výrobný faktor práca. Firma zamestnáva L pracovníkov za 400 peňažných jednotiek (p. j.) na deň a prenajíma si stroje K za 200 p. j. na deň. Cena P, za ktorú svoj produkt predáva, je 20 p. j. za jednotku. Vypočítajme, akú kombináciu výrobných faktorov L a K by mala firma použiť, aby dosiahla za daných podmienok maximálny zisk.

3.1 Úspešnosť v riešení úloh a známky na skúške z matematiky

V akademickom roku 2020/2021 bol realizovaný didaktický prieskum v 1. ročníku na FEM SPU. Výskumnú vzorku tvorila skupina 36 študentov v externej forme štúdia a hodnotili sme nasledovné 4 typy úloh:

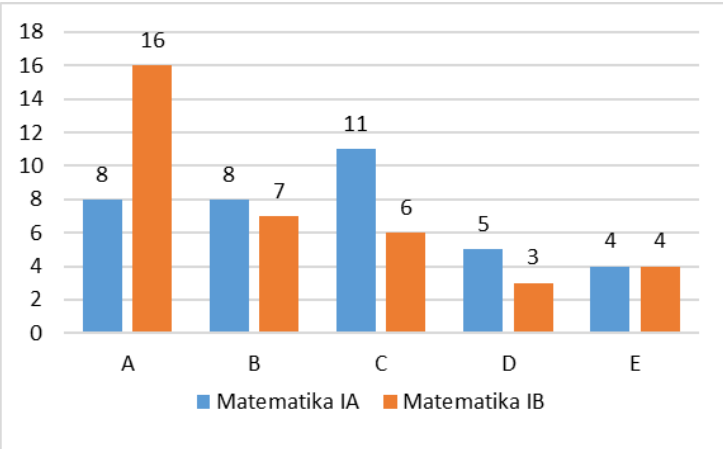
U1: Zistiť lokálne maximum funkcie y = f(x)
U2: Zistiť lokálne minimum funkcie y = f(x)
U3: Vypočítať lokálne extrémy funkcie z = f(x, y)
U4: Vypočítať viazane extrémy funkcie z = f(x, y)



Obrázok 4: Analýza aplikačných úloh z diferenciálneho počtu

Úspešnosť študentov v riešení aplikačných úloh sme zoradili do troch kategórií: 86 – 100 %, 71 – 85 % a 55 – 70 % (Obrázok 4). Z analýzy úloh vidíme, že lepšiu úspešnosť dosahujú študenti v riešení úloh U1 a U2, ktoré obsahujú funkciu s jednou reálnou premennou. V úlohách U3 a U4 mala skúmaná funkcia dve reálne premenné, kde je potrebný výpočet parciálnych derivácií funkcie. Tento celok ja zaradený na konci semestra pred skúškou, preto vyžaduje časový manažment od študentov, aby v rámci prípravy na skúšku získali potrebné teoretické znalosti a praktické výpočtové zručnosti. Z komunikácie so študentmi vieme, že ako prvotný študijný materiál používajú vlastné poznámky z matematických prednášok a cvičení.

Analýza známok na skúške z predmetov Matematika IA a Matematika IB v roku 2020/2021 (Obrázok 5) ukázala, že vo výskumnej vzorke viac študentov dosiahlo na skúške hodnotenie A v letnom semestri v predmete Matematika IB. Priemerná známka na skúške z predmetu Matematika IA bola 1,85 a z predmetu Matematika IB 1,61. Tento stav potvrdzuje adaptačnú fázu študentov v zimnom semestri, kedy študenti v prvom (zimnom) semestri dosahujú na skúške horšie výsledky než v druhom (letnom semestri). Realizovaný párový *z*-test nepreukázal významné rozdiely medzi známkami z predmetov na skúške.



Obrázok 5: Študijné výsledky v matematických predmetoch

4 Záver

Vysokoškolské vzdelávanie prebiehalo v akademickom roku 2020/2021 v dištančnej podobe z dôvodu pandémie koronavírusu. Digitálne kompetencie boli potrebné na strane pedagógov pri inovácii vzdelávania, implementácii on-line edukačných nástrojov a pri tvorbe elektronických študijných materiálov na podporu samostatného štúdia.

V príspevku sme analyzovali úspešnosť študentov 1. ročníka FEM SPU v Nitre v externej forme štúdia v riešení aplikačných úloh z diferenciálneho počtu, kde študenti preukázali potrebné vedomosti. Na základe skúškových výsledkov z matematických predmetov konštatujeme, že aj počas dištančného vzdelávania študenti aktívne získavali matematické vedomosti. Digitálne prostriedky vedeli študenti používať počas on-line výučby, aj počas testovania na skúškach.

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A PANDÉMIA IDEJE ALATT ALKALMAZOTT E-TESZT MEGBÍZHATÓSÁGÁNAK VIZSGÁLATA

Gabriella PAPP, HU

Abstract: A COVID-19 pandémia sokban változtatta meg a matematika oktatást is. A tanár számára az egyik nehézség a hallgatók tudásának objektív és megbízható felmérése az online oktatás során. A matematikában jellemzően a nyitott feladatokból álló feladatlapokat preferálják a diákok tudásának szummatív értékeléséhez. Bár az e-tesztek oktatási alkalmazása már jelen volt, a távoktatás bevezetésével vált a matematikában is még inkább aktuálissá. A tanárok által aktuálisan alkalmazott tudásszintmérő e-teszteket közben nem vizsgálják a jóságmutatók (objektivitás, érvényesség, megbízhatóság) szempontjából. A cikkben a II. Rákóczi Ferenc Kárpátaljai Magyar Főiskola matematika oktatásának e-tesztekkel való tudásmérését, és annak megbízhatóságát vizsgálom. A kutatás célja az általam készített összefoglaló e-teszt statisztikai kiértékelése, megbízhatóságának vizsgálata és annak bemutatása.

Keywords: távoktatás, matematika oktatás, e-teszt, megbízhatóság, Bloom-taxonómia.

EXAMINING THE RELIABILITY OF THE E-TEST USED DURING A PANDEMIC

Abstract: The COVID-19 pandemic also changed mathematics education a lot. One of the difficulties for the teacher is the objective and reliable assessment of students' knowledge in online education. In mathematics, open-ended worksheets are typically preferred for summative assessment of students' knowledge. Although the educational application of e-tests was already present, with the introduction of distance learning it became even more relevant in mathematics. Meanwhile, the e-tests currently used by teachers are not examined in terms of goodness indicators (objectivity, validity, reliability). In this article I study the knowledge measurement with e-tests of the mathematics education at the Ferenc Rakoczi II Transcarpathian Hungarian College of Higher Education from its reliability. The aim of the research is to present the statistical evaluation of the summary e-test I prepared and examine its reliability.

Keywords: distance learning, mathematics education, e-test, reliability, Bloom-taxonomy.

1 Bevezetés

A Covid-19 pandémia miatt a 2020/21-es tanévben is szükség volt az online oktatás bevezetésére. Tanárként az objektív értékelésre törekszem. A távoktatásban a számonkérést és a tudásszint szummatív értékelését videóhívások és e-tesztek segítségével oldottam meg. Így merült fel az a probléma, hogy hogyan kell helyesen létrehozni a tudásszintmérő teszteket. A továbbiakban bemutatom a tesztkészítéshez szükséges fontosabb tudnivalókat, melyeket tanulmányoztam és felhasználtam a kutatásomhoz és önellenőrzésemhez.

1.1 Távoktatás és e-teszt

Fontos megérteni, mit jelent a „távoktatás”. Mivel a technológia fejlődik, a távoktatás definíciója folyamatosan változik [5]. Saykılı összegyűjtötte a távoktatás meghatározásának fő elemeit a Keegan szerint:

- a tanár és a tanuló elkülönítése, mely megkülönbözteti a személyes előadásoktól;
- egy oktatási szervezet hatása, amely megkülönbözteti a magántanulástól;
- technikai médiumok használata, általában nyomtatott, a tanár és a tanuló összefogására és a tanfolyam oktatási tartalmának hordozására;
- kétirányú kommunikáció biztosítása annak érdekében, hogy a hallgató profitálhasson a párbeszédből, vagy akár kezdeményezhesse azt;
- alkalmi találkozók lehetősége didaktikai és szocializációs célokra egyaránt;
- részvétel az iparosodott oktatási formában [15].

Burns szerint a távoktatás egy tervezett tanulási tapasztalat vagy oktatási módszer, amelyet az oktató és a tanuló(k) kvázi-állandó elválasztása jellemez. Az ilyen variáció magában foglalja az alkalmazott média vagy technológia típusait (nyomtatott, rádió, számítógép); a tanulás jellegét (workshop, szeminárium, a hagyományos tanterem kiegészítése, a támogatás szintje); intézményi keretek; tárgyalt témák; és az interaktivitás támogatásának szintje (személyes, online, kevert, nincs) [3].

A nyílt és távoktatást tervezését és lebonyolítását megkísérlő és fejlesztő személyek gyakorlata, filozófiája és kultúrája befolyásolja [15]. A távoktatás egyik leggyorsabban fejlődő módja a webalapú vagy online tanulás (virtuális tanulásnak vagy e-tanulásnak is nevezik). Valójában a világ számos pontján az online tanulás megegyezik a távoktatással. Az online tanulás lehetőségei a következőkben rejlő képességen alapulnak:

- Nyomtatott, audió, vizuális és videó alapú tartalmat átfogó többcsatornás utasítások kézbesítése
- Biztosítson többféle formátumot a szöveges, audió és video-alapú valós idejű kommunikációhoz és az együttműködéshez társakkal szerte a világon
- A „bármikor, bárhol" tanulást kínálja, feltéve, hogy a tanulók hozzáférnek az internethez [3].

Az online tanulás tudásszint ellenőrzésének egyik lehetősége az e-tesztek létrehozása és alkalmazása. Tesztnek nevezzük azokat a sztenderdizált eljárásokat, melyek segítenek egy adott viselkedés leírásában vagy mérésében, hogy eredményeképpen a személyekhez vagy eseményekhez előre meghatározott módon kategóriákat, vagy pontszámokat rendeljünk [8].

Korenova szerint kettősen definiálhatjuk az „e-teszt" kifejezést: 1. Szűkebb értelemben az e-teszt egy elektronikusan vezérelt didaktikai teszt, amelynek lehetősége van a multimédiás elemek gazdagítására. 2. Tágabb értelemben az e-teszt egy elektronikus interaktív anyag, amely kérdésrendszeren alapul és válaszokat keres, amelyek nemcsak mérésre, hanem az oktatási célok elérésére is létrejönnek (ezáltal az innovatív tanítási módszerek eszközeként szolgálhat). Az e-teszt segítségével nemcsak a hallgatók tudását tudjuk meghatározni, hanem ezekkel az új digitális eszközökkel növelhetjük a hallgatók motivációját, felhasználhatjuk őket ismétlés, gyakorlás, ellenőrzött felfedezési módszerek során. Az e-teszt a hallgatók szempontjából nagyon vonzó, mert a digitális világ nagyon közel áll hozzájuk [9].

A digitális technológiák alkalmazásával az oktatásban, a távoktatásban és az e-tesztekben számos szerző publikációja foglalkozik (bővebben [7], [10], [11], [12], [13], [16], [19], [20]).

1.2 Megbízhatóság és Cronbach-alfa

A mérés központi szerepet játszik a minőségi tanulói értékelés kialakításában, még egy osztálytermi tervezésű vagy nem szabványosított értékelési eszköz esetében is [4]. A tesztelések többségében használt tesztek általában teljesítménytesztek, amelyek esetén az egyes itemekre adott válasz lehet helyes (korrekt), illetve helytelen (inkorrekt). Az ilyen itemeket, változókat dichotóm (kétértékű) változóknak nevezzük [8]. Az automatikus e-teszt értékelés és szervezés egyik legfontosabb prioritása az erőforrások megtakarítása [18].

A minőség értékelése során elengedhetetlen a megbízhatóság és az érvényesség megbeszélése. A megbízhatóság az, hogy az eszköz milyen mértékben következetesen méri az egyén vagy a csoport képességeit [4]. A megbízhatóságra hatással van a mérések száma és a vizsgált csoport heterogenitása is. [8]. Az érvényesség az, hogy az eszköz milyen mértékben méri azt, amit mérni kíván. A klasszikus tesztelmélet nagyon egyszerű módszert kínál a teszt érvényességének és megbízhatóságának meghatározására [4].

Cronbach 1951-ben javasolt egy alfa-t, ami egyenlő az összes lehetséges tesztfelezéskor kapott együtthatók átlagával [8]. A Cronbach alfa a mérés vagy tesztelemek megbízhatóságának vagy belső konzisztenciájának értékelésére szolgál. Más szavakkal, bármely adott mérés megbízhatósága arra utal, hogy ez mennyire következetes mértéke egy fogalomnak, és Cronbach alfája az egyik módja annak, hogy megmérje ennek a konzisztenciának az erejét [6].

Panayides bemutatja az egyenletet: $\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_i V_i}{V_t}\right)$ [14], (1)

ahol n az itemek számát, V_t a teljes pontszámok varianciáját, V_i pedig az elem pontszámainak szórását jelöli [14].

Az eredményül kapott α megbízhatósági együttható 0 és 1 között mozog. Bár a „jó” α együttható előállítására vonatkozó szabványok teljesen önkényesek, és függenek a kérdéses skála elméleti ismereteitől, sok módszertanos 0,65 és 0,8 között javasolja a minimális α együtthatót (vagy sok esetben magasabbat); A 0,5-nél kisebb α együtthatók általában elfogadhatatlanok [6]. Ha az itemek száma kevés, vagy az átlagos korreláció alacsony, akkor alacsony lesz a Cronbach–féle alfa értéke is. A magas Cronbach–féle alfa sem jelenti azt, hogy a teszt itemjei egy dimenziót mérnek [8].

Az e-Learning környezetekkel történő vizsga garantálja a megbízhatóságot, az objektív értékelést és az azonos vizsgakritériumok alkalmazását minden vizsgázó számára. Az e-tesztek segítségével a tanárok a klasszikus vizsgaformához képest sokkal több területen ellenőrizhetik az ismereteket és készségeket. A tanulók ráadásul sokkal gyorsabban láthatják eredményeiket és a tanulás előrehaladását, mint a klasszikus vizsgaidőhöz szükséges idő [18].

1.2 Bloom taxonómia

A konkrét e-tesztben szereplő tesztkérdések és feladatok különböző elvek és szabályok alapján választhatók meg. A különböző szerzők szakirodalomban kifejtett véleménye nagyon ellentmondásos. Egyes szerzők úgy vélik, hogy a teszteket a típusuknak megfelelően kell megválasztani (a megfelelő osztályozás szerint), mások pedig úgy gondolják, hogy tartalmuk (beleértve a tantárgyhoz való viszonyukat) és/vagy a tanulási folyamat kognitív célkitűzései alapján kell őket választani [18].

A Bloom taxonómiája a különböző célok és készségek egy osztályozása, amelyeket az oktatók tanítványaik számára kitűznek (tanulási célok). A rendszert 1956-ban javasolta Benjamin Bloom, a Chicagói Egyetem oktatási pszichológusa [17]. Kognitív pszichológusok, tantervelméleti és oktatói kutatók, valamint tesztelési és értékelési szakemberek csoportja 2001-ben Bloom taxonómiájának felülvizsgálatát publikálta „A Taxonomy for Teaching, Learning, and Assessment" címmel [2]. Az 1. ábrán a taxonómia így megalkotott kétdimenziós táblázatát mutatja.

A tudás dimenziója	A kognitív folyamat dimenziója					
	1. Emlékezni	2. Megérteni	3. Alkalmazni	4. Elemezni	5. Értékelni	6. Létrehozni
A. Tárgyi tudás						
B. Fogalmi tudás						
C. Eljárási tudás						
D. Metakognitív tudás						

1. ábra: Taxonómia táblázat [1]

Ez a 6 szint felhasználható az óra tanulási céljainak, tanulságainak és értékelésének strukturálására:

- Emlékezés: A releváns ismeretek előhívása, felismerése és felidézése a hosszú távú memóriából.
- Megértés: A jelentés konstruálása szóbeli, írott és grafikus üzenetekből értelmezés, példamutatás, osztályozás, összefoglalás, következtetés, összehasonlítás és magyarázat útján.
- Alkalmazás: Végrehajtási folyamat elvégzése.

- Elemzés: Az anyag felosztása alkotó részekre, annak meghatározása, hogy az alkatrészek hogyan viszonyulnak egymáshoz és egy általános struktúrához vagy célhoz differenciálás, rendszerezés és hozzárendelés révén.
- Értékelés: Kritériumok és standardok alapján ítéletek meghozása ellenőrzés és kritikák útján.
- Létrehozás: Az elemek összerakása egy koherens vagy funkcionális egész kialakításához; az elemek új mintává vagy struktúrává történő átszervezése generálás, tervezés vagy gyártás útján [17].

A felülvizsgált taxonómiában a tudás ennek a hat kognitív folyamatnak az alapja, de szerzői külön taxonómiát hoztak létre a megismerésben használt tudástípusokról:

- Tárgyi tudás
  - A terminológia ismerete
  - Speciális részletek és elemek ismerete
- Fogalmi tudás
  - Osztályozások és kategóriák ismerete
  - Alapelvek és általánosítások ismerete
  - Elméletek, modellek és struktúrák ismerete
- Eljárási tudás
  - Tantárgy-specifikus készségek és algoritmusok ismerete
  - Tantárgy-specifikus technikák és módszerek ismerete
  - A megfelelő eljárások alkalmazásának meghatározásához szükséges kritériumok ismerete
- Metakognitív tudás
  - Stratégiai tudás
  - Tudás a kognitív feladatokról, beleértve a megfelelő kontextusbeli és feltételes ismereteket
  - Önismeret [2].

2 Módszerek

A covid-19 miatt bevezetett távoktatás folyamán több tesztet is készítettem a 2020/21-es tanévben. Eleinte még nem vettem figyelembe a tesztelméletet, majd hiányát érezve utánajártam, és egyre inkább próbáltam megfelelő tudsásszintmérőket létrehozni.

Egy pilot kutatást végeztem a II. Rákóczi Ferenc Kárpátaljai Magyar Főiskola Matematika és Informatika szakos hallgatói között. A 8 főből álló csoport több tesztet is írt 2021 tavaszán, melyeket különböző felületeken hoztam létre. A továbbiakban a 20 itemből álló vizsgatesztet vizsgálatát mutatom be, melynek nyitott és zárt feladatait a Bloom taxonómiára támaszkodva hoztam létre. A taxonómiák és az itemek eloszlását a 2. ábra mutatja.

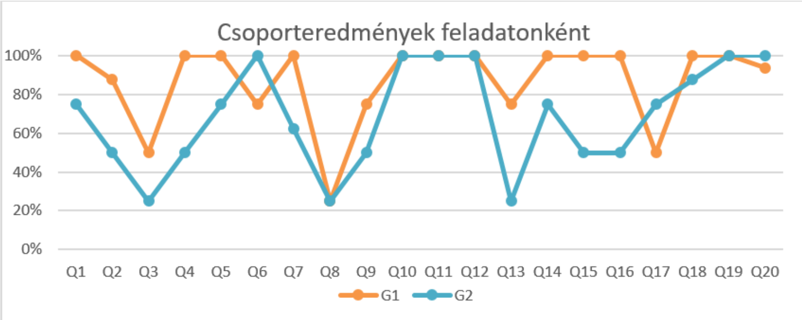
Bloom taxonómia	Darab		Itemtípusok	Darab
B1	5		Egyszeres választás	6
B2	2		Többszörös választás	1
B3	2		Igaz/Hamis	4
C1	4		Párosítás	5
C2	2		Numerikus	2
C3	5		Szövegbevitel	2
Összesen	**20**		**Összesen**	**20**

2. ábra: Taxonómiák és itemtípusok

A teszt szerkesztésére az Online Test Pad [21] felületet alkalmaztam. Több szempont miatt esett a választásom erre a platformra: itt találtam meg az általam keresett legtöbb itemtípust egyszerű szerkesztési felülettel; összetett beállítási lehetőségek a kitöltők korlátozásaira tekintve; regisztráció és csoport létrehozása nélkül is ki lehet osztani a tesztet egy link megosztásával (szükség szerint csoport létrehozás is lehetséges a felületen); a szerkesztő letöltheti pdf formátumban; számítógép és mobiltelefon alkalmazásával egyaránt könnyen kitölthető online formában a link megnyitását követően.
A teszt kitöltésére 30 perc állt a hallgatók rendelkezésére, miközben videóhívásban voltak velem. A videóhívás során figyelni tudtam arra, hogy a saját tudásukon kívül ne alkalmazzanak segítséget. Az elméleti tudnivalók mellett gyakorlati feladatok megoldására is szükség volt.

3 Az eredmények elemzése

A summatív teszten minden hallgatónak sikerült elérni a kötelező minimumot, az 50 %-os teljesítést. A legjobb eredmény 95 %-os lett. A helyes megoldások terjedelme a hallgatókra tekintve 7,5. A teszt hatékonyságának pontosabb elemzése érdekében a beérkezett 8 eredményt 2 osztályba soroltam a teljesített átlag fölötti (G1) és alatti (G2) csoportba. A 3. ábra mutatja, melyik (Q1, Q2, …, Q20) kérdések mutatnak figyelemreméltó eredményeket.



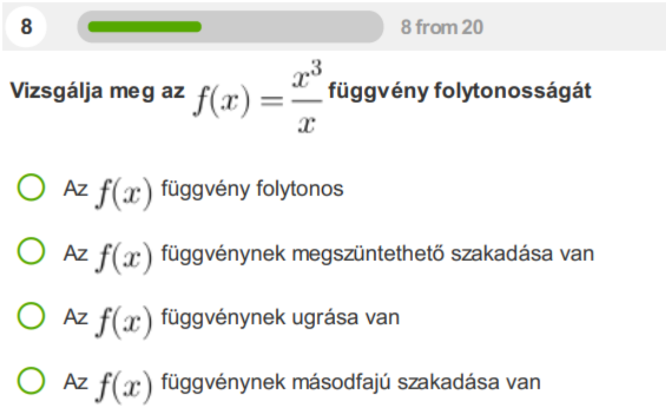
3. ábra: A két csoport átlageredményei feladatonként

Tekintsük először a Q6 és Q17 feladatokat, melyek esetében a G2 csoportból több helyes válasz érkezett. A Q6-os kérdés Bloom taxonómia alapján egy C3-as (eljárási tudás + alkalmazni tudás), nyitott kérdés volt, egy függvény határértékének meghatározásával. Kizártam a választás lehetőségét, önálló számítást volt szükséges elvégezni, így az átlag fölötti hallgatóktól volt elvárható a jobb eredmény. A Q17-es feladat esetében B1-es (fogalmi tudás + emlékezni) igaz-hamis típusú item megoldását kellett megadni. Itt a helytelen és helyes megoldások esetén is felmerülnek mindkét csoportban az emlékezés mellett a bizonytalanság és a nem emlékezés lehetőségei, amelyek miatt a látott eredmények születtek.

A Q10, Q11, Q12 és Q19 kérdésekre mindkét csoport összes tagja helyesen válaszolt. Ezek a kérdések Bloom B1 és C1 szintű párosítás, szövegbevitel, igaz/hamis és egy választás típusú itemek volta. A kutatás hibájának is tekinthető, hogy ezeknél az itemeknél alapismeretekre kellett visszaemlékezni, bár nagy figyelemmel voltam aziránt, hogy csak egyértelmű tudással lehessen helyes választ adni.

Statisztikailag a legnehezebbek a Q3, Q8 és Q13 kérdések voltak, melyeknél a csoportok úgy adtak helyes vagy helytelen választ, hogy közben az eredmények csoportnak megfelelő szinten maradtak, vagy egyformán rosszul teljesítettek. Mindhárom item gyakorlati feladatot tartalmazott, C3 feleletválasztó típusú. A Q3 kérdésben egy függvény értelmezési tartományának meghatározása volt a feladat, melyhez ismerni és alkalmazni kellett a tört nevezőjében lévő gyökös kifejezés kritériumát. A gyök alatt álló másodfokú egyenlet könnyen megoldható volt Viete formula segítségével.

Mindkét csoport számára legnehezebb itemnek bizonyult a Q8 kérdés, melyet a 4. ábra mutat be. A csoportokból egy-egy helyes válasz érkezett arra a kérdésre, melyben függvény folytonosságát vagy szakadását kellett meghatározni.



4. ábra: A két csoport átlageredményei feladatonként

Ebben az esetben azt feltételezem, hogy a rossz számítások mellett időhiány miatt a hallgatók inkább csak tippeltek, úgy választottak egyet a felsoroltak közül. Ezt a következtetést az előtte lévő kérdésre adott válaszok miatt vontam le. Mivel a Q7 kérdésben az itt felsorolt válaszokhoz hozzá kellett párosítani a meghatározáshoz szükséges képleteket. A G1 csoportban mindenki, míg a G2-ben csak 1 hallgató párosított helyesen, a többiek csak a kérdés felét tudták megoldani. Mindezek ellenére is a G2 csoportban nem az a hallgató adott helyes választ a Q8-ra, aki a Q7-re is.

A Q13 kérdés esetében nagyobb volt a 2 csoport közötti eltérés. Míg a G1 csoportból 1 ember rontotta el a választ, addig a G2-ből 1 személy tudta helyesen megválaszolni. A feladatban az adott függvény primitívjét kellett megjelölni. A helyes válaszhoz szükséges volt ismerni a primitív függvény fogalmát és a trigonometrikus függvények primitívjét. Rossz válasz jelölésére volt lehetősége annak a hallgatónak, aki keveri a függvény primitívje és deriváltja fogalmakat.

Meglepően sokan elhibázták a kérdéseket mindkét csoportban. Ez számomra azt engedi feltételezni, hogy ezekben az esetekben a feleltválasztó típus teret engedett a pontatlan munkának, vagy a számítások és gondolkodás nélküli téves választásnak.

A korábban nem említett kérdések a két csoport között várható különbséget mutatnak, ami azt engedi feltételezni, hogy jó a megbízhatóságuk és jól mérnek. Ezek között vegyesen oszlanak el az itemek típusai és a Bloom taxonómia szintjeinek megfelelő kérdések.

A feladatok elemzésének ellenére statisztikai elemzés szempontjából nem mondható megbízható e-tesztnek a vizsgált feladatsor, mivel a 0,15 értékű Cronbach-alfa túl alacsony, így az elfogadhatatlan kategóriába esik.

4 Összegzés

Az elemzés végén látva az eredményeimet, azt a következtetést vonom le, hogy bár a legjobb kezdet, ha elmélyülünk az elméleti tudnivalókban mielőtt gyakorlatban kipróbáljuk, de nem kell megállni, ha első próbára nem jelennek meg a várt eredmények.

A kutatás egyik célját sikerült teljesíteni, a Bloom taxonómiát felhasználva könnyebb volt objektív e-tesztet létrehozni. Az objektivitás megőrzésében segített, hogy online platformon lett létrehozva, és a rendszer maga javította. Validitása még függ a megbízhatóságától, amit figyelembe véve a kapott eredményeket még nem tudom biztosan megállapítani.

A 2. ábra arra enged következtetni, hogy inkább megbízható a vizsgált e-teszt és eredménye. Ellentétben a Cronbach alfa alacsony értékével. Ez kialakulhatott az alacsony átlagos korreláció vagy a kis létszámú mintavétel miatt. Ennek tisztázása érdekében célszerű lenne megismételni a kutatást, lehetőség szerint nagyobb létszámú csoportban, mivel a több elemű mintával pontosabb számításokat lehet elvégezni. Amennyiben ismétlés után hasonló eredményre jutok, megállapíthatom, hogy valóban nem megbízható ez az e-teszt.

Összességében a kutatás nem lett teljesen eredményes, így további kutatásokat kíván.

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SZÁMÍTÓGÉPPEL SEGÍTETT SZÁMONKÉRÉS A NUMERIKUS MÓDSZEREK OKTATÁSBAN

Gábor FÁBIÁN, HU

Absztrakt: A jelenkori informatika oktatásban egyre nagyobb szerepet kapnak az oktatói munkát segítő programozási nyelvek, programkönyvtárak, szoftverek. Bár a programozási és technológiai ismeretek elsajátítását célzó tárgyak oktatásában és számonkérésében ezen eszközök már évek óta jelen vannak, az elméleti ismeretek gyarapításáért felelős matematika központú tárgyak esetében jelentőségük sokszor méltatlanul alulértékelt. Elmélyült matematikai ismeretek átadása talán még a jelen digitális világban sem képzelhető el papír alapú oktatás és számonkérés nélkül, ugyanakkor az évfolyamok évről évre növekvő létszáma miatt a tradicionális zárthelyi dolgozatok összeállítása és javítása nagy feladat elé állítja az oktatókat. Jelen tanulmányban ismertetünk néhány eszközt, melyek lehetőséget nyújtanak algoritmikusan megoldható matematikai példák előállítására, számonkérésére és automatikus értékelésére. Áttekintjük, hogy az Eötvös Loránd Tudományegyetem Informatika Karán oktatott Numerikus módszerek tárgy számonkérési módszerei hogyan változtak a 2020-ban kényszerűségből bevezetett online oktatás során. Arra keressük majd a választ, hogy számonkérhető-e megnyugtató részletességgel egy matematika alapú tárgy online módon. Összehasonlítjuk egymással a papír alapú és az online kvíz alapú feladatokat, valamint megvizsgáljuk a hallgatóság véleményét és eredményeit az új számonkérési formával kapcsolatban.

Kulcsszavak: numerikus módszerek, számítógéppel segített oktatás

COMPUTER AIDED ASSESSMENTS IN TEACHING NUMERICAL METHODS

Abstract: Programming languages, libraries, and software that help the work of teachers play an increasingly important role in today's IT education. Although these tools have been present for years in the teaching and tests of programming courses, their importance in the case of mathematics-based courses is often inevitably underestimated. The transfer of in-depth mathematical knowledge may not be feasible even in today’s digital world without paper-based education and assessments.

However, due to the yearly increasing number of students, designing and correcting in-class tests poses a major challenge for educators. In this paper, we present some tools that allow the generation and automatic evaluation of algorithmically solvable mathematical exercises. We overview how the methods of assessments changed last year in the case of Numerical Methods courses taught at Faculty of Informatics of Eötvös Loránd University. We will look for the answer to whether a mathematics-based subject can be tested in satisfying details online. We compare paper-based and online quiz-based tests and examine the opinions and results of students regarding the new form of assessment.

Keywords: numerical methods, computer-aided teaching

1 Bevezetés

2020 márciusának elején Magyarországon a COVID-19 világjárvány miatt bezártak az egyetemek, az oktatás ezután csak távoktatás formájában valósulhatott meg [1]. A budapesti Eötvös Loránd Tudományegyetem a március 12-23. közötti időszakot tűzte ki az online oktatásra történő átállásra [2]. Az Informatikai Kar Numerikus Analízis Tanszékén oktatott tárgyak esetében is aránylag zökkenőmentesen megtörtént az átállás, és ennek korai mivolta miatt már az első zárthelyi dolgozatokat is online módon kellett lebonyolítanunk. Az Informatikai Karon oktatott kurzusok egy részében már évekkel ezelőtt megkezdődött a Canvas LMS rendszer használata [3], aztán a távoktatásra való váltás hatására sok olyan kurzus oktatója is a rendszer lehetőségeinek igénybevétele mellett döntött, aki korábban egyáltalán nem használta azt. Így történt ez a Numerikus Analízis Tanszéken, ahol a matematika központú tárgyak túlsúlya miatt sokaknak feleslegesnek tűnt a Canvas használata, hiszen a legtöbb kurzus oktatása és számonkérése is papír alapú. Ráadásul sokan rendelkeznek olyan Excel-táblázatokkal, melyek segítik a követelmények ellenőrzését és a hallgatói eredmények értékelését, ezek a funkciók a Canvas-ben pedig csak részlegesen használhatók.

A matematika központú tárgyak esetében nehezen megkérdőjelezhető a papír alapú oktatás és számonkérés fontossága, hiszen sok feladatnál nem feltétlenül a végeredmény, hanem az ennek meghatározásához szükséges egymásra épülő lépések megértése és végrehajtásának képessége az, ami igazán érdekli az oktatót. A Numerikus Analízis Tanszék által oktatott nagylétszámú kurzusok számonkéréseinek egységessége érdekében sok esetben évfolyamzárthelyiket alkalmazunk, melyek esetenként 300-400 hallgatót is érinthetnek. A zárthelyit összeállító oktatónak ekkor érdemes arra törekednie, hogy a feladat megoldásában a hallgatónak ne legyen túlzott szabadsága, hiszen a sokféle megoldási lehetőség sokféle értékelési lehetőséget kíván, amely az egységesség fenntartását jócskán megnehezíti. Emiatt a feladatok sokszor algoritmikusan megoldhatók, ebből következően azok összeállítását és kiértékelését is többé-kevésbé algoritmikussá lehetne tenni.

A következőkben áttekintjük, hogy hogyan változtattuk meg az ELTE-IK programtervező informatikus képzésén a Numerikus módszerek gyakorlatok zárthelyi dolgozatait. A 2. fejezetben röviden összefoglaljuk a korábbi, papír alapú számonkéréssel kapcsolatos problémákat, a 3. fejezetben áttekintjük, mely eszközök voltak segítségünkre feladatok tervezésénél. A 4. fejezetben egy minta feladaton keresztül vizsgáljuk meg, hogy milyen módon változott a számonkérés, mikor azt online környezetbe helyeztük, továbbá, hogyan használhatók a 3. fejezetben tárgyalt eszközök feladatok megoldásának automatikus generálására. Az 5. fejezetben áttekintjük, milyenek lettek a 2019-es évfolyam eredményei, továbbá, hogy a hallgatók miként vélekedtek az új számonkérési formáról. Végül összegezzük a tapasztalatainkat, és levonjuk a lehetséges következtetéseket.

2 Motiváció

A papír alapú számonkérések javítása nagyon erőforrásigényes. Az ELTE-IK-n oktatott Numerikus módszerek gyakorlatok létszáma általában 20 fő, de nem szokatlan a 30 főt számláló gyakorlati csoport sem. Egy tanársegéd vagy adjunktus, aki csak gyakorlatokat tart, egy félévben akár 5-6 gyakorlati csoportot is vezethet. Emiatt egy oktatónak egyetlen zárthelyi időszakban akár 120 dolgozatot kell kijavítania, ami darabonként átlagosan 10 perccel számolva akár 20 óráig is eltarthat. Nem csoda, hogy olykor nem sikerül a gyakorlatvezetőknek egy héten belül kijavítani a zárthelyiket, hiszen a javítás mellett a szokásos kutatási és oktatási tevékenységet is végezniük kell.

A papír alapú számonkéréshez általában papír alapú javítási és pontozási útmutató tartozik, amely több szempontból is problémás. Egyfelől, a feladatok megoldását ekkor a zárthelyit összeállító oktató általában számítógép használata nélkül készíti el, mely magában rejti a hibázás lehetőségét. Persze az efféle hibák előfordulásának valószínűsége csökkenthető, ha a megoldást készítő oktató kollégái átnézik a minta megoldásokat, vagy számítógéppel ellenőrzik a számításokat. A másik probléma a papír alapú javítókulccsal, hogy sok esetben az algoritmikusan megoldható feladatoknak is több elfogadható megoldása létezik, melyek mindegyikét – számítógépes segítség nélkül – kidolgozni roppant időigényes feladat volna. Példaképp gondoljuk meg, hogy egy végtelen sok megoldással rendelkező lineáris egyenletrendszer megoldása miképpen történik. Sok helyen – így az ELTE Informatikai Karán tartott lineáris algebrai alapozó kurzuson is [4] – a Gauss—Jordan-elimináció algoritmusát olyan módon tárgyalják, hogy az egyes sorműveleteket megelőzően a hallgató választhatja ki az úgynevezett generáló elemeket. Természetesen a különböző kiválasztási stratégiák különböző mátrixsorozatokat eredményeznek, mások lesznek az egyenletrendszer kötött és a szabad változói, a javító tanárnak pedig rendelkeznie kellene az összes lehetséges megoldással.

3 Felhasznált eszközök

Az alábbiakban áttekintjük, hogy milyen eszközökkel segítettük a 2020. és 2021. évi online számonkéréseket. A zárthelyi dolgozatokat Canvas-kvíz formájában írta a hallgatóság, a feladatok tervezésénél pedig nagy segítségünkre voltak a későbbiekben részletezendő Python könyvtárak.

3.1 Canvas-kvízek

A Canvas rendszerben a kvízkérdések típusa meglehetősen limitált. A munkánk során hasznosnak talált kérdéstípusok a következők voltak.

- Igaz/hamis: igaz és hamis lehetőség választható.
- Feleletválasztós: a megadott válaszlehetőségek közül pontosan egy választható.
- Behelyettesítős: egy szövegdobozba tetszőleges karakterlánc írható, kiértékeléskor az előre megadott helyes sztringekkel kerül összevetésre a szövegdobozba írt szöveg.
- Többszörös behelyettesítős: több, különböző behelyettesítős szövegdoboz egyazon kérdésben.
- Numerikus válasz: egy szövegdobozba numerikus érték írható (előjellel, tizedesponttal), kiértékeléskor a megadott érték numerikusan, előre definiált hibahatár mellett kerül összevetésre az elvárt megoldással.
- Képlet alapú kérdés: hasonló a numerikus válaszhoz, itt azonban a helyes numerikus értéket az oktató explicit módon nem adja meg, az egy egyszerű képleten keresztül kerül kiszámításra. A képletbe a feladat szövegezésében definiált változók értékei kerülnek, melyek hallgatóról hallgatóra

változhatnak. A változók értékei pszeudovéletlen módon előre legenerálhatók.

A Canvas-rendszer most felsorolt lehetőségeivel változatos kvízek állíthatók össze, azonban a szimbolikus matematikai számítások számonkérését túlzottan nem könnyítik meg. A tizedestörtekkel végzett numerikus műveletek sok esetben nagyon hasznosak, viszont az absztrakciós képesség növeléséhez nagyon fontos volna szimbolikus számításokat végezni. A komolyabb levezetések, bizonyítások megértéséhez nélkülözhetetlen, hogy a hallgatók jól tudjanak számolni szimbólumokkal, legyen szó akár gyökös kifejezésekről vagy nevezetes konstansokról. Ezek számonkérése a fentiek szerint csak a szöveg alapú behelyettesítős feladatokon keresztül történhetne, viszont már a legegyszerűbb kifejezések esetében is lényegében elképzelhetetlen, hogy a hallgatók által bevitt formulákat szöveg alapon ellenőrizni lehessen. Ezen nehézségek miatt úgy döntöttünk, hogy a lehető legtöbb feladat esetében közönséges tört vagy egész szám alakban kérjük a megoldást. A közönséges törtek bevitele már nem kínált akkora szabadságot, mint a szimbólumokat tartalmazó formuláké, azonban itt is törődnünk kellett azzal az eshetőséggel, hogy a hallgató a megoldás (helyes) kiszámítása után elmulasztotta egyszerűsíteni a törtet.

A numerikus és képlet alapú kérdések is nagyon hasznosak egy-egy feladatban. A használatukat nehezíti, hogy mindkét kérdéstípus esetén egy kvízkérdéshez egyetlen választ tudunk rendelni, pedig szerencsésebb volna, ha többet is lehetne. Összefoglalva tehát, jó lehetőségeket kínál a Canvas-rendszer, de sok mindent meg kellene változtatni ahhoz, hogy egy matematika központú kurzus számonkérését kellően ki tudja szolgálni.

3.2 Python a feladat tervezésben

Egy szokványosnak mondható Numerikus módszerek kurzus feladatainak megoldásához a hallgatóknak birtokában kell lenni a fontosabb lineáris algebrai ismereteknek, és az analízis (kalkulus) megfelelő technikáit is ismerniük kell. Amennyiben az oktató számítógéppel szeretné segíteni a feladatok tervezését és kiértékelését, olyan nyelvet célszerű választania, amelyben az alapvető matematikai operációkon kívül a kalkulus és a lineáris algebra fontosabb műveletei is rendelkezésre állnak. A mi választásunk a Python-ra esett, mely ingyenessége és széleskörű támogatottsága miatt a hallgatóink körében is népszerű. A legfontosabb könyvtárak, amelyeket használtunk a NumPy [5], a SciPy [6], a MatPlotLib [7] és a SymPy [8], melyek évek óta nagymértékben segítik a zárthelyi dolgozatok feladatainak tervezését és megoldásainak előállítását. A legfontosabb vektor és mátrixműveletek a NumPy és a SciPy lineáris algebrai alcsomagjaiban elérhetők, ezekkel főként numerikus ellenőrzéseket szoktunk végezni. Sok esetben akár egy ábra is elegendő ahhoz, hogy eldöntsük, a kitűzött feladatnak van-e megoldása, a függvények ábrázolásához a MatPlotLib PyPlot alcsomagját szoktuk használni. Oktatói munkánk során kiemelkedően hasznosnak találtuk a SymPy csomagot, amely nem csupán szimbolikus aritmetikai számítások elvégzésére alkalmazható, de pontos, szimbolikus lineáris algebrai számítások is végezhetők a csomag segítségével, továbbá függvények deriválása és (egyes esetekben) integrálása is lehetséges. Mindezek mellett a SymPy képes LaTeX-kódot generálni az egyes Python által értelmezhető kifejezésekből, ezért rövid idő alatt akár jegyzet minőségű feladatmegoldásokat tudtunk létrehozni. A megoldások generálása tehát sok típusfeladat esetében automatikusan történt, a feladatot tervező oktató csupán néhány előfeltétel teljesülésének biztosításával segítette a megoldások létrejöttét.

4 Egy minta feladat

Tekintsünk egy szokványos feladatot. A következő példa egy nemlineáris egyenlet megoldásának megkeresését célozza fixpont iteráció használatával [9, 10]. Az iterációs módszer alakját a feladatban rögzítjük, a hallgatónak csak a konvergenciát kell igazolni, illetve a hibabecslést értő módon használnia.

Az $f(x) := x^3 - 2x + 5 = 0$ *nemlineáris egyenlet* $[0,1]$ *intervallumbeli megoldásának meghatározására az alábbi fixpont iterációt használjuk:*

$$x_{k+1} := \varphi(x_k) = \frac{x_k^3 + 2}{5}.$$

Bizonyítsuk, hogy az iteráció konvergens! Hány lépést kell tennünk a 10^{-3} *pontosság eléréséhez?*

A feladat megoldását a következő módon várjuk. Az iteráció konvergenciájához a következőket kell megmutatni.

i) Az $x^3 - 5x + 2 = 0$ egyenletnek van gyöke a $[0,1]$ intervallumon.

ii) A φ függvény a $[0,1]$ intervallumot önmagára képezi.

iii) A φ' deriváltfüggvény abszolút maximuma a $[0,1]$ intervallumon kisebb, mint 1, azaz

$$q \coloneqq \max_{x\in[0,1]} |\varphi'(x)| \ < 1,$$

ahol q az úgynevezett kontrakciós együttható.

Ezután a kívánt 10^{-3} pontosság eléréséhez szükséges lépésszám meghatározható a

$$q^k \cdot (b-a) \leq 10^{-3}$$

egyenlőtlenség (egész értékű) k-ra való megoldásával. Általában a zárthelyi feladatokban a folytonos f függvény valóban jelet vált a kijelölt intervallumon, továbbá φ és φ' monoton függvények, ezért a konvergencia igazolásához szükséges feltételek könnyen ellenőrizhetők.

4.1 Papír alapú értékelés

A fenti minta példa tökéletesen megfelel az ELTE-IK programtervező informatikus képzésén jelenleg oktatott (2018-as tanrend szerinti) Numerikus módszerek 2. zárthelyi dolgozat egy feladatának. A papír alapú zárthelyik esetében a minta feladat megoldását tollal, papírra írva kérjük. Egy 50 pontos zárthelyi esetén egy ehhez hasonló feladatra közelítőleg 10 pontot adunk. A következő táblázatban megtekinthető egy javasolt, reális értékelési útmutató, amelyben az látható, hogy a feladat megoldásáért adható 10 pont hogyan oszlik meg az egyes részfeladatok között.

Részfeladat	Pont
a gyök létezésének igazolása	2
annak belátása, hogy φ önmagára képezi a kijelölt intervallumot	2
φ' kiszámítása	1
kontrakciós együttható meghatározása	2
hibabecslés felírása	1
az elvárt pontossághoz szükséges lépésszám meghatározása	2

Fontos kiemelni, hogy – ahogyan az a feladat szövegezésében is olvasható – a részfeladatok a papír alapú zárthelyi esetében a fenti részletességgel nincsenek feltüntetve. Ez esetben a hallgatónak tudnia kell, hogy melyek azok a lépések, amelyeket el kell végeznie, hogy a feladat által megfogalmazott kérdésre érdemi választ tudjon adni.

4.2 Kvíz alapú számonkérés

A 2019/20-as tanév tavaszi félévének esti tagozatos Numerikus módszerek kurzusában már online kvíz alapú volt a számonkérés. Egy, a fentihez hasonló példát a Canvas-ben rendelkezésre álló eszközökkel nem tudunk számonkérni szem előtt tartva az automatikus javítás lehetőségét és igényét. Ezért úgy döntöttünk, hogy az egyes részszámítások eredményeire kérdezünk rá. Az alábbi táblázatban megtekinthető, hogy egy ehhez hasonló feladat esetében milyen jellegű kvízkérdésekkel tudtuk nagyjából ugyanazokat a számolásokat végrehajtatni a dolgozatot író hallgatókkal. A táblázatban szerepel még, hogy az egyes részfeladatok a Canvas-ben milyen típusú kérdésként jelentek meg, továbbá, hogy milyen alakban vártuk a megoldást.

Feladat	Típus	Bemenet	Pont
Létezik-e fixpontja a $\varphi(x) = \frac{x^3+2}{5}$ függvénynek a [0,1] intervallumon?	Igaz/hamis	Igaz/hamis	1
Létezik-e gyöke az $f(x) = x^3 - 5x + 2$ függvénynek a [0,1] intervallumon?	Igaz/hamis	Igaz/hamis	1
Legyen $\varphi(x) = \frac{x^3+2}{5}$. Határozza meg a $\varphi([0,1])$ intervallum végpontjait!	Többszörös behelyettesítős	Két közönséges tört	2
Legyen $\varphi(x) = \frac{x^3+2}{5}$. Határozza meg a $\varphi'\left(\frac{1}{2}\right)$ értékét!	Behelyettesítős	Közönséges tört	2
Határozza meg a $\varphi(x) = \frac{x^3+2}{5}$ függvény kontrakciós együtthatóját a[0,1] intervallumon!	Behelyettesítős	Közönséges tört	2
Hány lépést kell tennünk a [0,1] intervallumon az $x_{k+1} = \varphi(x_k)$ konvergens iterációval a 10^{-3} pontosság eléréséhez, ha tudjuk, hogy φ az intervallumon kontrakció a $q = \frac{3}{5}$ kontrakciós együtthatóval?	Numerikus	Egész szám	2

Látható, hogy az egyes részfeladatok, és az azokra adható pontok lényegében változatlanok maradtak, mindössze annyi változás történt, hogy a kvízt kitöltő hallgatónak nem feltétlenül kell tudnia, hogy melyek azok a lépések, amelyek elvezetnek a megoldáshoz, hiszen a kvíz végigvezeti azokon. A kompetenciák, amelyek szükségesek a részfeladatok megoldásához pontosan ugyanazok, mint amelyek a papír alapú megoldáshoz szükségesek voltak.

A pontos, papíron történő számolás előtérbe helyezése miatt sok esetben egész számként vagy közönséges törtként vártuk a végeredményt. Az első, 2020-as online számonkérés alkalmával sokan rossz formátumban adták meg a megoldásaikat (pl. közönséges tört alak helyett tizedestört alakban), ezért 2021-től a következőkhöz hasonló figyelmeztető ábrákkal emlékeztettük a hallgatókat a helyes formátum megtartására.

Írja a kontrakciós együtthatót *közönséges tört* alakban a szövegdobozba! Csak a numerikus karaktereket használja, valamint a / és a − szimbólumokat. Ne használjon szóközöket! Egyszerűsítse a törtet, egész szám esetén ne használja a / jelet!

Írja a becsült minimális lépésszámot *egész szám* alakban a szövegdobozba! Csak a numerikus karaktereket használja, valamint a − jelet, ha szükséges. Ne használjon szóközöket!

4.3 Automatikus megoldás

A minta példához hasonló feladatok megoldásának automatikus generálásához a SymPy csomagot használtuk. A következő Python kódrészletben azt illusztráltuk, hogy a fenti feladat megoldása milyen egyszerűen előállítható SymPy függvények segítségével. Az egyszerűség kedvéért azzal a feltételezéssel éltünk, hogy φ és φ' monoton függvények.

```
from sympy import *
x=symbols('x')

# Fixpont-iterációs feladat automatikus megoldása,
# feltételezve, hogy phi és phi' monoton függvények.

def fixedpoint(f,phi,a,b,d):
    # Bolzano-tétel => ha a folytonos f függvény jelet vált
    # az [a,b]-n, akkor van gyöke az intervallum belsejében.
    f_a,f_b=f.subs(x,a),f.subs(x,b)
    if f_a*f_b<0:
        # phi([a,b]) kiszámítása:
        phi_a,phi_b=phi.subs(x,a),phi.subs(x,b)
        A,B=min(phi_a,phi_b),max(phi_a,phi_b)
        # Igaz-e, hogy phi : [a,b] -> [a,b] típusú?
        if a<=A and B<=b:
            # A derivált, phi' kiszámítása:
            dphi=phi.diff(x)
            # A kontrakciós együttható kiszámítása:
            q=max(abs(dphi.subs(x,a)),abs(dphi.subs(x,b)))
            # Igaz-e, hogy phi kontrakció?
            if q<1:
                # Ha mindhárom feltétel teljesül, az iteráció
                # konvergens. A kívánt pontossághoz szükséges lépésszám:
                k=ceiling((log((b-a)*10**d) / log(1/q)))
                print(k)

f=x**3-5*x+2
phi=(x**3+2)/5
a,b,d=0,1,3
fixedpoint(f,phi,a,b,3)
```

A fenti kódot könnyen alkalmassá tehetjük LaTeX-kód generálására a megfelelő szöveges kimenetek elhelyezésével. Jelen kód módosításával generáltuk az alábbi LaTeX kimenetet.

```
\begin{enumerate}[i)]
    \item $f(0)=2$ és $f\left(1\right)=-2$, ezért az $f(x)=x^{3} - 5 x + 2$
    függvénynek a Bolzano-tétel miatt van gyöke a(z) $\left[ 0, 1 \right]$
    intervallumon.
    \item $\varphi\left( \left[ 0, 1 \right] \right) = \left[ \frac{2}{5},
    \frac{3}{5} \right] \subset \left[ 0, 1 \right]$, vagyis $\varphi$ a(z)
    $\left[ 0, 1 \right]$ intervallumot önmagára képezi.
    \item $\max \left\{\frac{3 x^{2}}{5}~~ | ~~ x \in\left[ 0, 1 \right]
    \right\} = \frac{3}{5} =: q, $ ezért $\varphi$ kontrakció a kijelölt
    intervallumon, $q=\frac{3}{5}$ kontrakciós együtthatóval.
\end{enumerate}

A fentiek alapján az $x_{k+1} = \varphi(x_k)$ iteráció valóban konvergens.
A hibabecslés:
\[ \left| x_k - x^* \right| \leq \left(\frac{3}{5}\right)^k \cdot \left( 1 -
0 \right). \]
Továbbá, mivel
\[ \left(\frac{3}{5}\right)^k \cdot 1 \leq 10^{-3} ~~ \Longleftrightarrow ~~
\frac{\ln\left( 1 \cdot 10^{3} \right)}{\ln\left(\frac{5}{3}\right)} \leq k
~~ \Longleftrightarrow ~~ k \geq 14, \]
 ezért legalább 14 lépést kell tennünk a $10^{-3}$ pontosság eléréséhez.
```

A fenti LaTeX-kód (a megfelelő környezetbe helyezve) fordítás után a következő kimenetet eredményezi.

i) $f(0) = 2$ és $f(1) = -2$, ezért az $f(x) = x^3 - 5x + 2$ függvénynek a Bolzano-tétel miatt van gyöke a(z) $[0, 1]$ intervallumon.

ii) $\varphi([0, 1]) = \left[\frac{2}{5}, \frac{3}{5}\right] \subset [0, 1]$, vagyis φ a(z) $[0, 1]$ intervallumot önmagára képezi.

iii) $\max\left\{\frac{3x^2}{5} \mid x \in [0, 1]\right\} = \frac{3}{5} =: q$, ezért φ kontrakció a kijelölt intervallumon, $q = \frac{3}{5}$ kontrakciós együtthatóval.

A fentiek alapján az $x_{k+1} = \varphi(x_k)$ iteráció valóban konvergens. A hibabecslés:

$$|x_k - x^*| \leq \left(\frac{3}{5}\right)^k \cdot (1 - 0).$$

Továbbá, mivel

$$\left(\frac{3}{5}\right)^k \cdot 1 \leq 10^{-3} \quad \Longleftrightarrow \quad \frac{\ln(1 \cdot 10^3)}{\ln\left(\frac{5}{3}\right)} \leq k \quad \Longleftrightarrow \quad k \geq 14,$$

ezért legalább 14 lépést kell tennünk a 10^{-3} pontosság eléréséhez.

Ezzel tehát a feladat megoldása olvasható, azonnal közzétehető, az oktató részéről további munkát nem igényel, legfeljebb az előfeltételek teljesülésének ellenőrzését.

5 Összefoglalás

A következőkben összefoglaljuk a 2019/20-as tanévben szerzett tapasztalatainkat az online kvíz alapú zárthelyik bevezetése kapcsán. Az esti tagozatos évfolyam tehát a 4.2 fejezetben bemutatott számonkérési formával találkozott, míg az évfolyam nappali tagozatos hallgatói a 4.1 részben tárgyalt szokásos papír alapú zárthelyi dolgozatot írták meg. A következő alfejezetben összevetjük a két évfolyamzárthelyi eredményét.

Az új típusú számonkérés bevezetésekor fontosnak találtuk kikérni a hallgatóság véleményét, ezért az estisek 2020-as 1. zárthelyi dolgozatának utolsó feladatában három aspektusban minősítettük az új számonkérési formát. A véleményezés eredménye szintén a következő alfejezetben található.

5.1 Eredmények és fogadtatás

Esti tagozaton 62 hallgatóból 12 nem írt, ezzel szemben nappali tagozaton 48 hallgatóból mindenki megírta az első zárthelyit. Mindkét esetben 50 pontos volt a dolgozat. Az eredményekről készült statisztika megtekinthető a következő táblázatban.

	2019/20 esti tagozat (online számonkérés)	2019/20 nappali tagozat (papír alapú számonkérés)
Átlag	30,9	36,0
Szórás	9,3	7,9
Minimum	15,0	21,0
Alsó kvartilis	21,4	31,3
Medián	32,5	37,0
Felső kvartilis	38,1	43,0
Maximum	48,0	46,0

Látható, hogy a nappalis dolgozatok jobban sikerültek, azonban eddigi tapasztalataink alapján ez a tendencia általános. Valószínűleg ez annak köszönhető, hogy az esti tagozatos hallgatók nagy része az egyetemi képzés mellett dolgozik, míg a nappalisok túlnyomó többsége kizárólag az egyetemi tanulmányaira koncentrál. Ha azonban csak a számokat tekintjük, a 30 pont feletti átlag és medián, valamint a 20 pont feletti alsó kvartilis – amely az elégséges ponthatára felett van – elfogadható, reális eloszlásról árulkodik.

Az estis hallgatók három kérdésre válaszolhattak a zárthelyi kvíz beadása előtt. Ezek a dolgozat nehézségére, a megoldásra fordítható időre, valamint a kérdések átfogó mivoltára vonatkoztak. Minden kérdésre 1 és 10 közötti pontot lehetett adni. A zárthelyit 31 hallgató véleményezte, az ezek alapján készült statisztika megtekinthető a következő táblázatban.

Kérdés	Átlag	Szórás
Mennyire találta nehéznek a zárthelyit?	6,3	1,5
Mennyire találta elegendőnek a zárthelyi megírására fordítható időt?	7,5	2,8
Mennyire mérte átfogóan a zárthelyi az első zh-hoz szükséges tudásanyagot?	9,0	1,1

A fentiek alapján a hallgatók közepesen nehéznek és kifejezetten átfogónak találták a zárthelyit, a kitöltésre fordítható időt viszont többen kevésnek találták.

Mindent összevetve az első online zárthelyi dolgozat sikeres volt, a 2. és a javító zárthelyiket, valamint a gyakorlati jegy utóvizsgát is ugyanígy bonyolítottuk. A 2020/21-es évfolyamban is ezt a számonkérési módot alkalmaztuk, és folyamatosan törekszünk javítani annak színvonalát.

5.2 Összegzés, további célok

Már a második tanévben alkalmaztuk sikeresen a teljesen online Canvas-kvíz alapú számonkérést a Numerikus módszerek oktatásban. Eddigi tapasztalataink alapján hisszük, hogy lehetséges olyan színvonalasan és széleskörűen számonkérni matematika alapú tárgyakban szerzett ismereteket számítógépes tesztekkel, mint papír alapon. Mindazonáltal megjegyezzük, hogy jelen tanulmány nem kíván a papír alapú oktatás ellen érvelni. Nagyon fontos része a matematika oktatásnak a papíron történő számolás, levezetés, azonban fejlett számítógépes eszközökkel elérhető a feladatok generálása, és a hallgatók irányítása, hogy ők maguk lehetőleg számítógépes segítség nélkül oldják meg a kijelölt részfeladatokat.

A Canvas LMS sajnos nem alkalmas a matematikai képletek kezelésére, ezért az új számonkérési módban a hallgatók munkája irányított, nem feltétlenül kell tudniuk, mely lépések vezetik őket a megoldáshoz, hiszen az ahhoz vezető út már magában a tesztben jelen van. Ez kétség kívül egy, a későbbiekben kiküszöbölendő probléma. Viszont a kifejezetten szimbolikus matematikai jellegű dolgozatok íratásához egy új, a Canvas-től különböző rendszerre volna szükség, amely a szöveges bemeneteknél lényegesen bonyolultabb képletek értelmezésére és összehasonlítására is képes. Az efféle rendszer azonban – jelen tanulmány szerzőjének ismeretei szerint – még várat magára.

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VÝSKUM TEORETICKÝCH VEDOMOSTÍ A PSYCHOMOTORICKÝCH ZRUČNOSTÍ ŽIAKOV V TECHNICKOM VZDELÁVANÍ

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Abstract:
Vedecká štúdia je zameraná na riešenie výskumu korelácie teoretických vedomostí a psychomotorických zručností pri riešení technických problémových úloh v nižšom strednom vzdelávaní. V technických predmetoch v základnej škole sa žiaci oboznamujú nielen s teoretickými informáciami, ale dôraz sa kladie najmä na osvojenie si zručností v psychomotorickej oblasti. Cieľom vedeckej štúdie je charakterizovať psychomotorické zručnosti. V druhej časti štúdie uvádzame návrh praktických problémových úloh pre žiakov 7. ročníka na nižšom strednom vzdelávaní. Následne sme realizovali pedagogický výskum zameraný na zistenie nielen úrovne nadobudnutých zručností u edukantov v kognitívnej a psychomotorickej oblasti vzdelávania, ale i vplyv teoretických vedomostí na osvojovanie praktických zručností žiakmi 7. ročníka základnej školy.

Keywords: technika, zručnosti, žiak, vedomosti, základná škola

RESEARCH OF THEORETICAL KNOWLEDGE AND PSYCHOMOTOR SKILLS OF PUPILS IN TECHNICAL EDUCATION

Abstract:
The scientific study is focused on solving research on the correlation of theoretical knowledge and psychomotor skills in solving technical problem problems in lower secondary education. In technical subjects in primary school, students are not only acquainted with theoretical information, but the emphasis is mainly on the acquisition of skills in the psychomotor field. The aim of the scientific study is to characterize psychomotor skills. In the second part of the study, we present a proposal of practical problem tasks for 7th grade students in lower secondary education. Subsequently, we carried out pedagogical research aimed at finding out not only the level of acquired skills of educators in the cognitive and psychomotor education, but also the influence of theoretical knowledge on the acquisition of practical skills by pupils in the 7th grade of primary school.

Keywords: technique, skills, pupil, knowledge, elementary school

1 Introduction

Potreby slovenského priemyslu si dnes vyžadujú výbornú technickú úroveň a pripravenosť pracovníkov riešiť každodenné technické problémy v praxi. Základné a následne postupné zdokonaľované technické poznatky by si mali žiaci osvojiť na nižšom a vyššom strednom stupni vzdelávania. V minulosti i v súčasnosti viacerí autori problematiku technického vzdelávania skúmali. Zistili, že technické vzdelávanie je naďalej odsúvané na okraj záujmu v súčasnej škole. Kompetentné orgány veľmi často menili samotný obsah technického vzdelávania a časovú dotáciu vyučovania, a to najmä na nižšom strednom vzdelávaní (Pavelka a kol., 2019). Zistený stav problematiky technického vzdelávania má taktiež negatívny dopad na úroveň osvojenia si teoretických a praktických poznatkov potrebných pre úspešné riešenie technických problémov v praxi.

Je potrebné naučiť žiakov vnímať technické úlohy a problémy spojené s modernou informačnou spoločnosťou, vytvoriť im kladný vzťah k technike ako súčasť profesionálnej výchovy. Vyučovanie predmetu technika sa prevažne realizuje v školských dielňach. Výučba v školských dielňach sa vyznačuje tým, že sa žiaci učia aplikovať nadobudnuté teoretické poznatky pri praktických činnostiach. Žiaci spoznávajú a oboznamujú sa s technickými materiálmi, pracovnými nástrojmi a náradím. Skúmajú vlastnosti technických materiálov, z ktorých zhotovujú úžitkové a darčekové predmety, výrobky. Tímová práca a tvorivosť sú dôležitými faktormi pre úspešné riešenie praktických technických úloh. Najmä faktory tvorivosti je potrebné rozvíjať u žiakov pri riešení praktických technických úloh. Treba učiť žiakov pohotovo a ľahko vytvárať náčrty rôznych technických úžitkových a darčekových výrobkov. Žiaci by mali byť schopní vytvárať rôznorodé riešenia tej istej problémovej úlohy. Schopnosť žiakov rozpoznať problémy, zmeniť význam a použitie výrobku, vypracovať detaily riešenia a navrhovať a zhotovovať neobvyklé výrobky sú predpokladom úspešného riešenia nielen typických školských úloh, ale i problémových technických úloh s využitím praktických zručností.

1.1 Vedomosti a zručnosti v technickom vzdelávaní

V technickom vzdelávaní veľký význam majú praktické zručnosti. Aby žiak dokázal disponovať čo najlepšie praktickými zručnosťami pri riešení rôznych praktických úloh, potrebuje najprv nadobudnúť kvalitné teoretické poznatky (vedomosti). Môžeme povedať, že teória má vplyv na nadobudnutie správnych praktických zručností. Ak si žiak osvojí na primeranej úrovni kvalitné poznatky (vedomosti) a praktické zručnosti, bude sa ľahšie orientovať pri riešení náročnejších technických a praktických problémových úloh.

Zvládnutie teórie a praxe a ich vzájomné prepojenie garantuje aj možné úspešné riešenie náročnejších problémových technických úloh. Zručnosti v predmete technika možno nadobúdať v rôznych formách vyučovania. A to najmä pri ručných prácach, pri konštruovaní a experimentovaní a pod. Nadobudnuté teoretické vedomosti v praxi sú vo väčšej miere nepostačujúce. Pre uplatnenie sa na trhu práce je potrebné poznať a verifikovať vzťah teórie k praxi a jej zákonitosti. Vyučovanie predmetu technika slúži k rozvoju schopností a zručností žiakov, ktoré sú potrebné v ich ďalšom živote, pre ich budúce povolanie. Funkcia praktického učenia sa posilňuje skúsenosťami žiakov. Pracovné činnosti a ich rozvoj sú dôležité nielen pre budúce povolania žiakov, ich uplatnenie sa v praxi, ale taktiež sa stávajú motivačným činiteľom (stimulom) k učeniu sa a pokračovaniu v štúdiu na strednej odbornej škole. Žiak v technickom vzdelávaní nadobúda praktické zručnosti v jednotlivých úrovniach učenia. Najprv je žiak pripravený psychicky a fyzicky vykonávať určitú činnosť. Následne opakuje činnosti demonštrované učiteľom. Žiak samostatne vykonáva mechanické činnosti podľa pokynov učiteľa. Ďalej rýchlo a ľahko vykonáva menej komplexné činnosti. Nasleduje úroveň učenia charakteristická už vykonávaním automatických komplexných zložitých činností. A v neposlednom rade nasleduje samostatné automatické vykonávanie činnosti žiakmi a aplikovanie osvojených spôsobov činnosti v nových, neznámych a problémových situáciách. Ak tieto úrovne učenia žiak zvládne už v základnej škole, môžeme povedať, že je pripravený na ďalšie vzdelávanie v súčasnej škole.

2 Návrh problémových praktických úloh pre žiakov nižšieho stredného vzdelávania v predmete technika

Viacerí uznávaní pedagógovia už v minulosti odporúčali taký priebeh vyučovania, pri ktorom je viac aktívny žiak ako učiteľ. V dnešných školách (základných aj stredných) sú rozšírené novšie koncepcie vyučovania. V rámci nich môžeme v technických a odborných predmetoch zadávať žiakom rôzne praktické problémové úlohy. Ide o úlohy, ktoré sú zamerané na nešpecifický transfer podľa Niemierkovej taxonómie vzdelávacích cieľov (Niemierko, 1979). Uvádzame nami navrhnuté praktické problémové úlohy pre predmet technika, ktoré riešili žiaci 7. ročníka základných škôl. Následne boli získané údaje analyzované v rámci pedagogického výskumu.

Problémová úloha č. 1:
Vešiak z kovu je určený na pripevnenie na stenu a následne sa bude využívať na vešanie bundy a pod. Najprv navrhni technický náčrt alebo technický výkres vešiaka. Na zhotovenie vešiaka bude použitý oceľový plech s hrúbkou 2 mm. Medzi základné pracovné operácie potrebné na zhotovenie tohto výrobku patrí meranie a obrysovanie, vŕtanie, rezanie, pilovanie a ohýbanie.
Výstup problémovej úlohy č. 1:
Podľa Niemierkovej taxonómie cieľov, zaradíme problémovú situáciu č. 1 do úloh vyžadujúcich nešpecifický transfer. Táto situácia si vyžaduje aplikovať získané vedomosti pri riešení praktickej problémovej úlohy. Keďže učiteľ vysvetlil a prezentoval žiakom teoretické informácie z oblasti ručného spracovania kovových materiálov.

Takýmto spôsobom sme postupne navrhli ďalšie štyri problémové úlohy, ktoré detailne sme popísali a zrealizovali výstupy.

3 Pedagogický výskum

Cieľom pedagogického výskumu je zistiť, ako dokážu žiaci 7. ročníka aplikovať nadobudnuté teoretické vedomosti pri riešení praktických problémových úloh, resp. ako vedomosti ovplyvňujú výkony žiakov v psychomotorickej oblasti vzdelávania.

3.1 Vymedzenie výskumného problému

Náš výskumný problém špecifikujeme ako relačný výskumný problém: Aký je vplyv teoretických vedomostí na riešenie technických problémových úloh u žiakov v nižšom strednom vzdelávaní? Takto formulovaným výskumným problémom smerujeme k zisťovaniu vzťahu medzi skúmanými javmi (nadobudnuté teoretické vedomosti v predmete technika) a zisťujeme, aký je ich vplyv na efektívne riešenie technických problémových úloh. Ide o vysvetľovanie vzťahu kognitívnymi procesmi a psychomotorickými zručnosťami pri riešení problémových úloh v úrovni učenia špecifický a nešpecifický transfer podľa Niemierkovej taxonómie vzdelávacích cieľov. Po metodologickej stránke sa orientujeme na realizovanie kvantitatívneho výskumu, kde vzťah medzi danými javmi zisťujeme prostredníctvom výskumných metód a nástrojov.

3.2 Cieľ, úlohy a hypotézy výskumu

Hlavným cieľom výskumu bolo zistiť, aké výkony dosahujú žiaci po nadobudnutí teoretických poznatkov pri riešení praktických problémových úloh v jednotlivých krajoch v SR. Ďalším čiastkovým cieľom bolo zistiť, či existujú rozdiely vo výkonoch žiakov pri riešení praktických problémových úloh v rámci štyroch krajov v SR. Predmetom výskumu boli zručnosti, výkony žiakov v psychomotorickej oblasti vzdelávania v závislosti na predchádzajúcich vedomostiach v základných školách vo vybraných regiónoch SR. Výskum bol realizovaný v období september 2019 – jún 2020.

Na základe formulovaného výskumného problému a cieľa výskumu sme zadefinovali hlavné hypotézy. Stanovené hypotézy sme testovali na hladine významnosti $\alpha = 0{,}05$ (95%).

H_1: Predpokladáme, že žiaci, ktorí dosiahnu skóre vo vedomostnom didaktickom teste, dosiahnu i rovnaké skóre pri riešení praktických problémových úloh. Medzi dosiahnutým skóre žiakov vo vedomostnom didaktickom teste a dosiahnutým skóre v praktickom teste nebude štatisticky významný rozdiel.

H_2: Predpokladáme, že výsledky dosiahnuté žiakmi zo Žilinského, Prešovského, Banskobystrického a Nitrianskeho kraja pri riešení praktických problémových úloh budú rovnaké.

S cieľom operacionalizácie premenných v hlavných hypotézach a ich následné potvrdenie alebo zamietnutie, sme stanovili nasledujúce pracovné hypotézy:

$H_{2,1}$: *Žiaci Žilinského kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Prešovského kraja.*

$H_{2.2}$: *Žiaci Žilinského kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Banskobystrického kraja.*

$H_{2.3}$: *Žiaci Žilinského kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Nitrianskeho kraja.*

$H_{2.4}$: *Žiaci Banskobystrického kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Prešovského kraja.*

$H_{2.5}$: *Žiaci Banskobystrického kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Nitrianskeho kraja.*

$H_{2.6}$: *Žiaci Prešovského kraja dosiahnu pri riešení praktických problémových úloh vyšší výkon v porovnaní so žiakmi Nitrianskeho kraja.*

3.3 Výskumné metódy

Výskumná metóda je súhrnný názov pre súbor postupov, pomocou ktorých sa získavajú dáta v teréne. V našom prípade sme na zber údajov potrebných pre verifikovanie hypotéz použili vedomostný didaktický test, ktorý uvádzame v prílohe B. Didaktický test sme navrhli neštandardizovaný a pri jeho tvorbe sme postupovali podľa Tureka (1997). Ďalej sme navrhli praktické problémové úlohy a ich riešenie žiakmi sme zaznamenávali do pozorovacích hárkov, kde sme každej správnej odpovedi prideľovali potrebné skóre. Pri spracovaní získaných údajov a pri ich interpretácii sme zvolili metódy matematickej štatistiky. Verifikáciu stanovených hypotéz sme realizovali na základe výpočtu testovacej štatistiky a vypočítania p hodnoty. Ak je vypočítaná p hodnota menšia ako hladina významnosti (v našom prípade 95 %), tak nulová hypotéza sa zamietne. Rozdiel zistený vo výskumnej vzorke je štatistický významný. Ak p hodnota je rovná alebo väčšia ako stanovená hladina významnosti, tak nulová hypotéza sa nezamietame (Chajdiak, 2003). Pre štatistickú verifikáciu stanovených hypotéz sme uplatnili základnú popisnú štatistiku, meranie štatistickej závislosti, a neparametrický test (Kruskal-Wallisov test). Koeficient korelácie meria štatistickú lineárnu závislosť medzi hodnotami premenných X a Y (Chajdiak, 2003). V našom prípade meriame štatistickú závislosť medzi vedomosťami a zručnosťami. Kladné hodnoty koeficientu korelácie svedčia o priamej závislosti a záporné hodnoty o nepriamej závislosti.

3.4 Výber a charakteristika výskumnej vzorky

Výskum bol realizovaný v priebehu školského roka 2019/2020 v 10 základných školách v Slovenskej republike. 2 základné školy boli zo Žilinského kraja, 3 základné školy boli z Banskobystrického kraja, 3 základné školy boli z Prešovského kraja, 2 základné školy boli z Nitrianskeho kraja. Výber výskumnej vzorky podliehal zámernému výberu. Na základe dostupných možností a vzhľadom na efektívnosť a ekonomickosť výskumu sme vybrali žiakov 7. ročníka základných škôl. Chráska (2007) uvádza, že rozsah výberu počtu respondentov je možné empiricky odhadnúť na základe určenia jeho minimálnej a maximálnej hodnoty podľa vzťahov:

$n_{min} = 0{,}1\sqrt{n}$ a $n_{max} = \sqrt{n}$

kde n je celkový počet prvkov základného súboru. V našom prípade mal podľa Štatistickej ročenky základný súbor k 15. 9. 2018 rozsah n = 41 046 žiakov 7. ročníka ZŠ. Podľa vyššie uvedených vzťahov by mal byť interval nášho výberového súboru v rozsahu od 20 do 203 žiakov. Výberový súbor v našom výskume tvorilo n = 120 žiakov 7. ročníka základných škôl. Zo Žilinského a Nitrianskeho kraja bolo zahrnutých vo výskumnej vzorke po 30 žiakov (spolu 60 žiakov), z Banskobystrického a Prešovského kraja bolo zahrnutých po 30 žiakov (spolu 60 žiakov).

3.5 Výsledky výskumu

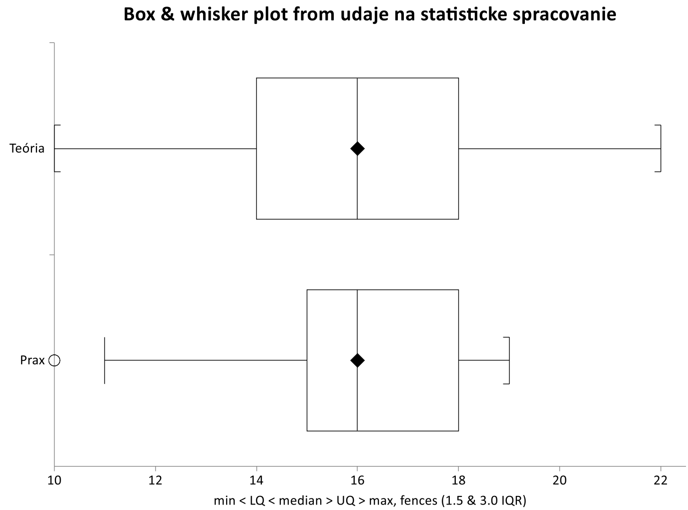
Tabuľka 1 Porovnanie výkonov žiakov v kognitívnej a psychomotorickej oblasti

Variables	**Teória**	**Prax**
Valid data	120	120
Missing data	0	0
Sum	1 950	1 939
Mean	16,25	16,158333
Variance	6,054622	4,537745
Standard deviation	2,460614	2,130198
Variance coefficient	0,151422	0,131833
Standard error of mean	0,224622	0,19446
Upper 95% CL of mean	16,694775	16,543383
Lower 95% CL of mean	15,805225	15,773284
Geometric mean	16,05497	16,005857
Skewness	-0,256164	-0,742019
Kurtosis	2,751176	3,107922
Maximum	22	19
Upper quartile	18	18
Median	16	16
Lower quartile	14	15
Interquartile range	4	3
Minimum	10	10
Range	12	9
Centile 95	20	19
Centile 5	12	12

Zo základnej štatistiky vidieť (Tabuľka 1, Graf 1), že výkony žiakov v kognitívnej oblasti (vedomostný didaktický test) a psychomotorickej oblasti (riešenie praktických problémových úloh) boli dosiahnuté na približne rovnakej úrovni. Pri riešení praktických problémových úloh ani jeden žiak nedosiahol maximálne skóre 19 bodov. Či existuje štatistická závislosť medzi vedomosťami a zručnosťami sme skúmali pomocou regresnej korelačnej analýzy.

Tabuľka 2 Jednoduchá lineárna regresia

Equation: Prax = 0,526371 Teória + 7,604811
Standard Error of slope = 0,063272
95% CI for population value of slope = 0,401074 to 0,651667
Correlation coefficient (r) = 0,608016 (r_2 = 0,369684)
95% CI for r (Fisher's z transformed) = 0,481219 to 0,709892
t with 118 DF = 8,319108
Two sided **P < 0,0001**
Power (for 5% significance) > 99.99%
Correlation coefficient is significantly different from zero



Graf 1 Porovnanie teoretických vedomostí so zručnosťami

Na testovanie závislosti medzi výsledkami vo vedomostnom didaktickom teste a v praktických problémových úlohách sme použili regresnú korelačnú analýzu. Žiaci mohli dosiahnuť maximálne skóre 22 bodov vo vedomostnom didaktickom teste i pri riešení praktických problémových úloh. Na základe tabuľky 6 môžeme konštatovať, že korelačný koeficient bol vypočítaný 0,608, čo predstavuje strednú pozitívnu závislosť medzi výsledkami žiakov ZŠ vo vedomostnom teste a riešeniami praktických problémových úloh.

Pozitívna znamená, že vyššiemu skóre z vedomostného didaktického testu zodpovedá i vyššie skóre z riešenia praktických problémových úloh. Na základe p-hodnoty 0,0001 považujeme korelačný koeficient za štatisticky významný na hladine významnosti 0,05 (95 %). Hypotézu H_1 zamietame. Môžeme povedať, že v 60,8 % prípadov je výkon žiakov v kognitívnej oblasti vzdelávania pozitívne ovplyvňovaný výkonom žiakov v psychomotorickej oblasti vzdelávania, a teda platí, že teoretickým vedomostiam žiakov odpovedajú aj ich praktické zručnosti. Preukázali sme, že medzi výsledkami žiakov ZŠ vo vedomostnom didaktickom teste a v praktických problémových úlohách je štatisticky významná lineárna závislosť. Žiaci, ktorí získali dobré výsledky v teoretickom teste, získali dobré výsledky aj pri riešení praktických problémových úloh. Ďalej nás zaujímalo, aké výkony žiaci dosahujú pri riešení praktických problémových úloh v predmete technika vo vybraných regiónoch Slovenska. Verifikovali sme hypotézu H_1. Správnym riešením praktických úloh žiak mohol získať maximálne 22 bodov hrubého skóre (hs) pri riešení 22 čiastkových praktických úloh. Z popisnej štatistiky (Tabuľka 2) je zrejmé, že žiaci zvládli učivo na nadpriemernej úrovni. Vypočítaný aritmetický priemer a smerodajná odchýlka u žiakov zo Žilinského, Prešovského, Banskobystrického a Nitrianskeho kraja boli vypočítané na intervale spoľahlivosti: dolný interval -95%, horný interval +95%. Z priemeru získaného z nameranej výskumnej vzorky vyvodzujeme informáciu, že vypočítaný aritmetický priemer u žiakov zo Žilinského kraja je z intervalu spoľahlivosti merania od 15,74 po 17,40, u žiakov Prešovského kraja z intervalu spoľahlivosti merania od 14,99 po 16,74, u žiakov Banskobystrického kraja z intervalu spoľahlivosti merania od 15,19 po 16,75 a u žiakov Nitrianskeho kraja z intervalu spoľahlivosti merania 15,38 po 16,75. Môžeme povedať, že žiaci vyriešili praktické problémové úlohy približne na rovnakej úrovni. Najlepší priemer dosiahli žiaci zo Žilinského kraja. Variačné rozpätie u žiakov Žilinského kraja je určené minimálnou hodnotou 10 a maximálnou 19, u žiakov Prešovského kraja je určené minimálnou hodnotou 10, maximálnou 18, u žiakov Banskobystrického kraja je určené minimálnou hodnotou 11 a maximálnou hodnotou 19, a u žiakov Nitrianskeho kraja je variačné rozpätie určené minimálnou hodnotou 12 a maximálnou hodnotou 19.

Medián u žiakov Žilinského kraja bol vypočítaný 18, u žiakov Prešovského kraja 16, u žiakov Banskobystrického kraja 16 a u žiakov Nitrianskeho kraja 16. Čiže polovica žiakov Žilinského kraja dosiahla výkon pri riešení praktických problémových úloh (PPÚ) ≤ 18 bodov a druhá polovica žiakov dosiahla výkon pri riešení praktických problémových úloh (PPÚ) ≥ 18 bodov, taktiež jedna polovica žiakov z Prešovského, Banskobystrického a Nitrianskeho kraja dosiahla výkon pri riešení praktických problémových úloh (PPÚ) ≤ 16bodov a druhá polovica žiakov dosiahla výkon pri riešení PPÚ ≥ 16 bodov. Taktiež z popisnej štatistiky môžeme tvrdiť, že koeficient špicatosti nie je rovný nule a preto konštatujeme, že rozdelenie hodnôt je viac špicatým (nesymetrickým), ako je normálne rozdelenie hodnôt.

Z grafu 2 je možné taktiež vidieť, že dosiahnuté výsledky u žiakov zo všetkých štyroch krajov sa líšia. Z grafu 2 je vidieť, že stredná hodnota súboru u žiakov Žilinského kraja je rovná 28, u žiakov Prešovského kraja je rovná 16 a u žiakov Banskobystrického a Nitrianskeho kraja je rovná 16. Medián je prostredná hodnota, ktorá delí príslušný rad hodnôt na dve približne rovnaké polovice. V prípade symetrického rozdelenia hodnôt je medián zhodný s priemerom. V našom prípade sme zistili, že vypočítaný aritmetický priemer a medián nie sú zhodné. Odchýlky mediánu od priemeru sme namerali veľmi malé, a to u všetkých žiakov zo všetkých krajov. Kvartilové rozpätie reprezentuje oblasť stredných 50 percent hodnôt premenných, t. j. u žiakov Žilinského kraja od 13 do 19, u žiakov Prešovského kraja od 10 do 18, u žiakov Banskobystrického kraja od 12 do 19 a nakoniec u žiakov Nitrianskeho kraja od 13 do 18. Kvartilové rozpätie predstavuje rozdiel medzi tretím a prvým kvartilom (75. a 25. percentilom). Kvartilové rozpätie má význam pri určovaní tzv. vybočujúcich hodnôt (outliers). V našom prípade sme zistili, že okrem súboru žiakov zo Žilinského a Prešovského kraja je v ďalších výskumných súboroch málo vybočujúcich hodnôt mimo intervalu (kvartilového rozpätia).

Tabuľka 2 Popisná (základná) štatistika

Variables	ZA	PO	BB	NR
Valid data	30	30	30	30
Missing data	0	0	0	0
Sum	497	476	479	482
Mean	16,57	15,87	15,97	16,07
Variance	4,94	5,50	4,38	3,37
Standard deviation	2,22	2,34	2,09	1,84
Variance coefficient	0,13	0,15	0,13	0,11
Standard error of mean	0,41	0,43	0,38	0,34
Upper 95% CL of mean	17,40	16,74	16,75	16,75
Lower 95% CL of mean	15,74	14,99	15,19	15,38
Geometric mean	16,40	15,68	15,83	15,96
Skewness	-1,05	-1,01	-0,30	-0,24
Kurtosis	3,49	3,42	2,47	2,06
Maximum	19	18	19	19
Upper quartile	18	18	18	18
Median	18	16	16	16
Lower quartile	15	15	15	15
Interquartile range	3	3	3	3
Minimum	10	10	11	12
Range	9	8	8	7
Centile 95	19	18	19	18
Centile 5	13	10	12	13

Tabuľka 3 Kruskal-Wallisov test

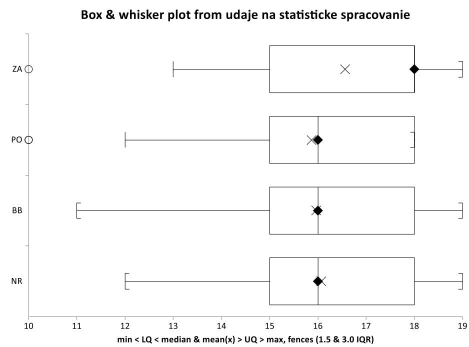
Variables: ZA, PO, BB, NR
Groups = 4 df = 3 Total observations = 120
T = 2,077314 P = 0,5565

Adjusted for ties:

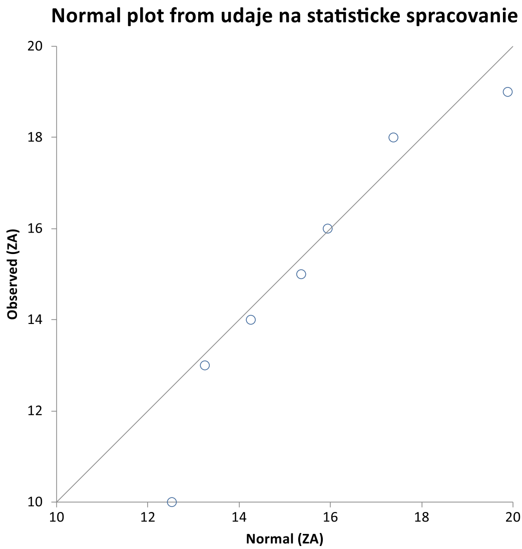
T = 2,225042
P = 0,527

Tabuľka 4 Kruskal-Wallisov test: všetky porovnania

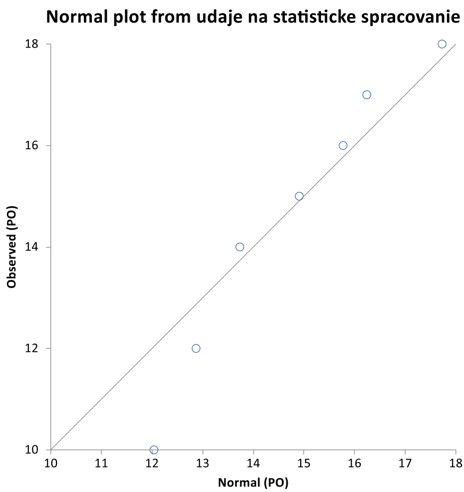
<table>
<tr><td>Critical q (range) = 3,63316</td><td></td></tr>
<tr><td>ZA vs. PO</td><td>not significant</td></tr>
<tr><td>(|-1,95048| > 3,63316)</td><td>P = 0,5124</td></tr>
<tr><td></td><td></td></tr>
<tr><td>ZA vs. BB</td><td>not significant</td></tr>
<tr><td>(|-1,506391| > 3,63316)</td><td>P = 0,7108</td></tr>
<tr><td></td><td></td></tr>
<tr><td>ZA vs. NR</td><td>not significant</td></tr>
<tr><td>(|-1,725646| > 3,63316)</td><td>P = 0,614</td></tr>
<tr><td></td><td></td></tr>
<tr><td>PO vs. BB</td><td>not significant</td></tr>
<tr><td>(|0,085939| > 3,63316)</td><td>P > 0,9999</td></tr>
<tr><td></td><td></td></tr>
<tr><td>PO vs. NR</td><td>not significant</td></tr>
<tr><td>(|0,108066| > 3,63316)</td><td>P = 0,614</td></tr>
<tr><td></td><td></td></tr>
<tr><td>BB vs. NR</td><td>not significant</td></tr>
<tr><td>(|0,107133| > 3,63316)</td><td>P = 0,9998</td></tr>
</table>



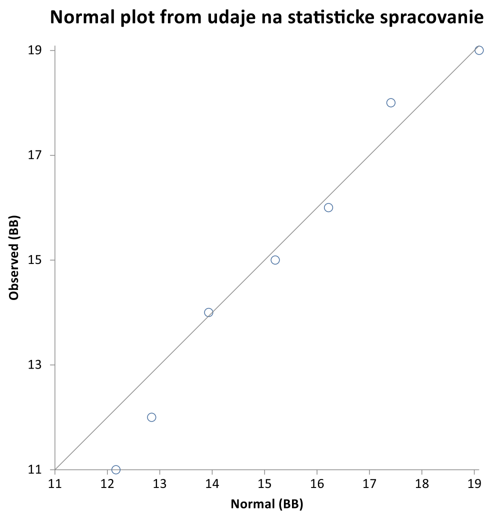
Graf 2 Medián, kvartilové a variačné rozpätie premenných z riešenia praktických úloh u žiakov 7. ročníka



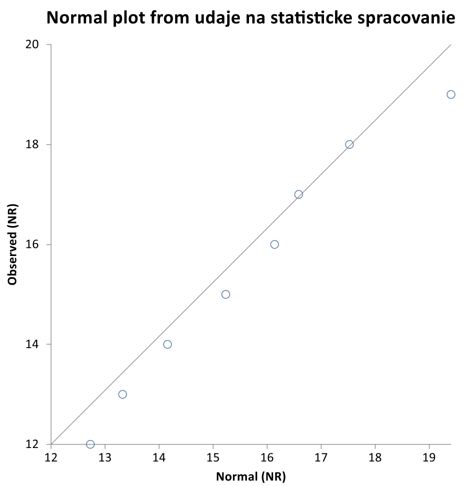
Graf 3 Vyhodnotenie normality náhodných chýb – graf normality rezíduí vo výskumnom súbore (ZA kraj)



Graf 4 Vyhodnotenie normality náhodných chýb – graf normality rezíduí vo výskumnom súbore (PO kraj)



Graf 5 Vyhodnotenie normality náhodných chýb – graf normality rezíduí vo výskumnom súbore (BB kraj)



Graf 6 Vyhodnotenie normality náhodných chýb – graf normality rezíduí vo výskumnom súbore (NR kraj)

Rezíduum je rozdiel medzi skutočnou a odhadnutou hodnotou. V našom prípade majú rezíduá normálne rozdelenie (Graf 3 až Graf 6), lebo graf normality rezíduí vytvoril priamku, resp. podoba normálnych pravdepodobnostných grafov je prijateľná. Aj na základe splnenej požiadavky (rozptyly medzi výskumnými súbormi sa nerovnajú) sme sa rozhodli použiť neparametrický test. Na základe zistených skutočností sme sa rozhodli použiť neparametrický Kruskal-Wallisov test (Tabuľka 8, 9). Hypotézu H_2 zamietame, ak $H \geq \chi^2_{1-\alpha\,(k-1)}$. Pre hladinu významnosti $\alpha = 0,05$ je oblasť zamietnutia určená hodnotou kvantilu $\chi^2_{1-\alpha\,(k-1)} = \chi^2_{0,95(1)} = 3,63316$. To znamená, že hodnota testovacej štatistiky sa nenachádza v oblasti zamietnutia hypotézy H_2. Zistili sme, že vypočítaná p hodnota je príliš veľká hodnota, to znamená, že hypotéza H_2 sa potvrdila na hladine významnosti $\alpha = 0,05$ (95 %). Ďalej sme ešte zisťovali, či existujú štatisticky významné rozdiely aj medzi jednotlivými krajmi. Z toho vyplýva záver, že výkony, ktoré dosiahli žiaci z jednotlivých krajov, nie sú štatisticky rozdielne. Vypočítaná p hodnota je príliš veľká a teda hypotézu H_2 nielen potvrdzujeme, ale záverom môžeme konštatovať, že hypotézy $H_{2.1}$ a $H_{2.6}$ neboli potvrdené. Ako dokladujú výsledky nášho výskumu, že rozdiely medzi žiakmi z jednotlivých krajov sú z popisnej štatistiky rozdielne, no ďalším skúmaním zisťujeme, že medzi výkonmi žiakov z jednotlivých krajov neexistujú štatisticky významné rozdiely.

4 Diskusia a odporúčania

Pedagogickým výskumom sme zistili, že žiaci 7. ročníka ZŠ v jednotlivých samosprávnych krajoch nadobudli približne rovnaké teoretické poznatky, no pri riešení technických problémových úloh vykazujú len menšie nedostatky. Navrhujeme, aby sa väčší dôraz kládol na zadávanie a riešenie technických problémových úloh priamo v edukačnom procese v predmete technika v nižšom strednom vzdelávaní. Túto pozornosť treba venovať už skôr, a to v technickom vzdelávaní detí a žiakov na predprimárnom a primárnom stupni vzdelávania. Problematike nadobúdania zručností u žiakov v psychomotorickej oblasti sa dlhodobo venujú viacerí odborníci. Profesor Ján Bajtoš publikoval niekoľko vedeckých štúdií v danej oblasti. Nielen rozpracoval taxonómiu vzdelávacích cieľov v psychomotorickej oblasti, ale aj detailne rozpracoval a analyzoval kritériá hodnotenia výkonov žiakov v psychomotorickej oblasti. Táto oblasť výskumu v odborovej didaktike je dôležitá. Rozvíjanie a formovanie psychomotorických zručností patrí do všeobecného vzdelávania. V zahraničí sa danej problematike venovali

Flitner (1990) a Hurrelmann (1998). Psychomotorické zručnosti možno nadobúdať v rozličných formách vyučovania. V predmete technika sú to: ručné opracovanie technických materiálov, experimentálna činnosť (skúmanie základných vlastností technických materiálov) a pod. Vyučovanie predmetu technika slúži k rozvoju schopností a zručností žiakov, ktoré sú potrebné pre rôznorodé činnosti v ich ďalšom živote, prípadne pre ich budúce povolanie. Dôležitú úlohu zohrávajú teoretické vedomosti, ktoré môžu veľmi významne vplývať na výkony žiakov v psychomotorickej oblasti. Edukatori by mali na výkony edukantov pôsobiť priaznivo. Podporovať edukantov pri osvojovaní vedomostí a zručností samostatným hľadaním, skúmaním a experimentovaním. Dôležité je viac sa zamerať na úroveň osvojenia zručností, využívať teoretické vedomosti v praktických činnostiach, pracovnú zručnosť. Učiteľ musí dbať na to, aby žiak nadobudnuté teoretické vedomosti vedel aplikovať do praxe, dbať na úroveň odborných zručností, tak, aby jeho pracovná zručnosť bola hodná uplatnenia na trhu práce. Preto je dôležité, aby učiteľ správne hodnotil a kontroloval pripravenosť žiaka na vyučovanie, kvalitu a rozsah intelektuálnych spôsobilostí a návykov, motorických zručností, osvojené vedomosti a zručnosti, aktivitu, teoretické vedomosti. Učiteľ by sa mal zamerať na to, aby žiaci v priebehu vyučovania boli informovaní o tom, čo sa od nich očakáva, inak sa ich iniciatíva k učeniu bude znižovať. Pri hodnotení psychomotorických zručností v závislosti od povahy vyučovacieho procesu je treba mať na pamäti aj vhodný výber úrovne taxonómie. Problémové úlohy je dobre zamerať na všetky úrovne učenia v psychomotorickej oblasti vzdelávania. V súčasnej škole veľký význam majú úlohy zamerané na vyššie úrovne učenia podľa Simpsonovej taxonómie vzdelávacích cieľov. Dôležité sú úrovne učenia, adaptácia činností a tvorivá činnosť. Zo zistených a spracovaných údajov v rámci riešenia danej problematiky odporúčame:

- Navrhovať a vytvárať kvalitné učebné texty žiakov tak, aby mali čo najväčší vplyv na dosahovanie výkonov v psychomotorickej oblasti vzdelávania, pri riešení typických i problémových školských úloh.
- Pri riešení praktických úloh preniesť aktivitu na žiakov, učiteľ by mal vystupovať ako pomocník a konzultant.
- Aplikovať do edukačného procesu čo najviac aktivizujúcich metód, ktoré by pomohli žiakom rozvíjať technické myslenie a tvorivosť.

Riešenú problematiku nepovažujeme za uzavretú. Existuje priestor na detailnejšie preskúmanie vzťahov vedomostí a zručností vo vyučovaní technických odborných predmetov.

Vedecká štúdia bola vypracovaná s podporou projektu VEGA 1/1047/19 pod názvom Výskum miery korelácie medzi vedomosťami a zručnosťami riešiť technické problémy v odbornom a technickom vzdelávaní.

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STUDENTS' ATTITUDES TO THE USE OF MS TEAMS/G-MEET IN UNIVERSITY MATHEMATICS TEACHING

Mária MIŠÚTOVÁ, Martin MIŠÚT SK

Abstract: Due to the COVID-19 pandemic, it was necessary to move teaching to virtual space. The forms and methods of teaching used in full-time teaching have mostly been transferred to online teaching. However, this approach has been the cause of many problems, which have often resulted in a reduction in the quality and effectiveness of education. Therefore, we have started working on a project whose main goal was to develop and validate innovative online teaching models. A prerequisite for success in designing a model is, in addition to its effectiveness, its acceptance by students. The paper, therefore, describes students' attitudes to online education through applications as the starting point in new teaching methods design.

The presented research had two primary goals. The first goal was to find out students' attitudes to the exercises realized through the MS Tea/Google Meet application. Students' attitudes towards online teaching were identified by the students' activity within the subject Mathematics I. By students activities were also identified the students' opinions on the usability and applicability of the acquired knowledge. Another goal of the research was to find out whether gender influences students' perceptions of online teaching. At the same time, we wanted to verify the results of previous research on a larger group of respondents. They predicted the influence of gender on students' attitudes to online teaching. **The obtained results indicate that students' attitude to online exercises and full-time exercises is the same - positive in the whole group of respondents. In addition, the prediction of previous research that gender influences students' attitudes to online exercises have been confirmed. Women prefer face to face exercises, while men prefer online exercises.**

Keywords: MS TEAMS, G-Meet, e-assessment, attitude, mathematics, digital technologies, online education.

1. Introduction

In the last two years, educational institutions have faced a considerable challenge of shifting teaching from classrooms to online. However, if the forms and methods used in face-to-face teaching are also used in distance teaching, their effectiveness may be lost [1]. Therefore, it is necessary to develop innovative models of online teaching [2]. Our project aims to design, verify, and implement innovative online teaching models of mathematics and computer science subjects, emphasizing increasing educational outcomes. The focus is on the student who is to become a flexible, creative graduate/engineer with critical thinking, able to solve problems, constantly learn and work in a team. The target group consists of students of the Faculty of Materials Technology SUT, and the Faculty of Economic Informatics of the EU.

Project solving has led to finding out students' attitudes to online education by identifying the required learning outcomes to designing a model of online teaching using digital technologies and emphasizing cross-cutting competencies. Project results will include recommendations on how to teach effectively online as well as e-learning courses. This paper describes the results of the first part of the research project.

Exercises are an essential part of an effective learning process [3]. Recently, due to the Covid 19 pandemic, the role of MS TEAMS/Google Meet technologies in teaching have increased. Many education professionals and education experts are currently solving how to ensure teaching in higher education to maintain the quality of education. Acceptability is a required quality for reliable online education [4]. However, it still seems necessary to examine what students think and feel in this type of education.

The growing number of reports on online forms of training courses is not surprising given the potential benefits of this approach. These include (compared to traditional methods of education) cost and time savings due to access any location; space to provide feedback that can have pedagogical benefits; increasing the level of student activity due to the relative novelty and attractiveness of this approach; increased flexibility, such as allowing students to submit assignments at a distance without having to come to the school's headquarters [5]. Some studies have tried to measure attitudes and perceptions of online learning methods, e.g. the authors in [6] proposed a model that predicts students' attitudes to online education. However, there is a clear need for further studies to examine students' attitudes, perceptions and preferences concerning online learning methods.

Numerous research studies have shown that the use of digital technologies helps to improve the educational process [3, 7-12].

2. Research goals and methodology

The research had two main objectives. The first goal was to find out students' attitudes to the exercises realized through the MS TEAMS / Google Meet application. Students' attitudes to online education were identified by students' activity in the subject and students' views on preference, applicability in the study of other subjects, the amount and usefulness of acquired knowledge and skills. Another goal of the research was to find out whether gender affects students' perception of online education. Based on the above objectives, we have defined the following research questions:

- What is the semantic profile of face-to-face exercises and exercises through the MS TEAMS / Google Meet application regarding selected factors in the whole group of respondents?
- What is the semantic profile of face-to-face and MS TEAMS / Google Meet exercises for the men and women?

We used a questionnaire based on Likert scales to answer the research questions. Attitudes towards the subjects were measured using several 5-point scales in terms of selected factors. A value of 1 corresponded to a negative attitude, and a value of 5 on a 5-point scale corresponded to a positive attitude. Based on the completed questionnaire, we created a semantic profile of exercises from the subject Mathematics 1 regarding factors: Preference, Applicability in the study, the Volume of acquired knowledge and Usefulness.

Preference was expressed by whether students were satisfied with more exercises through MS TEAMS / GOOGLE MEET or face-to-face exercises. Applicability expresses the recommendation of students to use online exercises in further study. The Volume of knowledge expresses the student's opinion on whether they will learn more in online exercises than in face-to-face exercises. Usefulness is expressed by whether students consider the exercises through the MS TEAMS / GOOGLE MEET application more beneficial than face-to-face exercises.

The group of respondents consisted of 185 first-year students of the bachelor's study programs: Industrial Management, Quality Production, Personnel Policy in Industrial Plant, Integrated Safety, Production

Technologies, Materials Engineering, Production Technologies nad Production Management, Production Devices and Systems. At the end of the semester, we asked students to fill out an anonymous e-questionnaire. The return rate of the questionnaire was 51%. The questionnaire was completed and submitted by 95 students. Of these, 25% were women, and 75% were men.

T-test using SPSS was used for statistical verification.

3. Research results and discussion

3.1. Results for the whole group of respondents

The overall results showed (Fig.1) that students' attitude to online exercises and face-to-face exercises is the same in the whole group of respondents. Although the mean value assigned to online exercises in three of the four factors (Preference, Applicability, Usefulness) (M_P = 3.83, M_A = 3.76, M_U = 3.96), it was higher than the mean value assigned to face-to-face exercises (M_P = 3.65, M_A = 3.54, M_U = 3.66) the difference was not statistically significant in either factor. (p = 0.406, p = 0.319, p = 0.088) The value of p is always> 0.05. Surprisingly, compared to previous research, the "Volume of knowledge" factor had a higher average value for face-to-face exercises. (M = 3.75) as for online exercises. (M = 3.51) However, the difference was not statistically significant. Students expressed that they will acquire the same amount of knowledge in face-to-face exercises as in online exercises. (p = 0.213) We used Paired Sample T-test using SPSS for verification.

The average values of all four factors used to determine students' attitudes to teaching through MS TEAMS / G-Meet are higher than value three on the Likert scale, which represents a positive attitude (a value of three represents a neutral attitude and a value less than three an attitude negative). Based on the above, it can be stated that students have a positive attitude to online exercises.

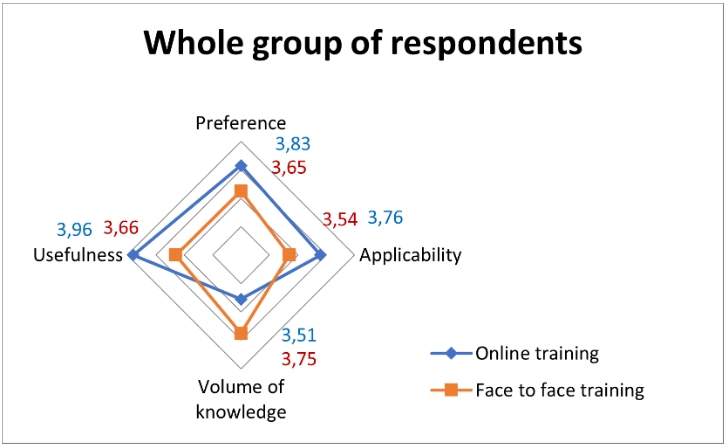

Figure 6 Semantic profile of training in the whole respondents group

3.2. Results for a group of men and women

The situation is different in students' attitudes to the exercises conducted through MS TEAMS / GMEET in a group of men. (Fig.2) The average value assigned to the Applicability factor for online exercises (M = 3.9) was higher than the average value assigned to this factor for face to face exercises (M = 3.35). The difference was statistically significant ($p = 0.027$, $p < 0.05$). Men recommend online exercises to use more in the next study than face to face exercises. Online exercises are also considered more useful (M = 3.89) than face-to-face exercises (M = 3.49). The difference in the average values assigned to the Usefulness factor was also statistically significant ($p = 0.046$). Although men assigned a higher mean value to the Preference factor of online exercises (M = 3.87) than to the face-to-face exercise (M = 3.46), the difference in values was not statistically significant ($p = 0.098$, $p > 0.05$). In the male group as well as in the whole group, a higher mean value was assigned to the Volume of knowledge factor of the face to face exercise (M = 3.58), compared to this factor of online exercise. (M = 3.49). However, the difference was not statistically significant. ($p = 0.709$) We used Paired Sample T-test using SPSS for verification.

Based on the above, it can be stated that both forms of exercise are equally suitable for men, and the Volume of acquired knowledge is independent of the form of exercises. Men stated that the Volume of acquired knowledge in online exercises is the same as in face-to-face exercises.

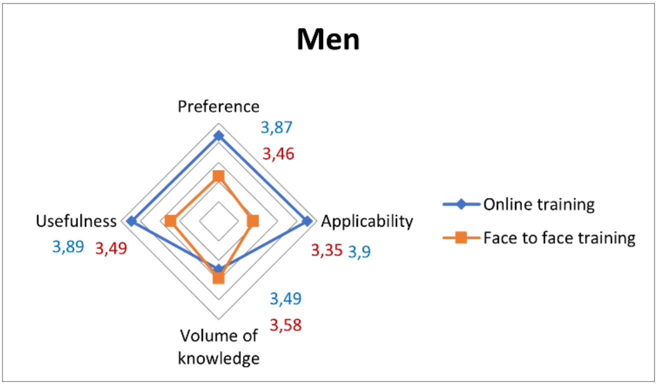

Figure 7 Semantic profile of training in the group of Men

As shown in Figures 1 and 2, the semantic profile of online exercises and face-to-face exercises in a group of men is visually similar to the semantic profile of the entire group of respondents. In the group of women, the semantic profile differs (see Fig. 3). Women assigned higher values to three of the four factors (Preference, Applicability, Volume of knowledge) face to face exercises (M_P = 4.21, M_A = 4.08, M_V = 4.25) compared to online exercises. . (M_P = 3.71, M_A = 3.3, M_V = 3.54) However, in neither case was the difference statistically significant. (p = 0.252, p = 0.107, p = 0.064) We used a Paired Sample T-test using SPSS for verification. In the Usefulness factor, the assigned average values even matched to 2 decimal places. ($M_{Uonline}$ = M_{Uface} = 4,17) Based on the above, it can be stated that women have the same attitude to online exercises and face to face exercises.

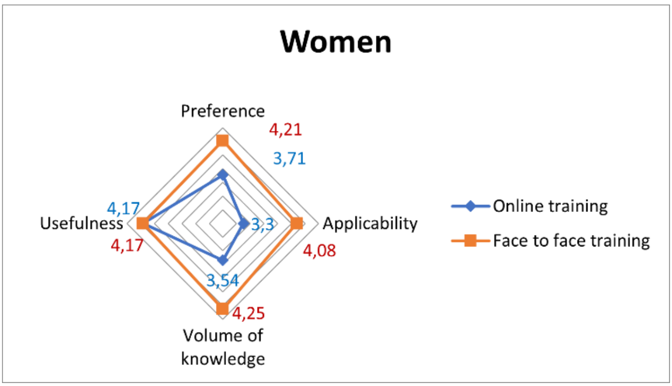

Figure 8 Semantic profile of training in the group of women

We used the Independent Sample T-test to compare the mean values in the group of men and women assigned to each factor online and face to face exercises.

As can be seen from Figure 4, men assigned a higher value ($M = 3.87$) to the Preference factor for online exercises than women ($M = 3.71$) and the difference in mean values was statistically significant ($p = 0.046$). Figure 5 shows that the same factor Preference for face to face exercise was assigned a higher value by women ($M = 4.21$) than men ($M = 3.46$). The difference in average values was again statistically significant ($p = 0.014$). Based on these results, it can be stated that women prefer face to face exercises, while men prefer exercises online. We got a similar result in the Applicability factor for online exercises. Men assigned a higher value to the factor ($M = 3.9$) than women ($M = 3.3$). The difference in average values was statistically significant ($p = 0.043$).

The factors Usefulness and Volume of knowledge were assigned a higher average value of women ($M_U = 4.17$, $M_V = 3.54$) for online exercises compared to men ($M_U = 3.89$, $M_V = 3.49$), but the difference was not statistically significant ($p = 0.986$, $p = 0.401$). women also assigned a higher average value to these factors (Usefulness and Volume of knowledge) ($M_U = 4.17$, $M_V = 4.25$) compared to men ($M_U = 3.49$, $M_V = 3.58$) for face-to-face exercises, but the difference was not statistically significant ($p = 0.882$, $p = 0.287$). Both men and women expressed the same positive attitude to the usefulness of both forms of exercise and the Volume of knowledge acquired in both forms of exercise.

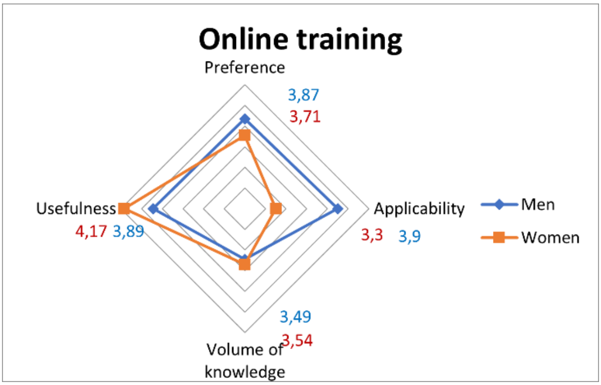

Figure 9 Semantic profile of online training in a group of men and women

The results of the research confirmed the prediction of previous research [13] that gender influences students' attitudes to online exercises.

The obtained results showed that the attitude of students to online exercises is positive. As many as 72% of students agreed with the statement, "Online exercises suit me, as can be seen from Fig. 6, which contains students' answers to one of the items of the questionnaire. Only 21% of students expressed a negative attitude, and only 7% of students have a neutral attitude to online exercises.

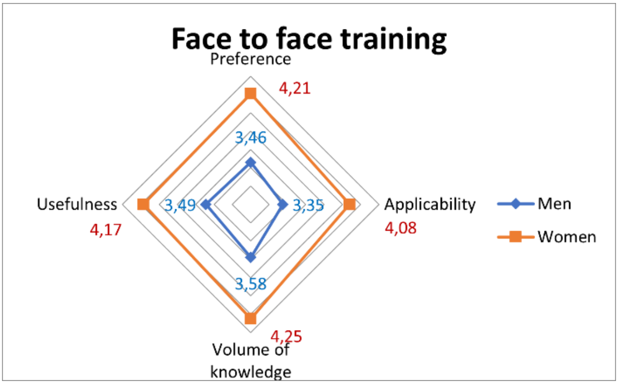

Figure 10 Semantic profile of face to face training in a group of men and women

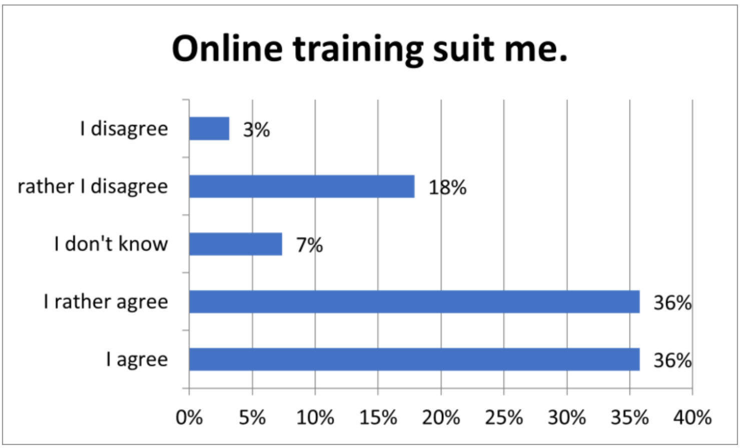

Figure 11 Students' answer to one of the items of the questionnaire

4 Conclusion

The presented research revealed three significant findings:

- In the whole group of respondents, students' attitudes to online exercises and face-to-face exercises are the same. Although the average value assigned to online exercises in three of the four factors (Preference, Applicability, Usefulness) was higher than the average value assigned to face-to-face exercises, the difference was not statistically significant in either factor. However, the obtained results showed that students have a positive attitude towards online exercises.
- Men recommend using the online exercises more in the subsequent study than face-to-face exercises. They also find online exercises more useful. The difference between the average values assigned to this factor was statistically significant. Women assigned higher values to three of the four factors (Preference, Applicability, Volume of knowledge) face-to-face exercises compared to online exercises. However, in neither case was the difference statistically significant. Women have the same attitude to online exercises as to face to face exercises.
- After comparing the attitudes of men and women, it was shown that men assigned a higher value to the Preference for Online Exercise factor than women, and the difference in mean values was statistically significant. Women assigned a higher value than men to the same factor Preference for face to face exercises. The difference in mean values was again statistically significant. Women prefer face-to-face exercises compared to men, while men prefer online exercises.

The results showed that both men and women expressed a positive attitude to the usefulness of both forms of exercise and the Volume of knowledge acquired in both forms of exercise. In addition, the results of the research confirmed the prediction of previous research [13] that gender affects students' attitudes to online exercises. As presented in this article, the obtained results were used in the design of a model for online teaching of mathematics and computer science subjects.

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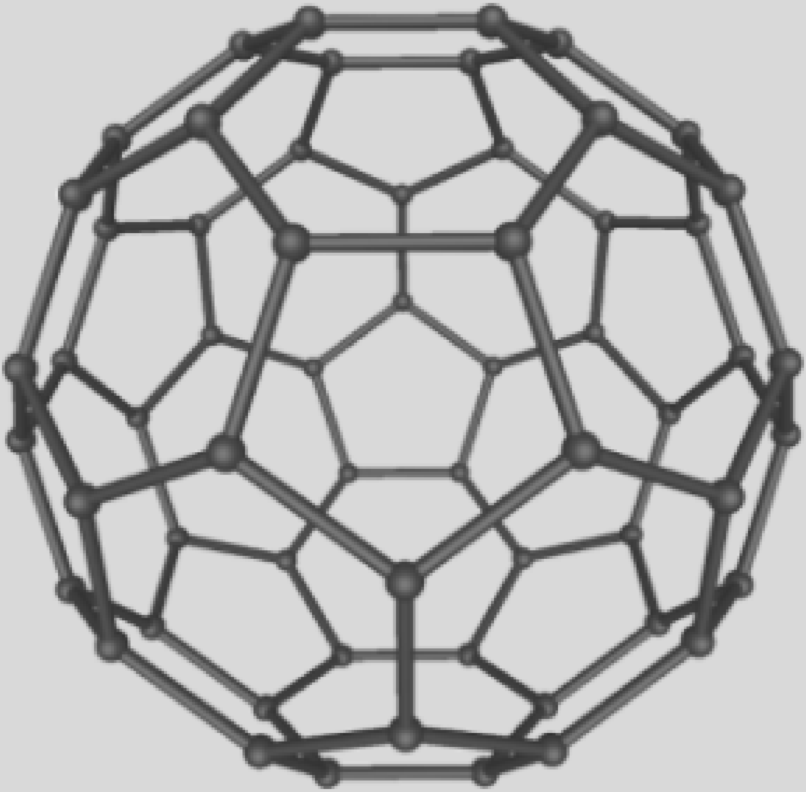

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