DiVAi 2022

14th International Scientific Conference on Distance Learning in Applied Informatics

Conference proceedings

May 2 - 4, 2022

Štúrovo, Slovakia

Wolters Kluwer

Constantine the Philosopher University in Nitra
Faculty of Natural Sciences and Informatics
Department of Informatics

and

University of Hradec Králové
Faculty of Science
Faculty of Informatics and Management

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Preface

Dear readers!

Eighteen years ago the Department of Informatics, Faculty of Natural Sciences, Constantine the Philosophy University in Nitra has decided to organize a conference focusing on the application of ICT in the teaching of informatics subjects. In the very first years of the conference, we were very careful about the number of participants. The participants came mostly from departments of informatics from the universities in the Czech and Slovak Republic, which was mainly connected to the considerable resentment of other fields against the use of modern information technologies for the support of education at their workplaces. In the first few years of the conference, called DIVAI (Distance Education in Applied Informatics), the influential community of informatics experts succeeded in proving that supporting education using the tools provided by Internet has its substantiation and a permanent place mainly in the distant form of educating the students. Departments of informatics in Slovakia and the Czech Republic started to use these tools and created educational environs for their activity. At the Department of Informatics, FNS, CPU in Nitra such a tool was the learning management system - LMS MOODLE, which has been constantly used not only at our workplace but also in the majority of European states.

Later, we extended the participation of experts from the surrounding states, mainly from the Czech Republic, Poland, Slovenia, Lithuania, Latvia, Hungary and in the upcoming 14th year we are going to welcome participants from other European countries. The conference and the university education have one thing in common and that is the utilization of services and tools of the Internet, thus eliminating barriers to permanent cooperation in this sphere.

The topics addressed and discussed at the conference are, at this time, of great importance. Education is moving away from school desks to the virtual space of the Internet, and educational institutions are looking for suitable virtual systems in order to support distance learning. The ongoing conference is about to confirm the justification for the use of learning management systems and their content for educational purposes at all levels of education institutions.

Another area of interest at the conference is the application of virtual systems throughout the lives of people with the support of high-speed networks in the field of IoT technology. This issue is addressed at the level of education with an impact on the progress of students working in unexpected conditions, such as distance education.

After finishing the 9th conference and based on the reviews and the feedback from the participants of the conference, we submitted the outcomes of the event in the form of proceedings from the conference into the database Clarivate - WoS for the indexing process. After a certain period, we were pleasantly surprised by a message on positive evaluation and the subsequent indexing of the proceedings in the Clarivate - WoS database. At the conference, we are ready to publish the accepted and reviewed contributions in the printed form of impeccable quality. We have asked the renowned publishing house Wolters Kluwer, which has its representation in Prague, for its realization. We believe that after rigorous reviews and selection of those best contributions you will receive professional material from the sphere of university instruction using modern information means of exceptional quality.

In conclusion, I wish all the readers of the outcomes of the conference coming from professional practice, as well as all those interested in these issues on all levels of education a quality experience and acquiring new knowledge in the given area.

In this form, I would like to express my greatest gratitude to all members of the programme committee, as well as to the members of the organizing committee for their willingness and helpfulness in the preparation and during the course of the DIVAI 2022 conference and editing of the final publication, which will be sent for indexing to the Clarivate - WoS database. We believe that the publication will be positively accepted not only by the readers but also by the evaluators from the Clarivate publishing house.

Milan Turčáni

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Keynote Lectures

Modeling and Simulation as Tool for Multidisciplinary Learning

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Abstract

Mathematical modeling and computer simulation have recently been understood as central concepts for the creation of scientific theories. The modeling of the reality is related to a systems approach. Thus, the system approach is one of the variants of how to approach human thinking. In this sense, we are talking about system thinking. System thinking, or thinking through systems, should be seen as one of the methods of thinking. Ultimately, this is a problem of a methodological approach to thinking. Within the framework of scientific research, the process of thinking and discovering is realized through modeling. Mathematical modeling is the highest form of cognition of reality. In recent decades, the creation of computer models in the form of computer simulations and visualizations has joined the process of discovery. Since modeling and computer simulation are essential for learning about reality, pupils and students need to be guided to develop their abilities, knowledge and skills using mathematical models and computer simulations. In addition to the mere use of models and simulations, students need to be encouraged to create simple forms of models and computer simulations themselves. Students thus develop a multidisciplinary understanding of the world.

Keywords

Mathematical modelling, Computer simulation, Multidisciplinary learning.

INTRODUCTION – THEORETICAL BACKGROUND

Originally, the terms system and systems approach were used only in connection with natural sciences and technical disciplines. Later, the systemic approach began to be applied in other scientific disciplines such as sociology, psychology and other social sciences that deal with the behavior of society.

What is the reason, what are the advantages, what do the terms system and system approach mean? The answers to these questions are related to how a person can use his senses to obtain information (inputs) about the environment, the external world, about the external reality that makes him It is also related to how he perceives this information, how he shapes and organizes it and how he creates a picture of this external reality. Based on these images, not only knowledge is formed, but also patterns of behavior and a spectrum of prejudices, which are then reflected in his actions, procedures and outputs. There is a process of thinking.

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Thinking means, in a broader sense, the sum total of all mental (psychic) activities, in the narrower sense of the word their most complex and probably only man's own part, which processes and uses information. Thinking from individual perceptions and experiences progresses to general concepts and through them to practical and theoretical mastery of the world, reality. It builds on sensory perception, uses memory and creativity, but treats its contents in a systematic and regular way. This specific way of connecting, distinguishing, comparing and reasoning is essentially related to speech, which is its means and at the same time its determining environment.

Thinking can be depicted as a process that transforms inputs into outputs. Schematically, this is shown in Figure 1.

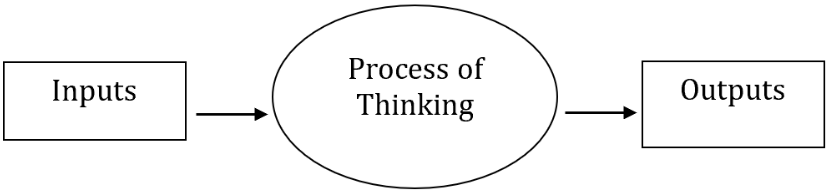

Figure 1 - The process of thinking as the transformation of input information into output information

Inputs to the thinking process are provided by the senses – sight, hearing, touch, smell and taste. With these senses we obtain information about the surrounding world. All the senses are important to us, without them we would be separated from the outside world and we would have no opportunity to learn anything about the surrounding world (Eckertová, 2004). Unfortunately, with our senses, we are limited to obtaining a very narrow range of information about the surrounding world. Sight is limited to the visible part of the electromagnetic spectrum, hearing is limited to a narrow range of frequencies, smell and taste provide us with only some information about the chemical by touch, we are only able to find out some information about the mechanical composition, dimension and temperature. In addition, we obtain information from the sense organs in a biased and distorted way. There are a number of optical illusions, the perception of heat and cold is relative, etc.

However, the thinking process is something that can work with a certain subset of the (often distorted) set of all available information and process it. Thinking requires time, a certain distance from the immediate situation, consistency, and an idea of the goal. Distance, experience, and generalizations represent man's greatest strengths, on which his overall success rate compared to other animal's rests. Simpler forms of thinking can be understood as a means to solve problems or achieve goals. A person first formulates a problem or goal, thereby refining it and imagining it so that he can begin to look for procedures of action and solutions. This is immediately followed by analysis and evaluation, which assesses and compares the achieved state with the target, experience with the idea. This is also how empirical science proceeds, formulating a hypothesis, constructing the experiment in question, and ultimately evaluating its outcome as confirmation or refutation of the hypothesis.

Based on experience —perceived, remembered, or learned — thinking can also estimate and plan, reducing uncertainty by analyzing possibilities or opportunities. An essential function of thinking is also connecting, searching for similarities and connections,

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or mental modeling, experimentation and construction. Thinking is able to create abstractions, introduce general concepts for a certain group of phenomena and events, generalize. Thinking is to construct new, unknown ideas and concepts (Thagard, 2001). The process of transformation, abstraction, generalization is related to the creation of concepts. A concept or concept is a collective idea of thought for a whole class of similar phenomena and realities, objects and abstract themes. A term is determined by a definition that indicates its essential properties and distinguishes it from others. With the development of man's intellectual abilities, concepts became more complex and abstract (Thagard, 2001). One example of such a highly abstract concept is gravity. Gravity cannot be seen or heard, it cannot be felt or tasted or sniffed. Gravity, of course, is all around us, but we can only perceive it vicariously by seeing objects falling, hearing their impact, binding us with the ground. Nevertheless, this phenomenon has been studied since ancient times (Archimedes, Heron). With the advent of Renaissance science at the beginning of the modern period, knowledge was refined and further expanded (Galileo Galilei, Blaise Pascal). The culmination was the work of Isaac Newton, who postulated the laws of classical mechanics and the concept of gravity. In the last century, Einstein proved the highest degree of abstraction within the framework of general relativity.

The process of thinking is not limited to one subject, to one particular person. Thinking is formed openly, which means that towards the environment it somehow manifests itself as acting on it. Such an action can be understood as the outputs of the thinking process. These are also carried out in several ways, such as behavior, feeling and communication – communication. Communication (or communication) is the communication of information, thoughts, opinions, and feelings, usually through a common set of symbols. The main means of communication of a person is verbal communication (language and speech), the so-called second signal system.

Let us now return to systems thinking. Systems thinking is the process of understanding how things affect each other within a whole. Throughout history, the development of systems thinking has gone hand in hand with the growing amount of information and knowledge acquired through the study of reality. People like Leonardo da Vinci, Michelangelo, who lived at the turn of the 15th and 16th century. Century, they are an example of versatile Renaissance personalities who knew everything that was known about the world in their time. Since the middle of the 16th century. Century, knowledge about the world multiplied rapidly, scholars began to be focused in their knowledge only on a certain area, on a certain set of knowledge. People began to specialize, which led to the emergence of new concepts, and these concepts were then classified into gradually emerging monodisciplinary fields. Examples are natural sciences, medicine, legislation, technology, social sciences, etc.

At the end of the 20. Century it is impossible to imagine a real system in which only one discipline, one discipline, would participate. Reality cannot be studied monodisciplinary. Reality is complex in nature.

However, given the amount of knowledge gained about reality, it cannot be explored in its entirety by people like Leonardo da Vinci. When studying reality, it is necessary to approach multidisciplinary. The multidisciplinary approach is based on the principle of cooperation of monodisciplinary disciplines that perform a partial analysis of a comprehensively studied system, or solve system problems and processes monodisciplinary (i.e. they analyze single aspect subsystems from their point of view). The above-mentioned

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partial monodisciplinary analyses are managed by an integrating investigator who has basic knowledge from multiple disciplines and whose task is to integrate partial system analyses into the summary analysis or implements the integration of partial solutions into the overall solution – see Figure 2.

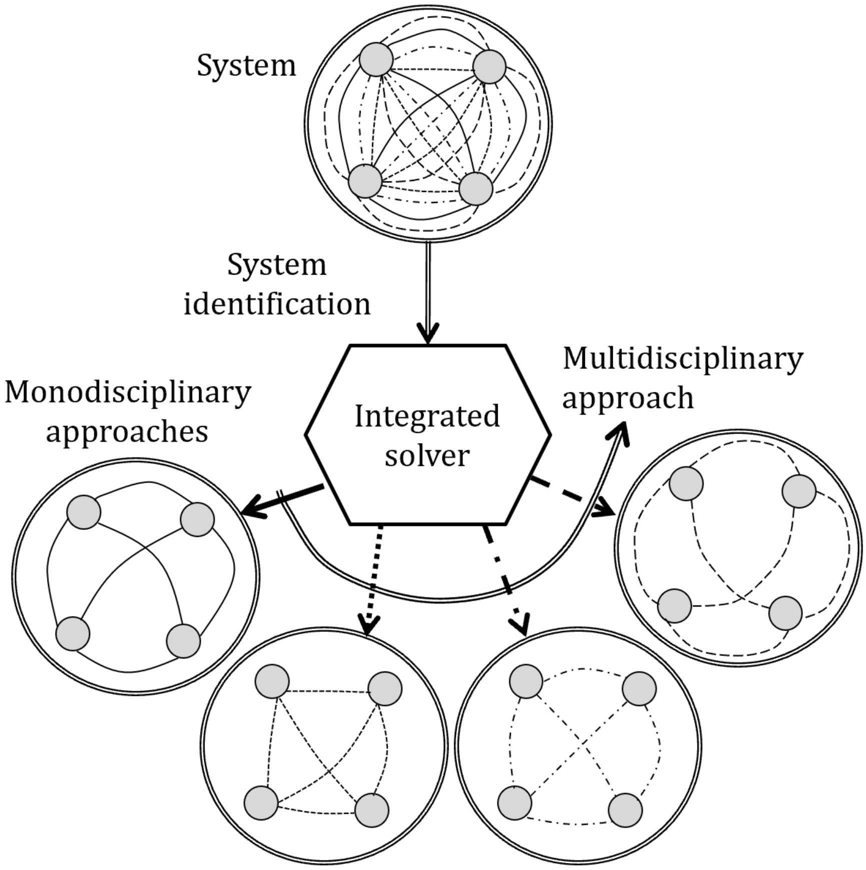

Figure 2 - Multidisciplinary system identification, Haaf, Bikker and Adriaanse (2002).

The multidisciplinary approach enables the emergence of new disciplines – scientific disciplines. A typical example is ecology, which arises in the space between economics, chemistry, biology, meteorology and other sciences that explore the environment.

The interdisciplinary approach is applied in the study of systems, but the mere integration of the mono-disciplinary approach (multi-disciplinary approach) cannot fully identify the system. Within the studied system, there are anomalies or problems that none of the scientific disciplines is able to independently (mono-discipline) clarify. In this "empty" space, a new discipline or science arises. A classic example can be biophysics, biochemistry, but also e.g. economic statistics, or econometrics. However, in an interdisciplinary approach, the emerging scientific discipline benefits from those disciplines that made its emergence possible, and at the same time its knowledge in-spires the original sciences to the next research. It is a transfer of knowledge, mutual inspiration, or methodological interconnection (Pstružina, 2002).

In the systems approach in the study of reality, modeling is an important term, an important activity. Modeling is a research method used in scientific practice in many fields of human activity.

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The purpose of modeling, the purpose of modeling, is to describe the content, structure and behavior of a real system representing a certain, defined part of reality (Bailer and Daniela, 2002). The concept of model is closely related to simulation, which can be used to represent the modeled system and its behavior in real time, for example on a computer, and to observe it, or modify.

The model is always only an approximation of reality, because real systems are usually more complex than the system itself – systemic homomorphism is applied here.

The model of the real system itself can be considered as a system – a simplified model system of the real system (template). The homomorphism between these two systems then means that each element (element and bond) of the model as a system corresponds to one element of the real system, but the opposite does not apply. The model should always be understood as a "simplified" of the original. If there were an isomorphism relationship between the model and the original, we would not be able to distinguish between the model and its original (Suárez, 2003; Frigg and Hartmann, 2006).

Modelling is a multidisciplinary activity, as knowledge from mathematics and physics, systems theory, probability theory, informatics, cybernetics or cognitive sciences can participate in it, operations research and others.

Modelling serves not only for solving problems from practice, but it is also intended for carrying out various research and experiments or for simulating phenomena and processes. The use of models and simulations is especially suitable for cases where an experiment on a real system would threaten damage to property or health.

Since the terms model and modelling appear in many different phrases, it is necessary to define the boundaries of the use of model in scientific modelling and in the creation of scientific models.

The model is in no way able to encompass reality itself, but looks at a certain part of the real world through a simplified view (Frigg and Hartmann, 2006). To successfully create and use the model, it is necessary to understand the problem that we want to capture with the model, have a pre-specified target and at the same time use high-quality source data.

Models are of great importance in many scientific disciplines. In physics we know, for example, the Model of the Ideal Gas, the Bohr Model of the Atom, in chemistry the Gaussian Chain Model of Polymers, in Biology the model of the DNA, in sociology the evolutionary models, etc. In these examples, the model for expressing a given real system is absolutely indispensable. Great attention and effort is therefore devoted to building, testing, comparing and revising models, their use and interpretation. The model is a fundamental tool of modern science in general (Frigg and Hartmann, 2006).

In practice, we encounter a great variety of different types of models (Bailer and Daniela, 2002). There are mental models, causal models, conceptual models, phenomenological models, mathematical models, development models, test models, idealized models, theoretical models, heuristic models, didactic models, sci-fi models, game models, imaginary models, substitution models, cult models, formal models, analog models and instrumental models, etc. It is clear that only some of them can be understood as models suitable for use in scientific work.

The model can be represented in various ways such as (Hughes, 1997) as a physical object, fictitious objects, linguistic construction, mathematical expression, symbolic, graphic

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formalism and scheme. The phenomenon of the end of the 20th and 21st century. century became computers, without which the process of knowing reality can no longer be imagined. The process of knowing reality thus gained a new assistant in the form of computer modeling, computer simulation and visualization. With some exaggeration, we can speak of a "visualization" of reality, which can be understood as one of the representations of factual modeling.

Contemporary research in both the natural and social sciences cannot be imagined without computer simulations. Computer simulation of real systems and real processes is one of the most effective methodological tools, because there is currently almost no academic discipline that it did not use simulations at least partially for its research.

Unlike the modeling process, simulation has been philosophically ignored until recently, even though it is of considerable importance to science and research. Only recently has simulation been recognized as an important part of scientific knowledge. The main reasons for this recognition are according to (Hartmann, 1996):

- Simulation is currently an essential part of the process of knowledge, especially it allows you to study models of reality that are not analytically solvable, especially dynamic models.
- Computer simulation makes it possible to process and qualitatively and quantitatively classify large amounts of experimental data. knowledge.
- Computer simulations provide a qualitatively new and different methodology of investigation that allows general theoretical models to be experimentally confirmed or refuted – validated.

Simulation can therefore be understood as an applied methodology that describes the behavior of a real system using a mathematical model.

In other words, by simulation we mean the process of transforming a mathematical model describing a real system into a simulation model.

Simulation is very often complemented by visualization techniques, which represents another stage in the exploration of real systems and their interpretation.

The simulation model is represented by an executable computer program. The simulation model must meet a basic requirement (Sokolowski and Banks, 2009): The simulation model must be isomorphic with the mathematical model of which it is a representation, i.e., both models must represent in the same way the examined real system, the elements of the system, the links between the elements – the structure of the system and the interaction of this system with the environment.

Another condition is that the simulation model must comply with the syntax and semantics of the programming language. A typical simulation model can be written using specialized programming languages that have been designed specifically for simulation requirements, as well as programming simulation models also use spreadsheets, respectively. standard programming languages.

Simulation is currently considered a third and extremely useful tool of scientific investigation (Hartmann, 1996), along with theoretical and experimental science. Its contribution is related to the fact that it enables the validation of theories and mathematical models using a numerical computer experiment, supports data processing and statistical

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analysis, It is suitable for real-time process control, predicts possible results, tests and evaluates mathematical models, allows visualization and animation of real systems and real processes.

Simulation is also important from the pedagogical point of view (Sokolowski and Banks, 2009). Using a simulation model and visualization of the simulation results on the screen, it is possible to better understand basic processes and real systems and develop intuition. It is also indispensable that teaching using simulations is much cheaper and faster than using a real experiment, if such an experiment is feasible at all. Importantly, the simulation experiment must be supported by a generally valid conceptual model of a real system.

Teaching through simulations develops students' motivation. It should be emphasized that if the student himself can identify a system, create a mathematical model and program a computer simulation including visualization, then all this has a positive effect on the development of abilities of students, develops students ' ability to solve problems, has an impact on the development of algorithmic thinking and promotes multidisciplinary understanding.

It is necessary to guide students to the following competencies:

- To acquaint and teach them basic knowledge and modern approaches to analysis, synthesis and identification of systems and with the basic properties of static and dynamic systems;
- To learn how to create a mathematical model and computer simulation in accordance with the scientific principles of modeling and simulation theory;
- Develop the ability to transform a real problem into a mathematical model and then a shape suitable for numerical solution and computer processing;
- Develop competencies to select a software simulation tool and to use the graphical, data and other functions of this software.

The process of system identification, mathematical modeling and computer simulation is shown in the Figure 3.

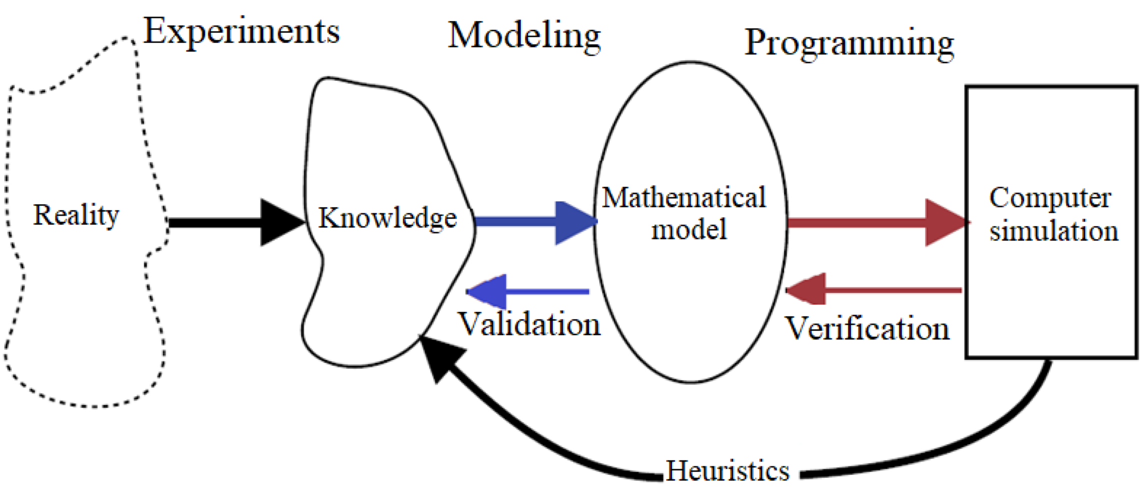

Figure 3 - Process of system identification, mathematical modeling and computer simulation, (Peringer, 2011).

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CASE STUDY – DEMONSTRATION OF MODELING AND SIMULATION IN MULTIDISCIPLINARY LEARNING

The presented case study is based on Hubalovsky (2011).

The impetus for the study of this system is the answer to the question: "Can a leaning tower of identical homogeneous blocks (such as bricks) be placed on a table so that the top block rests the whole outside the tabletop?" "If so, determine how many blocks we need in total." The blocks must not be connected to the tabletop or to each other by anything. The situation is illustrated in Figure 4.

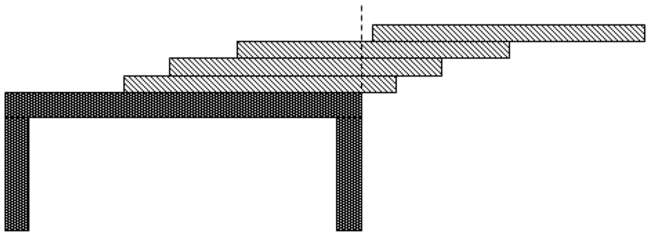

Figure 4 - Problem identification

In terms of categorization, this is a real system.

System identification

The elements of the system are material, material objects – homogeneous identical blocks (blocks in the form of bricks, CDs, etc.). The most important characteristics of elements are their mass and dimensions (for the purposes of this system, length – L is sufficient) – it is a continuous physical quantity. As a discrete characteristic of each block can be understood the order of the block k, calculated from the upper. Another characteristic of the element is the overlap of the X_k block *k-th* through the block (k + 1).

The links between the individual elements are also of a physical nature – it is mainly the gravitational force of the upper blocks on the lower blocks. The structure of the bonds can be considered as chain – the upper block gravitationally acts with the force F_k on the block below it, the gravitational force F_k + 1 on the next lower block, etc.. The next bond between two elements is given by the value of the X_k ejection of the *k-th* block through the block k + 1. Other links in the system do not need to be considered regarding the assignment.

The system is open to its surroundings. Openness can be demonstrated by the fact that the system (a tower of homogeneous blocks) rests on the edge of a table and it is located in the gravitational field of the Earth. Thus, the table together with the gravitational field can be considered as the surroundings of our system (it would not make sense to carry out this experiment in a weightless state).

Since the system is open, there are inputs to the system from the surroundings and outputs from the system to the surroundings. One of the inputs to the system is the already mentioned gravitational field, it is a material input in the form of gravitational action. Another input from the surroundings is the requirement for the value of the overlap S of the upper block over the edge of the table. It is an input of an immaterial nature expressed by the value of the variable dimension length.

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The outputs of the system are two, both of an immaterial nature. One of them is information whether the required system (tower of blocks) can exist. This is a discrete characteristic with two values "Yes", "No". The second output is the value of the variable N, which determines the minimum number of blocks required to achieve the maximum overlap of the upper block S so that the entire upper block rests outside the plate table. This characteristic is discrete with values of {1, 2, 3,...}.

Every element of the system (block) can be considered boundary because each element is located in a gravitational field.

In the identification of a system and the creation of a mathematical model, the multidisciplinary approach is represented by two disciplines, namely solid statics and numerical mathematics, as we will see below.

Creation of a mathematical model

Since the blocks are homogeneous, each of them has a center of gravity in its center. Block 1 (Figure 5) can therefore be maximally extended so that its center of gravity lies exactly above the edge of the block below it, i.e. by $X_1 = L/2$ over the lower block.

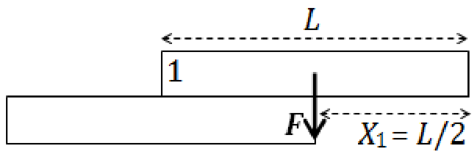

Figure 5 Overlap of the first block

A similar consideration will be made for the system of blocks 1 and 2. The situation is clear from Figure 6. The center of gravity of the pair of blocks 1 and 2 lies above the edge of the third block.

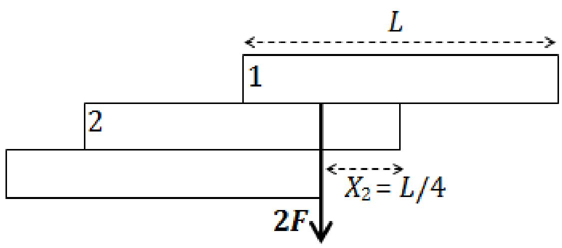

Figure 6 Overlap of the first and second block systems

Using the Moment Theorem (Svoboda, 1992)

$$F\left(\frac{L}{2} - X_2\right) = FX_2 \tag{1}$$

we get the solution $X_2 = L/4$. The center of gravity of the system of blocks 1 and 2 is located in 1/4 of the length L from the right edge of block 2. This means that a pair of blocks 1 and 2 can be overlapped by 1/4 of the length L over block 3.

Next, we proceed similarly – it is necessary to find out how much the system of blocks 1, 2 and 3 can be overlapped with respect to block 4 – Figure 7.

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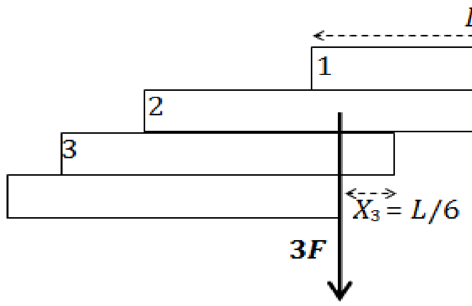


Figure 7 Overlap of the first, second, and third block systems

We will again determine the position of their common center of gravity and use the moment theorem:

$$F\left(\frac{L}{2} - X_3\right) = 2FX_3 \tag{2}$$

we get the position of the center of gravity $X_3 = L/6$ from the right edge of block 3. All three blocks together can therefore be extended by another 1/6 of the length L.

By similar consideration, we find that the system of blocks 1, 2, 3 and 4 can be extended by another 1/8 of the length L.

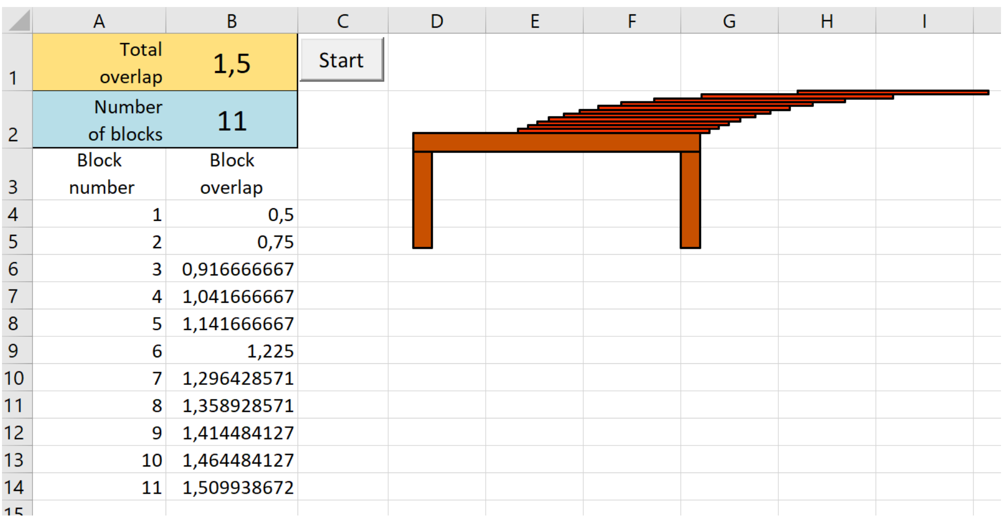
Thus, the total overlap of the right edge of block 1 over the edge of the table for a system of 4 blocks is equal to the partial sum of the series:

$$S = \left(\frac{1}{2} + \frac{1}{4} + \frac{1}{6} + \frac{1}{8}\right) = \frac{25}{24} \tag{3}$$

This means that already with four blocks it is possible to achieve a state where the upper block lies completely outside the edge of the table.

Computer simulation

For example, a simulation model can be created by using the Visual Basic for Application (VBA) programming language included with MS Excel. Visualization of the simulation model is shown in Figure 8.



	A	B
1	Total overlap	1,5
2	Number of blocks	11
3	Block number	Block overlap
4	1	0,5
5	2	0,75
6	3	0,916666667
7	4	1,041666667
8	5	1,141666667
9	6	1,225
10	7	1,296428571
11	8	1,358928571
12	9	1,414484127
13	10	1,464484127
14	11	1,509938672

Figure 8 Visualization of the simulation model

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CONCLUSION

In conclusion, it should be noted that the development of scientific knowledge and the development of scientific thinking must be cultivated in students already at the time of study. Like scientific knowledge, the development of education cannot do without a systemic approach, modeling and computer simulations that reflect elements of multidisciplinarity.

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Dos-Windows-Spaces: Benefits of Virtual Reality in Education

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Abstract

The natural evolution of informatics is to become three-dimensional after 1-dimensional DOS and two-dimensional Windows, so future digital work will take place in 3D virtual spaces. The goal of this paper is to present research findings that compare the capabilities of current 2D interfaces and 3D VR and highlight the positive effects of 3D VR on education. VR research lab at the Széchenyi István University seeking answers to the questions of whether 3D virtual realities are transforming current models of people's digital learning, replacing current platforms and methods in everyday education. The research group tried to explore the relationship between the causes associated with cognitive infocommunications and cognitive aspects of virtual reality background and the effects associated with the digital paradigm shift. Finally, we draw attention to the unique efficiency-enhancing capabilities and benefits of MaxWhere 3D web spaces that have been scientifically proven in the field of education.

Keywords

VR education, MaxWhere, Cognitive infocommunicarions (CogInfoCom).

INTRODUCTION

In the age of innovation, access to information is a basic requirement. Fast information retrieval, selection, efficient information processing, effective application of the acquired information and production of new information. The human brain is an experience-dependent, variable, evolving system that responds to environmental influences. The information processing investigations of different generations in the fieldof CogInfoCom (Baranyi, Csapó & Sallai, 2012) state that the processing of analytical, step-by-step information of the older generations in the case of the growing generations (Z, α, CE - Cognitive Entity (Baranyi & Csapó 2012)) it will be replaced by comprehensive, spatial-visual processing (Komlósi & Waldbuesser 2015,). The natural development of informatics to become three-dimensional after two-dimensional Windows, so the future of digital work is provided by 3D visualization and interaction. Results published in the international scientific world show that the 3-dimensional VR environment allows users to easily connect to remote events regardless of time and spaceand access more information in a significantly shorter time (M. Hussein, and C. Nätterdal2015). This paper highlight the positive effects of VR on performance, emotion, and engagement (Allcoat, D and A von Mühlenen, 2018). More and more educationalinstitutions around the world want to improve the educational efficiency of previously used e-Learning content through VR (Freina & Ott 2015).

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The structure of the article is as follows. The first section of the paper is a short presentation of the unique capabilities of the MaxWhere (www.maxwhere.com) 3D VR platform. The next section summarizes the research results of the VR research Lab that show how MaxWhere can improve information transfer efficiency, user attention, comprehension, and memory capabilities. Finally, the authors draw attention to the unique efficiency-enhancing capabilities and benefits of MaxWhere 3D web spaces that have been scientifically proven in the field of education.

MAXWHERE 3D VR

MaxWhere (www.maxwhere.com) – invented by Hungarian scientists - is a platformfor the management of all forms of digital content in 3D spaces. MaxWhere is much moreof a 3D operating system, it is suitable for creating and sharing virtual 3D spaces with integrated 2D (text, image, audio, and video-based) and 3D (object-based) functionality.Easy and convenient to use. Users don't have to use VR glasses or another device, you just need one laptop but of course, it doesn't rule out viewing 3D VR content in VR glasses. MaxWhere helps the users to be always on top of their projects with its fast and innovative interfaces. It gives you the chance to switch between projects & teams and share your content in the fastest way possible. It also connects you to other collaborationapps or open data software already used. MaxWhere allows anyone to create their own virtual reality, a three-dimensional environment on their own laptop, and then organize itwith any digital content. Can be used to render web pages in 3D space, or as an exhibitionspace for the structured presentation of creations of art; otherwise for content creation andsharing optimized for business workflows; Industry 4.0 for remote manipulation with Digital Twin and high efficient settings for work (Figure 1.).

Figure 1: MaxWhere VR spaces

The natural environment of human everyday life is in 3 dimensions. However, our digital life so far has taken place in 2D, especially in the tree structure of folder structures.The advent of 3D VR, has allowed users on 2D operating systems to download 3D spaces similar to downloading applications on mobile phones - then manipulate 2D and 3D content and share it in real-time.

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RESEARCH RESULTS

In the modern digital world, 3D VR is the preferred solution for higher-level thinkingskills, such as seeing connections, gaining insight, applying knowledge, or analyzing. The VR Learning research lab of Széchenyi István University conducts studies related to the dimensions of cognitive processes - memory, understanding, application, analysis, synthesis, creation - in order to determine the effectiveness of 3D VR education.

- The first study focused on the effectiveness of information transfer and thus the facilitation of understanding. The goal was the comparison of classic email / attachment-based sharing, sharing via a web-based e-learning platform(Moodle), and sharing via 3D MaxWhere VR interface. In the experiment participated 400 people, we examined how long it takes to process digital information for 1 PDF document and its questionnaire, 15 images and itsquestionnaire, 1 video and questionnaire, and 4 websites and their 1 common questionnaire. Tests show that users - regardless of their age - were able to complete the required workflow at least 50% faster in the MaxWhere 3Denvironment than in all other cases (Figure 2,3,4).

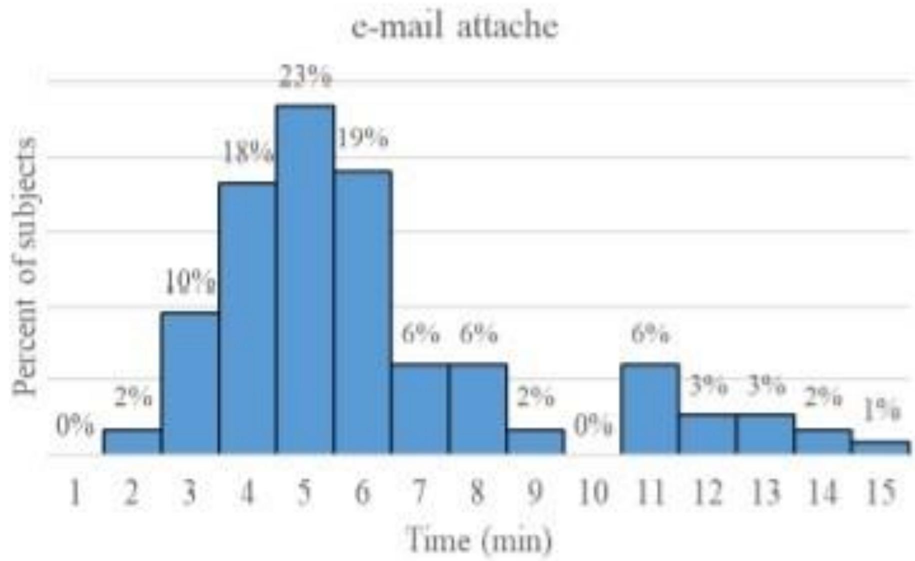

Figure 2: Response times for the examined content sharing interfaces (Lampert, 2018)

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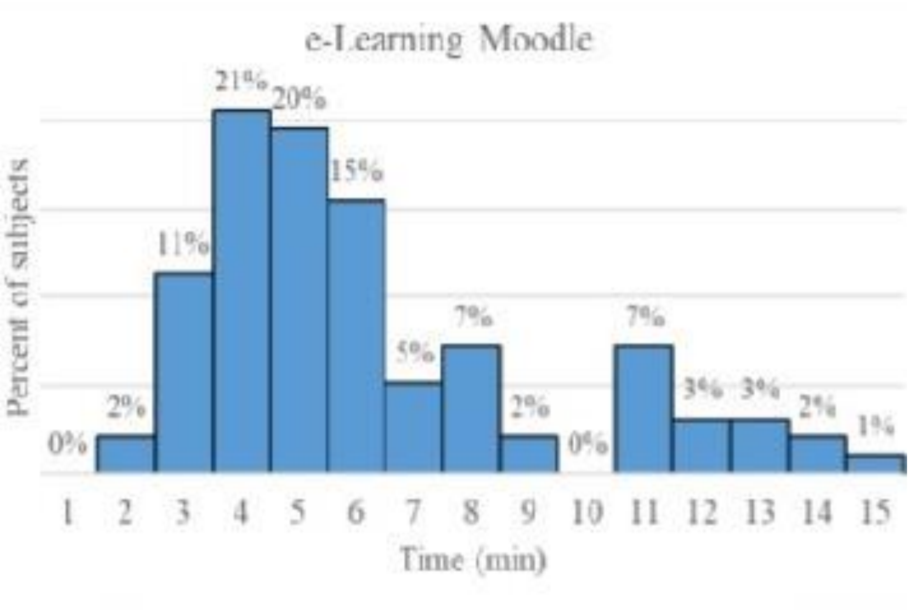

Figure 3: Response times for the examined content sharing interfaces (Lampert, 2018)

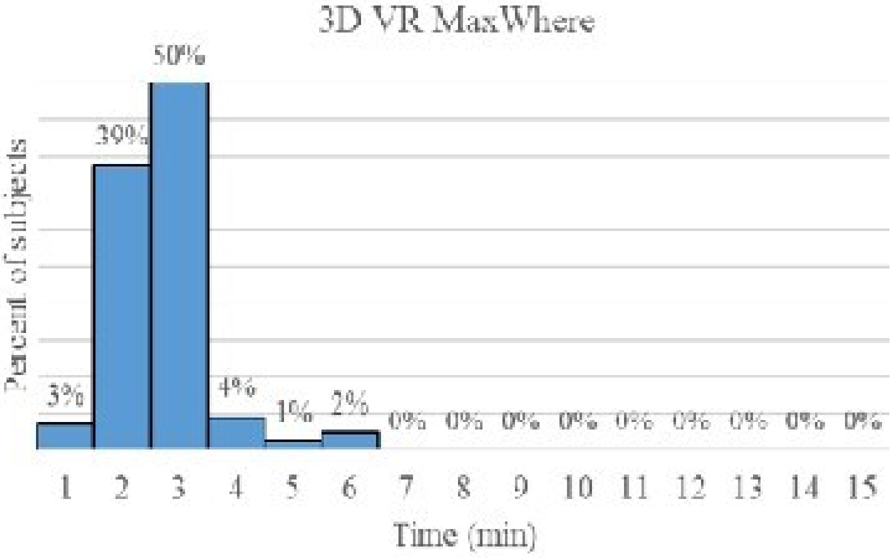

Figure 4: Response times for the examined content sharing interfaces (Lampert, 2018)

- The main question of the next study related to the above experiment was how the new technology affects the efficiency of user activities (Horváth & Sudár 2018). Different work environments require different operations. By counting these user and machine operations, the study finds that the number of user activities and the number of machine operations required to perform the operation will be 80% less in the MaxWhere 3D environment in the same digital workflow than in

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traditional 2D digital environments. Conclusion: As an educational platform, MaxWhere offers a number of options for users to perform tasks that would otherwise require extremely complex digital workflows in a traditional 2D environment.

The research experience is used by the VR Learning Center at Széchenyi István University to develop the ergonomics of 3D VR spaces and to develop a reliableand efficient methodology for efficient work and VR education.

- The research group of SZE VR Learning examined whether the structure of MaxWhere 3D VR spaces and their layouts adapted to work processes could accept whether we can consider 3D VR environments as an improved version of the Memory Palace method (Csapó at all, 2018). Because of the associative structure of the human brain, in many cases even the strongest techniques are associative — that is, they connect new concepts with others that are already well internalized. Many of these techniques work by creating abbreviations, keywords, or other easy-to-use mnemonics. Similar to the primarily audible modality of language, the visual modality also supports the formation of new memories. This is often effective because the human brain has evolved in an evolutionary environment where the recognition and remembrance of spatial relationships and places are of paramount importance. (Rodrıguez at all 2002, Logie 1986). In addition to the results of the research group, international research has also shown that VR can be used as an effective tool to support MPM(Legge at all, 2012). Provide more content for users that is more understandable and memorable than 2D visualization (Berki 2019).

CONCLUSION

After DOS - Windows, the main motivation for 3D-based operating systems is the same as the motivation for the MaxWhere 3D VR platform, to move in 3D space, turns on the parietal lobe, and change the information perception and processing. The researchresults presented in the study confirm that the work of students working in 3D spaces is 30% more efficient, memory (recall) is improved by 50%, and curriculum overview is 50% faster. The research lab gained further encouraging results regarding the use of personalized VR curricula. The use of learning style and information-gathering preferences in the personalized learning material resulted in a 20% higher score on the exams.

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Conference Papers

Section:
Information Technologies Supporting Learning

E-Learning and its Verification on the Example of Teaching Remote Sensing at the Constantine the Philosopher University in Nitra in Last Decade

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Abstract

Modern teaching methods and forms also create opportunities for learning styles other than the conventional ones. Using information and communication technologies (ICT) is one of them, as they are influencing the education process at the universities in a significant way. The paper focuses on the subject "remote sensing" and, in particular, on the e-learning course for the subject at the Department of Geography at the Faculty of Natural Sciences of Constantine the Philosopher University in Nitra. Study materials were implemented in the LMS Moodle environment within EDU portal in from of an e-learning course. Its efficiency in the teaching process was then monitored and verified by means of questionnaire survey on the sample of 100 students over the period of ten years (2011-2021) as a response to the project "A-CENTRE FNS UKF in Nitra, Innovative Education Centre (OPV)" from 2010 – 2013.

Keywords

Geography, IKT, e-learning, remote sensing, university education, Nitra.

INTRODUCTION

University education presents the highest form of educating the most qualified experts. The education is carried out at the universities which are, pursuant to the Act on Universities (Act No. 131/2002 Coll. – Act on Universities as amended) defined as "the highest education, scientific and art institutions". In the current context of the European university education and scientific research, their role is to "develop a harmonic personality, knowledge, wisdom, goodness and creativity in a person, contribute to the development of education, science, culture, and health for the wellbeing of the whole society. Fulfilling this role is one of the main goals of the activities at the universities".

The process of teaching can take various forms and its main goal is to meet the education objectives. When teaching geography and its main object – "landscape" – there is a wide range of didactic means that can be used. We find classic examples in textbooks or study texts as the most wide-spread physical didactic means in education. Modern teaching methods and forms create space for other than conventional learning styles. One of them is the use of information and communication technologies (ICT) which have impacted significantly the education process at universities. Probably the best known is the e-learning which is a very efficient tool as it offers the possibility of communicating and sharing precious information

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with the students remotely. Based on the existing experience with its use in Slovakia and around the world, it can be said that the development of information technologies as massively impacted the education and has improved the teaching process significantly. In the period of 2020-2021 with the pandemic situation of COVID-19 ruling the world, we have been witnessing the use of the so-called online remote education in combination with self-study. Thus the issue of using ICT and e-learning in the teaching process has become even more topical.

The aim of the present study is to verify e-learning education on the example of the subject “remote sensing” for which learning materials were implemented into the LMS Moodle (Learning Management System) environment within the EDU portal of the Constantine the Philosopher University in Nitra (https://edu.ukf.sk/) in form of an e-learning course with 10 topics primarily as a response to the faculty project. As at May 2021, 293 students have been taught using e-learning. The final lesson included an anonymous questionnaire filled out by each student in order to get feedback or assess students’ satisfaction with the e-learning course, which was one of the goals of the project. In this way, valuable data were obtained over the period of 10 years from 100 respondents which were subject to detailed analysis and assessment.

THEORETIC AND METHODOLOGICAL BACKGROUND

In the last decades, ICT have presented a very specific medium in the teaching process with direct effect on the further development of the society. I tis also connected with the priority of education strategies with the implementation of the ICT into the education declared in the documents of the European Union, as well as its member states at the national levels, with the emphasis on the information education, key competences, innovative teaching strategies, e-learning, virtual education environment, online teaching, multimedia, etc. (Madziková, Kancír, 2015, Alfaro et al. 2021, Naresh, Reddy, 2015, Lačný, 2013 and others).

Integration of ICT into the education is significantly changing the perception of education as such. The above-mentioned efficient e-learning is, to a great extent, supported by the ICT which, as a consequence, slowly reduces the acquiring of information in an encyclopedical way and improves the ability of independently acquiring, processing, and classifying information, evaluating its relevance or quality/contents and using it correctly. It is also interlinked with the availability of the internet network, as well as the key competence of students and teachers, which is the information or computer literacy. Students acquire it or are able to use ICT often before starting the studies which is a great advantage for the teaching process and, at the same time, upgrades it significantly (Petlák, 2004). There are several authors researching this issue in the education process (Stoffová, Stoffa, 1999, Průcha 1998, 2002, Fulková, 2006, Halás, 2011, Beňová, 2018, etc.), which confirms that the issue is highly topical and will probably remain so for a far future. They understand ICT in the teaching process as didactic tools and programmes which make it more efficient. Among the new forms of teaching, they include mainly: local computer networks, online libraries, videoconferences, multimedia (CD, DVD, or USB) etc. used mainly in distance learning. The best known is probably the e-learning, which is a highly efficient tool as it offers the possibility of communicating and sharing information with the students remotely

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E-learning, based on the existing experience with its use not only in Slovakia but also in the world and in connection with the development of information technologies, has massively impacted the education and has significantly improved the teaching process. There is a great amount of e-learning definitions and many people picture it as LMS, MOOC or another system designed for distance education (Schmidt, 2015, 2016). According to Stockey (2003), e-learning is most often defined as education process which uses ICT to distribute learning contents in form of various courses, serving for the communication between the teacher and students. This definition still reflects the classic model of teaching, however with the use of modern information channels for the exchange of information between the teacher and students (Schmidt, 2016). We find a more modern definition by Csapó (1999) paraphrased by Schmidt (2016, p. 207): *"Man and computer present a symbiotic system able to learn efficiently and solve certain problems. The interconnection between man and machine is so strong that man becomes dependent on the technology and this interconnection will become stronger over next years."*

It is, however, necessary to emphasise that the "*effect of using ICT, including e-learning, as didactic tool reflected in the more precise, more complex, faster understanding of the curricula also lies in the right and adequate choice of aids or didactic technique. Even though for students it is an attractive way of dealing with various problems or tasks, they need to be used appropriately, as no perfect software can make a student learn something*" (Madziková, Kancír, 2015) and next to the positives of their use (increased motivation, activity, lower stress, improving work with various sources of information, team work, interdisciplinary relations) it can also bring negative phenomena.

Of course, use of ICT is getting into the teaching process also with respect to the financial possibilities concerning the procurement of necessary equipment. Their implementation should, however, reflect the commitment of the Slovak Republic whereby in 2004 (Milenium Project) the country joined the action plan "Learning in the Information Society" declared by the representatives of the European Union in 1996 (Rosa, Turek, Zelina, 2000). The current Slovak government document for the period 2018-2027 is the National Program for the Development of Education "Learning Slovakia" from 2017 (https://www.minedu.sk/data/files/7532_uciace-sa-slovensko2017.pdf). It has reflected also a report of European University Association: „Trends 2015: Learning and Teaching in European Universities" (https://eua.eu/resources/publications/388:trends-2015-learning-and-teaching-in-european-universities.html).

In geography, we are mainly working with the so-called geodata which should be understood pursuant to Madzkova and Kancír (2015, p. 149) as *"formal descriptions (transcriptins) of geoinformation in form of numbers and signs suitable for computer processing. Geographic information (geoinformation) is a geometric, topological, thematic and dynamic description of spatial objects with respect to the needs of subjectively determined application. Geoinformation can be stored in various forms which can be reduced to a digital form. In other words, geoinformation technologies are such information technologies which enable the work with geodata in the broadest sense of the word, of course, fully respecting their spatial aspects."*

Within the last decades, several geoinformation technologies have been developed which are very suitable to be incorporated in the teaching process also with respect to its modernisation (Lara et al. 2014, 2020, 2018, Jafar Jalali et al. 2018). Several of them hold valuable potential and among them, remote sensing seems to be very interesting, as there

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is a support in a great amount of suitable internet sites or map servers (the so-called geowebs) which is connected mainly with the development of internet (Rapant, 2003, 2006). Many of them have relatively simple intuitive command features adequate for the education process at various education levels.

According to Hofierka (2003) "*remote sensing is technology devoted to the acquiring of information about landscape objects using the processing of images from non-contact sensing equipment.*"

At the Department of Geography and Regional Development of the Faculty of Natural Sciences of the Constantine the Philosopher University in Nitra, the author of the present study introduced and accredited in 2008 a new subject "Remote Sensing" within two study programmes "Teaching academic subjects" and "Geography in Regional Development". (Boltižiar, 2021). Also his research activities have focused this scientific area (Boltižiar, 2001, Hreško, Boltižiar, Bugár, 2003, Michaeli, Boltižiar, 2010, Michaeli, Solar, Maxim et al. 2021, Michaeli, Maxim, Solar, et al. 2021).

METHODS

The topic was elaborated in several phases. The learning materials for the subject Remote Sensing created by the author were implemented by the author into the electronic virtual online web environment LMS Moodle within EDU portal of the Constantine the Philosopher University in Nitra (https://edu.ukf.sk/) in form of an e-learning course, which was completed by almost 300 students by May 2021 and which is still being used and continuously innovated. E. g. recently, practical exercises using pilot-free devices – drones have been added, as well as virtual reality and other modern technologies and approaches.

E-learning course reflected one of the tasks/goals of the faculty project "A-CENTRUM FNS CPU in Nitra, Innovative Education Centre (OPV)" from the period of 1 May 2010 – 30 April 2013 (project leader prof. Ľ. Zelenický), in which the author from the department of geography was involved. The aim of the project was to "innovate the education at the FNS CPU in Nitra, update it to the needs of the academic society improving the quality and developing the competences of human resources". The strategic goal of the project was related to the global goal of operation programme through its specific goals and activities which shall specifically contribute to the improvement of the key competence qualities of the project participants. The project had two specific partial goals: 1. "Development of new forms of education with the emphasis on the virtual education" and 2. "innovation of education at the FNS CPU in Nitra, adjusting the education of the target groups to the needs of the academic society by improving the quality of education and developing the competences of human resources". More information can be still found on the project webpage: http://www.acentrum-civ.fpv.ukf.sk resp. https://www.ki.fpv.ukf.sk/a-centrum-fpv-ukf-v-nitre-centrum-inovativneho-vzdelavania/.

The feedback concerning the students' satisfaction with the e-learning course was obtained or verified within the electronic Google Form questionnaire which was an explicit part of the e-learning course. In total, 100 students participated in the anonymous survey over the period of 10 years (2011-2021). In this way, we have obtained valuable data, which constantly contribute to continuous improvement/updating of the e-learning course contents.

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We have also used the questionnaire, analysis of the data obtained through the survey, as well as statistic mathematical methods in processing the results from the questionnaire survey (graphs).

The e-learning course contains 10 topics with each topic consisting of learning materials in form of one or two Microsoft PowerPoint presentations with respective text and images, as well as assignments of tasks for the students. The presentations deal with the history of remote sensing and photogrammetry, they are graphic and motivational in order to activate the thinking and imagination (mainly spatial). They make the education process easier, emphasising the current requirements placed on e-learning. Task assignments (exercises) for the respective topics were elaborated by the students independently (during the lesson or completed outside the academic environment at home) and submitted electronically again – by uploading the file in form of "*.doc." into the LMS Moodle system within the EDU portal (picture 3, 4). The teacher was able to check the assignments in the system and point out what might have been missed in the assignment. After having corrected the assignments, the students could again upload new/corrected exercises replacing the original submitted file. The final exercises were graded by the teacher as completed.

The course contained the following 10 topics:

1. Remote sensing and photogrammetry; history and basic terms and definitions.
2. Types of carriers providing remote sensing data.
3. Types of aerial and satellite photographs.
4. Kinds of photographs classified by carriers, inclination, axis and image angle of view, and size (scale) of the territory.
5. Interpretation of aerial and satellite photographs.
6. Aerial photographs by spectral bands.
7. Areas of remote sensing use in respective industries.
8. Areas of remote sensing use in geography when mapping and evaluating landscape changes.
9. Institutions (university departments, institutes), learning materials and websites dealing with the issue of remote sensing.
10. Final practical exercise and test.

Practical exercise consisting in the interpretation of aerial photographs of various spectral bands (panachromatic, infrared, in true colours) from a selected territory of the Nitra region (Corine Land Cover – CLC) in the geographic information systems (GIS) environment was covered within the last lessons.

RESULTS

In the period of 2011-2019 the course was taught face to face in the classroom – the students and teacher were at the same place at the same time – in a specialised classroom equipped with computers for every student enabling them to enter the course online. Of course, there was always possibility to access the course outside the classroom – students

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could study the materials at any time from home while working on the assignments related to the respective tasks (picture 2), however, without consulting the teacher directly.

In years 2019-2021, however, due to the actions related to the COVID-19 pandemic the course was taught online remotely – i. e. students were not at the same place with the teacher at the time of the lesson and they used the “meet” internet platform to communicate in real time.

At the end of a semester during the final lesson of the course, the students were asked to complete the questionnaire survey consisting of 12 questions defined by the project researchers and covering the following:

- gender,
- access to the LMS Moodle course,
- convenience of the LMS Moodle environment,
- arrangement of the e-learning course,
- professional aspect of the LMS Moodle learning materials,
- contents aspect of the LMS Moodle learning materials,
- aesthetic aspect of the LMS Moodle learning materials,
- sufficient clarity of the respective lessons of the e-learning course,
- attractiveness or stimulation of interest by the lectures/exercises within the subject by means of the e-learning course as compared to the classic lecture/education,
- frequency of using learning materials in LMS Moodle,
- what the students missed in the learning materials in LMS Moodle.

The questions were mostly closed with the possibility of selecting one of the offered options.

Questionnaire analysis and evaluation

After having gathered 100 questionnaires downloading them from the web platform Google Form, we started the analysis and evaluation for each of the 12 questions. Even though the questionnaire, or the respective questions, were formed within the mentioned project for other disciplines (biology chemistry, physics), too, they are highly relevant for geographic e-learning courses, as well. We believe that 100 students present a sufficient statistic sample for our objectives. At the same time, when evaluating the answers, the percentage equals the actual number of students involved (100 students = 100%).

The age of the respondents was between 18 and 23 years. With respect to gender, there were 63 females (2/3) and 35 males (1/3).

Answers concerning the convenience of the LMS Moodle environment were very positive. 93% of respondents gave positive answers. More than a half (55%) were very satisfied with the environment, more than a third (38%) was quite satisfied, 5% was undecided and 2% considered it rather inconvenient.

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In the next question, concerning the arrangement of the e-learning course, 92% answers were positive (very satisfied 52% and satisfied 40%). 4% of answers were neutral and 4% were negative.

The responses of students with respect to how satisfied they were with the professional aspect of the learning materials in the LMS Moodle were also highly positive. 92% of respondents said they were very satisfied (41%) or satisfied (51%). 6% of students were neutral. The professional aspect of the materials was unsatisfactory for 2 students (2%).

Respondents' answers to the question how satisfied they were with the contents of the learning materials in LMS Moodle reflected the answers to the previous question concerning the professional aspect. 92% of the students were very satisfied (37%) or satisfied (54%) with the contents (picture 5). 8% of students could not decide and 1 student (1%) was rather dissatisfied.

The question about how satisfied they were with the aesthetic aspect of the learning materials in LMS Moodle was answered as follows. 86% were satisfied, either very satisfied (39%) or satisfied (47%). 9% of answers were neutral. 4% were not satisfied and 1 student (1%) was very dissatisfied.

The next question was dealing with the didactic clarity of the lessons in the e-learning course. For 95% of the students the materials were clear (very clear for 49% and sufficiently clear for 45%) and they understood the essence of the topic. 3% were neutral. 2% of respondents did not find the materials clear.

There were interesting answers from respondents to the question whether the lectures/exercises with the support of the e-learning course were more interesting than conventional lectures. Only 77% responses were positive, agreeing fully (47%) or rather agreeing (30%) with the claim. 16% could not decide (agree nor disagree). 6% of respondents rather disagreed. One student (1%) used the open-end question to state that "sometimes gets lost in other things to do and then he is unable to follow."

The answers of the respondents to the question concerning the frequency of use of the materials in LMS Moodle were as follows: 26% used them all the time, 41% very often and 30% sometimes. 1 student (1%) used it rarely and 2 students (2%) did not use them at all.

The respondents' reflections on what they were missing in the LMS Moodle learning materials were very diverse. A quarter of them said they would welcome video materials (25%), others would like interactive learning materials (11%), or audio support – podcasts (9%) or complex multimedia materials (2%). 16% were missing links or references to other information sources and other 9% thought the materials were lacking more up-to-date expert information or more theoretic expert information going more in depth (11%). Other students (5%) would like more tasks for practising. 3% would welcome more graphic information – illustrations. One student suggested the possibility to print the lectures (1%), one student pointed out that they were just learning to work with the LMS Moodle (1%), one was missing some overview (1%). 6% said the materials were lacking nothing.

The final question was dealing with the whether they would recommend the e-learning to other students taking the subject in the LMS Moodle in this form and contents. More than 2/3 (68%) would recommend it fully and 24% would recommend it partially. 7% could not decide and one student (1%) would not recommend this form.

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The above answers of the students and their statistical analysis imply the following interesting conclusions:

- 93% are satisfied with the LMS Moodle environment,

- 92% are satisfied with the arrangement and structure of the e-learning course,

- 92% are satisfied with the professional aspect of the learning materials in LMS Moodle,

- 91% were satisfied with the contents of the learning materials in LMS Moodle,

- 86% were satisfied with the aesthetic aspect of the learning materials in LMS Moodle,

- 95% thought the respective lessons in the e-learning course were clear enough,

- 77% thought the lectures/exercises with the support of the e-learning course were more interesting and attractive than conventional lectures,

- 67% were using the learning materials in LMS Moodle often,

- 47% would welcome more interactive complex audio-visual/multimedia materials in the LMS Moodle materials: video (25%), interactive learning materials (11%), audio – podcasting (9%), or complex multimedia materials (2%).

- 36% would welcome more expert and up-to-date information and links/references thereto. Specifically, references to more information (16%), more up-to-date expert information (9%), theoretic expert information going more in depth (11%).

The vast majority of students was very satisfied with the course from various aspects (professional, contents, aesthetic, or with respect to arrangement and clarity), with the answers over 90% - i. e. more than 90 students from the total of 100.

Based on the answers rated less than positive and students' statements about what was lacking in the course, we adopted the following actions for the continuous improvement of the e-learning course:

- adding more up-to-date expert information in forms of texts and images,

- incorporating internet links to other expert information or sources,

- incorporating internet links to videos supporting the learning.

These actions are aimed at continuous improvement of the quality of the e-learning course, motivating students, as well as more frequent use of it in the education process. Based on the author's own 10-year positive experience with e-learning, it can be said that the role of the teacher is irreplaceable and still very important in the learning process. We agree with the conclusions of Schmidt (2016, p. 214), who says that *"even though new forms of electronic learning have emerged in the recent years, nothing as good and important as a teacher has emerged. A good teacher has such skill that even if the student does not understand the matter being explained, he/she can immediately explain the subject matter in another way to make it understandable. This personalisation of the curriculum is what no machine can do."* The same opinion is held by Halás (2011, p. 425): *"The role of ICT is to enable the teachers and students to deal with demanding and attractive issues whenever appropriate. No software, however, can make a student learn something".*

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CONCLUSION

In the presented study we focused on the issue of verifying the e-learning on the example of the subject Remote Sensing, for which learning materials were implemented into the LMS Moodle (Learning Management System) within the EDU portal of the Constantine the Philosopher University in Nitra (https://edu.ukf.sk/) in form of e-learning course with 10 topics, which was created primarily as a response to the objectives of a faculty project. By May 2021, 293 students were taught using e-learning. The final lesson included an anonymous questionnaire completed by each student in order to obtain feedback or evaluation of students' satisfaction with the e-learning course. Over the period of 10 years, the quality of the course was verified on the sample of 100 respondents of the anonymous online questionnaire.

Based on the obtained answers ad their statistical analysis, we saw highly positive attitudes of the students to the respective course from several aspects (contents, professional, aesthetic, arrangement and clarity of the course) with several answers reaching more than 90% - i. e. more than 90 students of the total 100 were positive.

Based on the answers which were rated less than positive and statements of what was lacking in the course, we adopted adequate measures for continuous improvement of the e-learning course, adding more up-to-date expert information in form of texts and images, more sources and incorporating internet links to illustrative videos.

Our approach to the examination of phenomena, such as ICT and e-learning, presents one of the possible approaches to their analysis and evaluation in the education process not only in the university education. The results are primarily designated to teachers (not only geography teachers) using e-learning in the education process, however they can also serve a broader circle of researchers dealing with the issue of e-learning.

Teaching of geography as a traditional discipline with the tradition of hundreds of years has a great heuristic potential with respect to the didactic elaboration of its contents in the conditions of university education at Slovak university departments of geography, aided by the modern teaching forms. However, also based on our more than 20 years of pedagogical experience, we can state that the interaction between the teacher and students will always be important and it will never be replaced by any machine. We believe that the fulfilment of the ambitious goal – to become a really good teacher of geography – can be supported by this paper, as well.

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Selected Aspects of E-Learning in the Periods of Covid 19 Pandemic

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Abstract

The present study aims to evaluate the selected results of a questionnaire survey conducted at the end of the first and second waves of coronavirus pandemics in June 2020 and April 2021. In addition, the study aimed to evaluate and compare the year-on-year results of the evaluation of individual aspects of e-learning by students and teachers during the COVID 19 pandemic and to identify changes caused by the fully implemented distance learning during the pandemic. Distance learning is characterised by the absence of face-to-face contact, which is often complemented by technology. Finally, based on the selected results of the questionnaire survey, we expect students and teachers to be self-sufficient, make a significant shift towards higher education efficiency during the second wave of the pandemic, and increase the use of synchronous video tools in distance education.

Keywords

Distance education, E-learning, Moodle.

INTRODUCTION

Distance education (DiV), similarly to e-learning, is an area that has been resonating in university education for quite a long time. E-learning was first mentioned in 1999, and its birth is attributed to the mass diffusion of ICT (Klement, 2011). The main aim is to enable learning for those learners who, for various reasons, are unable to attend traditional face-to-face contact (Bednaříková, 2013). In the corona pandemic, the strengths, functions and possibilities of e-learning have become evident. Following the closure of schools, the need to implement e-learning in education became even more acute at all levels of education, even where we would never have anticipated it. Teachers started to use different electronic tools for learning, and from that point of view, uniformity was often absent in the educational process. At the Faculty of Education (University of Presov), e-learning has been used to support in-class teaching since 2005. The basic prerequisite for a fully functioning distance education is the LMS, which is currently probably the most widely used virtual

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environment to support e-learning (Zounek, Sudický 2012). Therefore, the faculty uses the LMS Moodle as a virtual support environment. There is electronic support for all courses. The students can primarily find logically organised and structured study materials, activities or electronic tests. Both teachers and students are used to working with e-learning, which made it easier to start distance learning during the corona crisis. As teachers are used to applying blended learning rather than fully distance courses, we were not fully prepared for the total absence of social contact. Those who were used to using Moodle and had experience with the application of principles of e-learning managed the situation without much difficulty. A number of issues came to the fore, which experts are trying to address *Ali (2020;* staff readiness, confidence, student accessibility and motivation), *Schlag* (2021), *Dovzhenko (2020;* negative consequences for children), *Mayo (2020*; engagement with communities), *Setiawan & Iasha (2020*; the knowledge about the coronavirus to prevent the spread of the virus in its environment), *Turcani (2017*), *Sun, Tang, & Zuo (2020*; problems dealing with the reform of online education through innovative course content, state-of-the-art technology and efficient management)) in several fields, which has been reflected in the number of scientific studies dealing with coronavirus not only in the context of education. The present study focuses on different aspects of distance education from the perspectives of the student and the educator. It aims to evaluate and compare the year-to-year results of students' and educators' evaluation of different aspects of e-learning during the coronavirus pandemic, and thus to identify the changes resulting from the implementation of distance education during the pandemic.

SAMPLE AND METHODS

The data collection (questionnaire survey) was realised in two periods; at the end of the first pandemic wave in June 2020 and at the second wave in April 2021. The total number of bachelor and master students at the Faculty of Education in the academic year 2019/2020 was 1506, out of which the amount of 777 students responded in a questionnaire survey (a response rate of 48%). In the next academic year, we received 474 filled-in questionnaires, representing 29% of students enrolled that academic year. The number of faculty involved in the survey was 49 in the first term and 40 in the second term. Thus, the total number of participants is 1340 students. The research groups were partially identical; however, the participants were not paired during the research, which was considered in the statistical procedure. The survey focused on comparing and evaluating different aspects of e-learning that both educators and students used during the pandemic period.

The non-standardised scale questionnaires were used to test the hypotheses. The questionnaires contained open-ended, dichotomous, scaled (six-point scale) and multiple-choice items. The scaled and dichotomous items were statistically analysed; the multiple-choice items were evaluated descriptively only. The same questionnaire was administered to all students (both academic years). The student questionnaire contained 41 items and was divided into four topic areas (*1) Hardware and Connections, (2) Software and Materials Distribution, (3) Structure of the Study Materials and Activities in LMS Moodle, (4) Communication.* The questionnaire for teachers was divided into six thematic areas and contained 46 items. The research instrument was always administered electronically via Microsoft forms, and information about the research was sent to students via e-mail and messages in the LMS Moodle. The questionnaire aimed to evaluate different aspects of the

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implemented distance learning in both years of testing and to define the changes caused by the pandemic situation by statistical analysis. All administered questionnaires are available at the following link: bit.ly/3t4ppfk

PROCEDURE

The t-test, Bayesian analysis of covariance and regression analysis were used to test the statistical significance of the differences between years. To test hypothesis 1, *"There is a statistically significant difference between students' attitude at the end of the first and second waves of the coronavirus pandemic in the different studied areas (according to the questionnaire sections)"*, the Student's t-test for independent samples was applied. In the analysis, the year-to-year means of the dependent variable were compared on the selected values of the independent variable. A t-test comparing means was performed on the following data. The binomial logistic regression method, which attempts to predict the probability that an observation falls into one of two categories of a dichotomous dependent variable based on one or more independent variables that may be either continuous or categorical (Statistic, n.d.), was used to detect a statistical difference in dichotomous items.

The above frequentist techniques were used to assess the significance of the difference between the groups, i.e., in order to maintain a controlled level of first-order error. As frequentist statistics cannot formally demonstrate the validity of the null hypothesis, the Bayesian statistics were used to evaluate the relative degree of empirical evidence in favour of the null (H0) or alternative hypothesis (Ha). For each of the hypotheses tested, a so-called Bayes factor was calculated to indicate the extent to which our beliefs in favour of one of the hypotheses needed to be revised based on the observed data. A Bayes factor greater than 3 is considered to be substantial evidence in favour of a given hypothesis.

RESULTS AND DISCUSSION

The developed instruments were administered twice (at the end of the first and the end of the second wave of the corona) to two target groups (students and lecturers at the Faculty of Pedagogy). The interpretation is divided into 3 sections - comparison of students' evaluation, comparison of educators' evaluation and comparison of students' vs educators' evaluation. The selected results are presented in this article.

The questionnaire survey results in the *Hardware and Connections area* show that distance learning was carried out on laptops and desktop devices, although a significant part was also mobile devices, which are often used mainly by students. On the other hand, a high proportion of laptop use was observed among the teachers, mainly the result of home-office mode and teaching from home.

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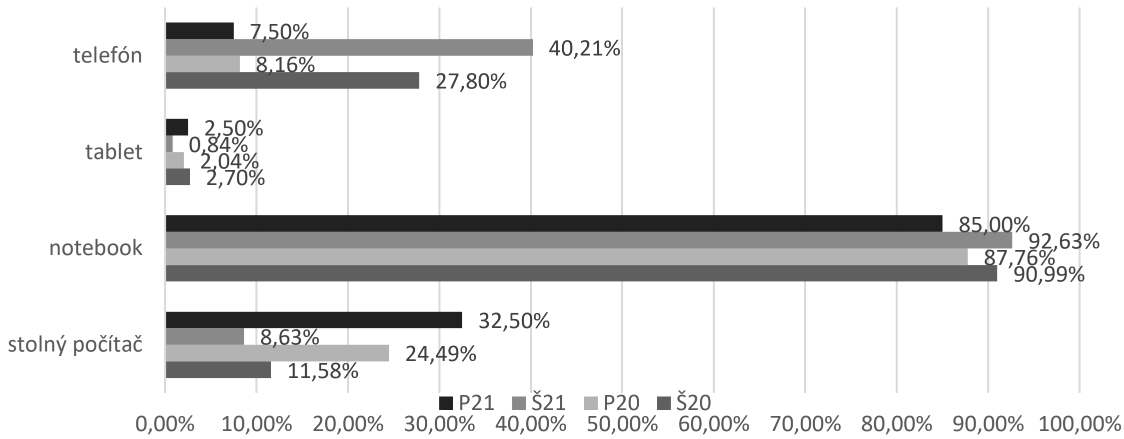

Figure 1: Comparison of student and educator hardware equipment during both pandemic waves (item 1 in the students' and teachers' questionnaire)

To a large extent, the laptop represents a cheaper alternative to a desktop computer. What is more, it is also a portable alternative what is one of the essential criteria declared by university students who travel a lot. This, potentially, has also affected the devices students and educators have used in online education. The market surveys present evidence of significant demand in the mid-price category of laptops. Concerning the educators, they use desktop computers more often than the students. University students nowadays are expected to own IT technology and to be able to effectively use it, which was also reflected in the year-on-year examination of students' personal hardware equipment.

The students had adequate technology for participation in online teaching, and according to teachers, they also had adequate technology (their score was even higher than the learner's score). Student scores did not change in a year-on-year comparison. Students had sufficient IT equipment before the onset of the pandemic and were not necessarily forced to replace it one year after the beginning of the pandemic. Teachers' scores changed slightly but not statistically significantly in year-on-year comparison. Thus, in general, we conclude that both educators and students had equipment with sufficient and adequate performance to be active in distance education. The higher demands on hardware in the second wave period probably caused teachers' scores to be slightly lower.

The pandemic situation caused a sudden transfer from in-class teaching to virtual space. The teacher's goal was to simulate, at least partially, an in-class environment, to provide students with the study materials, provide and collect the feedback. However, some signs indicated that some teachers had problems with such a transfer, and the classes were not realised. This was also the reason why question searching the answer to this question was included in a section *Software and materials distribution*. This section also focused on the problems with the software used for instruction.

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Table 1: Descriptive statistics for the item 6 in the students' and teachers' questionnaire in 2020 and 2021 (materials delivery)

Group Descriptives

	Group	N	Mean	Median	SD	SE
2020	Študent	777	4.46	5.00	1.41	0.0508
	Pedagóg	49	5.76	6.00	0.560	0.0800
2021	Študent	485	4.75	5.00	1.25	0.0567
	Pedagóg	40	5.83	6.00	0.385	0.0608

According to the data, students received more materials during the second wave of the coronavirus in the summer semester than in the first wave, and more teachers were active in e-learning (we observed a statistically significant difference between the students' scores in 2020 and 2021). Teachers scored this item highly positively in both observed periods, and we did not observe a statistically significant difference between the data collected in those two periods. Teachers claimed they worked in both periods intensively. A comparison of students' and teachers' scores at the end of both waves of the pandemic, however, brings interesting results. Both, students and educators rated this item differently in the two observed periods, and the difference is statistically significant at the end of both waves. Students rated the delivery and amount of materials more negatively compared to educators. A slight change occurred in the second wave, where the rating was slightly more positive, still we observed statistically significant difference between the teachers' and students' response at the end of both periods.

Table 2: Teacher-student t-test for the item 6 in 2020 and 2021 (materials delivery)

Independent Samples T-Test

		statistic	±%	df	p	Mean difference	SE difference	Cohen's d
2020	Student's t	−6.36 [a]		824	< .001	−1.29	0.203	−0.936
	Bayes factor$_{10}$	2.34e+7	1.05e−15					
2021	Student's t	−5.44 [a]		523	< .001	−1.08	0.198	−0.895
	Bayes factor$_{10}$	135029	2.47e−11					

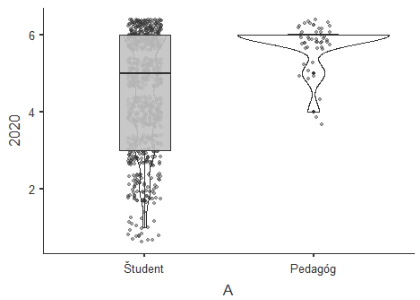

Figure 2: Density distribution of data in the item 6 in 2020 (delivery of the materials)

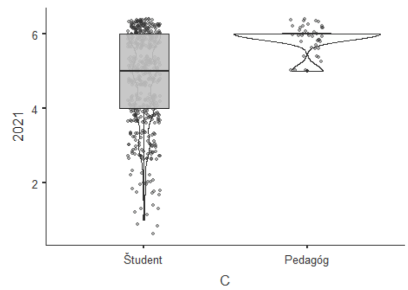

Figure 3: Density distribution of data in the item 6 in 2021 (delivery of the materials)

The first wave was characterised by the anticipated reopening of schools and the fast return of students to full-time education. Therefore, some teachers were teaching only the most necessary material, doing only the necessary activities and waiting for the return of students. This was, however, not accepted by the students as an adequate substitution of

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in-class teaching. From the student's point of view, the situation improved slightly in the second wave; a statistically significant difference in student evaluation of the two periods was observed. Also, the teachers' evaluation is more consistent in the second wave and almost all of them scored the item with the highest grade. The students' evaluations in the second wave indicated *a slight improvement in communication or distribution of educational materials*, it was not as marked as suggested by the teachers in their evaluations in both periods.

Apart from the available hardware, or the extent to which teachers communicated with students, the distance learning tool itself is also essential. We surveyed both educators and students in both observation periods to determine which tool they used in e-learning. In general, we can state that the LMS Moodle was the most frequently used system in both years, used by almost 90% of the students. Not surprisingly, we observe a significant change in using different tools in the year-on-year comparison. In 2021, we see a decrease in using e-mail and a significant increase in using MS Teams with its videoconferencing, grouping students, channels, chatting tools. We observed a striking increase from 15% to 85%. MS Teams as a virtual environment became the recommended tool of the university for running lectures, seminars, consultations, meetings and exams. Microsoft's version of OneDrive also dominated among the cloud applications. Thanks to its space and synchronisation features, it had already been used by some teachers and students before the corona crisis.

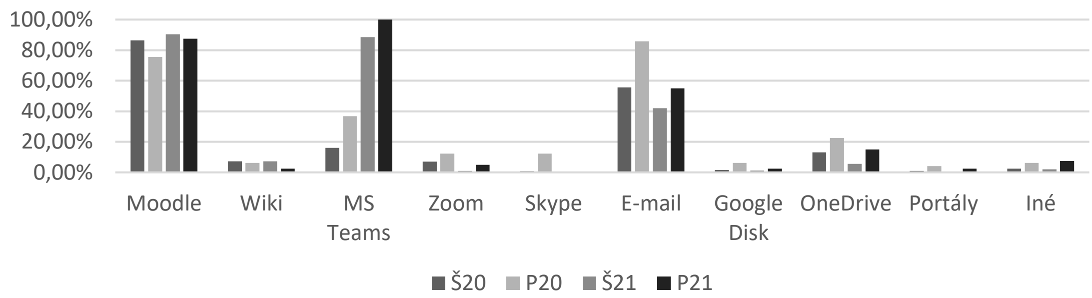

Figure 4: Comparison of the tools used during the two pandemic waves (item 7 in the students' and item 8 in the teachers' questionnaires)

This was also the case of teachers, and the most used tools included e-mail, LMS Moodle and MS Teams. An e-mail has its constant place in higher education due to its key features, and in the first wave up to 86% of educators used it to distribute materials. At the beginning of the pandemic, teachers used what they were familiar with and could easily use, which undoubtedly influenced the frequent use of e-mail. In the second, wave teachers opted for the more structured and logical organisation of the materials in, e.g. MS Teams or Moodle, with their functions and possibilities to store material in one place. Most teachers had used LMS Moodle before the pandemic, which was reflected in the high scores after the first wave. The most criticised aspect of distance education is the lack of social contact. This is also the problem of LMS Moodle that offers the possibilities to organise materials logically, it also has tools for synchronous and asynchronous communication, but some teachers miss the videoconferencing tool. Therefore, they used MS Teams to organise live synchronous lectures and seminars. Even though it was not massively used in the first wave, all teachers participating in the research reported using MS Teams in the second wave. The second wave of the corona was more severe than the first one, and it was expected that the students might do the entire semester online.

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We try to solve the lack of personal contact in e-learning by organising video conferences, webinars, or creating video lectures or seminars (see also Turcani, et al., 2017). In March 2020, when all educational institutions were closed due to the coronavirus pandemic, we all expected that it would take a few weeks to return to "normal" lives and work routines. During this uncertain period, distance education for university educators who were already using the LMS system as online support to in-class learning was mainly represented by uploading static and dynamic learning materials to existing courses, and some teachers were conducting regular webinars as they are now. This was also reflected in the students' evaluation of the organisation of the online meetings, which is significantly different in the observed periods (between the two waves).

Teachers during the first wave of the coronavirus pandemic mostly did not use live webinars for teaching, and as the results of the previous items show, e-mail and Moodle dominated as a tool. However, the situation changed in the second wave and most teachers expecting the more extended period of distance learning moved to MS Teams that the university recommended.

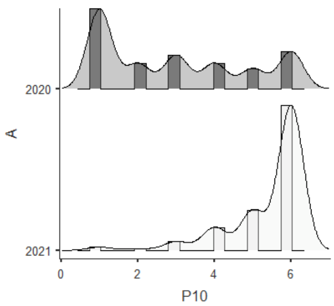

Figure 5: Observed distribution in a group of students in the item 10 in both observed periods (use of live meetings)

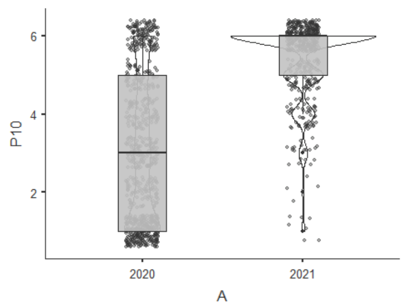

Figure 6: Density distribution of data in the item 10 in both observed periods (use of live meetings)

It was natural that the absence of social contact was less common in the second wave compared to the period before. Educational institutions thus responsibly approached the implementation of e-learning, which included live lectures and seminars as a compulsory part, following a slightly modified timetable from in-class lessons, striving to offer an adequate alternative to the "traditional" educational process.

The lack of personal contact within e-learning was compensated by the realization of video conferences - webinars. In the period March 2020, but also long before, distance learning was mainly implemented in the integrated learning environment LMS Moodle. The system was used as blended learning to support face-to-face learning. E-courses were mainly made up of uploading static, or ideally dynamic, learning materials and few educators conducted regular webinars as they do nowadays. This was also reflected in the evaluation of the organization of online meetings with students in the inter-annual evaluation, which is significantly different between the different waves, and we detect a significant difference in the evaluation.

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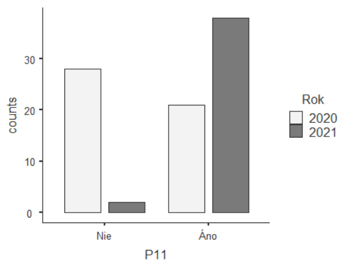

Figure 7: Frequency of responses to the item use of live meetings in distance education among teachers

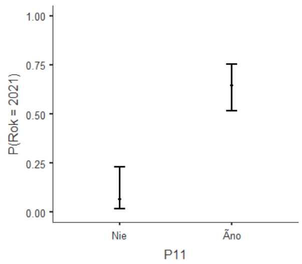

Figure: 8 Estimated marginal means of the item use of live meetings in distance education by educators

Implementing distance education is naturally associated with using various multimedia - a combination of text, graphics, audio, and video, animations, video lectures, audio-recording, etc. As many as 95% of students claimed that only 1-5 teachers out of 60 created such elements in the first wave. Teachers confirmed this finding; almost 75% of the teachers reported not creating such materials at that period. The situation changed slightly during the second wave. Multimedia elements are on decrease; online tools are used more frequently, mainly the mentioned above MS teams.

CONCLUSION

Distance education is an extensively discussed issue, which requires both technical knowledge in digital technologies, expertise in e-learning resources creation, and didactic, methodology knowledge. E-learning (both off-line/online forms - synchronous/asynchronous forms) enables sharing and use of intellectual capital and, last but not least, the whole process of managing complex learning (Fedorko 2013). A good e-learning course that activates and motivates the learner does not emerge in a day or a semester, but there is a long-term process of development based on student feedback. The interruption of face-to-face teaching created a space to confirm the meaningfulness of e-learning. In a pandemic period, there was space to actually 'try out' and implement distance learning to its full extent, as the definitions state.

A space was created for "collecting" a lot of data, surveying trainees' opinions, and mapping the situation during distance learning in the pandemic. We observe different opinions of teachers and students on the same issue, and the analysis of these findings can move us forward.

We are convinced that the current way of teaching using technology and special learning environments will be present in blended learning even after this challenging pandemic period is over, bringing effective resources, objective assessment, learner individualization, greater understanding of content, and perhaps someday the expected flow to education.

The paper's authors have long considered integrated learning environments in combination with online tools as an alternative, full-fledged option for streamlining and improving the quality of educational processes, also in the subject area of the project solution - Health Education.

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Possibilities of Automation of Data Collection from Facial Recognition Software

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Abstract

The topic of analysing human emotions is a complex one that has received considerable attention in recent years. It's essential to identify the ties between seemingly unrelated subjects and domains like computer science and psychology. As a result, it has a lot of potential for improving human-computer interaction in a range of domains, such as education, healthcare, and economy. Physiological and emotional monitoring, particularly in the areas of stress and anxiety monitoring, is of interest to researchers. There are available emotion recognition solutions, which can classify and output basic emotional states based on facial recognition and it can be used in combination with monitoring of physiological functions to get insights about how the physiological functions of the user increase or decrease during specific emotional states. The main purpose of this work is to analyse the available emotional recognition solutions based on the face of the user and to find the hardware and software solution that is financially available, it can be used in many areas and has the highest possible accuracy in the classification process. It is also important to modify the code, so the classified emotions can be transferred to a database table and the if needed, the taken image by the emotion recognition software is sent further to a storage on a server using file transfer protocol (FTP).

Keywords

Facial Recognition, Emotional States, Classification.

INTRODUCTION

Affective computing is a field of study that has gotten a lot of attention in recent years. It focuses on how people feel while interacting with computers and apps (Picard, Vyzas and Healey, 2001). It relates to issues in recognizing and reacting to emotions, as well as influencing emotional states. The use of affective computing in applications in numerous aspects of our lives, such as education (Tsoulouhas, Georgiou and Karakos, 2011; Landowska, 2014), entertainment (Landowska and Wróbel, 2015; Szwoch and Szwoch, 2015), software engineering (Wróbel, 2013), healthcare (Tivatansakul and Ohkura, 2013), and other fields (Kołakowska *et al.*, 2014), is becoming more common.

Affective computing tools differ in numerous ways. The most obvious is the information source considered for recognizing users' emotions. It could be something visual (Gunes and Piccardi, 2005), aural (Schuller, Lang and Rigoll, 2002), literary (Gill *et al.*, 2008), physiological

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(Wioleta, 2013), or behavioural (Kołakowska, 2013) in nature. In a general instance, determining the correct technique is challenging. Some of these input channels appear to be better at recognizing emotions than others. Some are noted for being discreet, while others are considered to be inconvenient for users. Facial expression analysis appears to strike a balance between high recognition accuracy and ease of data collection. Furthermore, because the face is usually the first thing people notice, it is the most natural way (Brodny *et al.*, 2016).

The aim of this work is to review several available emotion recognition solutions from the facial expressions of the user. Then, a software with open-source code will be selected and modified so that the recognized emotion can be later stored on a server in database tables. Recognizing the emotional state of the user with the highest possible accuracy and automatizing this process is an important task in affective computing, as we cannot expect the users to manually upload their data.

RELATED WORK

For a long time, the study of human emotions and their right interpretation has been a research topic in psychology. However, from the standpoint of computer science, it is a relatively recent field of study that has been explored collaboratively since the 1960s. Many algorithms and approaches have been developed as artificial intelligence has progressed (Essa and Pentland, 1997; Viola and Jones, 2001; Stastny and Skorpil, 2007; Chavhan *et al.*, 2015; Khadhraoui, Faouzi and Amiri, 2017; Pang *et al.*, 2017), and they have been employed and are still used in various phases of the recognition process today (Pantic and Rothkrantz, 2000; Aviezer, Trope and Todorov, 2012; Zhu *et al.*, 2014; Kucharik and Balogh, 2017; Mokhayeri and Granger, 2020; Reichel *et al.*, 2020).

A number of different analyses have identified a link between evoked emotional states and their typical expressions in the human face throughout the past years in the context of connecting the research fields of psychology and computer science (Ekman, Sorenson and Friesen, 1969; Matsumoto *et al.*, 2008; Røysamb *et al.*, 2018; Songa, Slabbinck and Vermeir, 2018; Magdin, Benko and Koprda, 2019; Francisti *et al.*, 2020; Munk *et al.*, 2021). A number of alternative models have been defined in psychology to help us identify emotional states (Weiner, 1980; Lövheim, 2012), but two in particular have been most prominent and are currently the most dominant: Ekman's classification (Ekman, 1992) and the Russell Circumplex model (Russell, 1980).

Ekman's classification is a classification system that is mostly used in the context of direct observation of a person's face. Different methods are utilized in the area of Ekman classification for different steps of the recognition process in the field of computer vision research (Minařík and Stastny, 2008). The usage of the Viola-Jones algorithm (Viola and Jones, 2004; Berkane, Kenza and Belhadef, 2019; Colak and Varol, 2019; Besnassi, Neggaz and Benyettou, 2020) is the most popular method for the detection phase.

Unfortunately, identifying an individual's emotional state only based on their face has significant drawbacks. Ekman's model is particularly strict; it does not take into account the individual's so-called dynamic multimodal behavioural patterns. Russell's model, on the other hand, assumes that, under certain circumstances, some traits that may unambiguously distinguish a given type of emotion may overlap (e.g., happiness and

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surprise, fear and sadness). As a result, numerous authors argue that in order to accurately identify an emotional state, additional criteria must be included as well. Changes in physiological processes, for example (Goetz, Keltner and Simon-Thomas, 2010; Oveis, Horberg and Keltner, 2010) are examples of such factors.

The Xpress Engine software from QuantumLab in Poland allows users to perceive and analyse emotions evoked by various stimuli. The analysis, which is based on the Facial Action Coding System (FACS) model, may be done both in real time and in batch mode. Xpress Engine can detect five of Ekman's emotions, including happiness, disgust, surprise, sadness, anger, and the neutral state. Xpress Engine also detects a subset of FACS Action Units. Xpress Engine outputs a vector of identified emotions and an action unit for each frame. The Xpress Engine interface analysis highlights the most important key matters in emotion recognition from facial expressions: face recognition in the entire available scene, recognition of eyes within the face, recognition of expressions on a normalized face image, and elimination of the influence of face angle towards camera on affect recognition results (Brodny *et al.*, 2016). The five basic emotions: joy, anger, disgust, sadness, surprise are expressed in the same way by most people in the world. Xpress Engine can recognize them with an accuracy of 91% (Trojmiasto.pl, 2015).

FaceReader by Noldus works in a similar way as Xpress Engine. It analyses the user's facial expressions to recognize emotions. The application assesses six of Ekman's emotions automatically: happiness, disgust, surprise, sadness, anger, fear, neutral and, additionally, contempt. FaceReader examines a subset of action units that are regularly utilized. FaceReader recognizes facial expressions and may describe them as valence and arousal values in the circumplex model of emotions, as well as the value of recognized emotions. The program displays a live analysis view, and each detected face is marked with a rectangle. Additional masks can also be displayed on the face to provide insight into the recognizing process. Emotions are expressed by bars and a pie chart on the screen. The user interface can be customized, and new sub-windows can be presented in a variety of ways (Brodny *et al.*, 2016). According to a validation study using ADFES (Amsterdam Dynamic Facial Expression Set), FaceReader 9 delivers accurate performance for emotion classification, with an average accuracy of 99% (Noldus, 2022). Earlier versions (FaceReader 6) reached an accuracy of 89% on the same dataset (Stöckli *et al.*, 2017).

Both technologies can do real-time or batch analysis, with the latter option providing results as a set of detected emotion vectors for each video frame. Data can be processed and then analysed separately, however, the source code of these solutions are not open, therefore, we cannot modify it to automatically send the detected emotions to a database table. A freely available emotion recognition software is available in Python language, which can be also used on Internet of Things devices, such as the Raspberry Pi microcomputer. This software has open-source code and it can be altered to automatically send the classified emotion to a server. This software and its modification will be discussed in the next section.

Authors Malygina et al., (Malygina *et al.*, 2019) have also tested facial recognition solutions on different datasets. According to these authors, Affectiva Affdex reached an accuracy of 39%, Neurodata Lab Emotion Detection reached an accuracy of 53%, Amazon Rekognition Facial Analysis an accuracy of 49% while Microsoft Face Emotion Recognition an accuracy of 62%.

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MATERIALS AND METHODS

It is also possible to use Internet of Things devices to detect emotions based on the facial features of users. The advantage of these solutions is that the used devices are portable and low-cost. A Raspberry Pi microcomputer can be used with a camera module to detect emotions. The created system can be used in an experiment; however, the accuracy and the performance of the system will be lower than professional devices. The experiment can be later replicated by using different systems. To detect and recognize emotions using Raspberry Pi IV with a camera module with the ability to send the data to a database, we used A. Balaji's repository (Balaji, 2018). The repository has a few dependencies, which includes OpenCV and Tensorflow. OpenCV (Open-Source Computer Vision Library) is an open-source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications. Since it is open source, OpenCV makes it easy for individuals to utilize and modify the code. TensorFlow is an end-to-end open-source platform for machine learning. It has a number of tools, libraries and community resources that lets researchers create modern machine learning solutions and developers easily build and deploy machine learning powered applications. The algorithm also detects basic emotions using Ekman's classification (Ekman, 1999), popularly known as "The Big Six." Happiness, sadness, fear, surprise, anger, and disgust were the emotions the software was able to detect, and they are still the most widely acknowledged choices for basic emotions among emotion theorists (Piórkowska and Wrobel, 2017). In the event that the model is unable to detect any of the six basic emotional states, a seventh emotional state — a neutral state – is added to the classification.

RESEARCH METHODOLOGY

The machine learning model was trained using 35887 pictures of faces from the Facial Expression Recognition 2013 (FER-2013) dataset (Carrier and Courville, 2013). This dataset contains 48x48 grayscale images labelled with the emotion depicted in the image. The model detects faces in each frame of the camera stream using the haar cascade method. Paul Viola and Michael Jones suggested an effective object recognition approach employing a cascade classifier based on Haar features in their 2001 paper "Rapid Object Detection with a Boosted Cascade of Simple Features" (Viola and Jones, 2001). A cascade function is trained from several photos in this method, which is based on machine learning (positive and negative). After then, it's utilized to find features in other photos. The recognized portion of the image containing the face is enlarged to 48x48 pixels to match the size of the photographs in the dataset, then supplied as input to the Keras-supported 4-layer convolutional neural network, which serves as an interface for the TensorFlow library. The network then generates a list of softmax scores for each of the seven emotion classes. Softmax translates the numerical output of a multi-class classification neural network's final linear layer (logits) to probabilities by computing the exponents of each output and then normalizing each number by the sum of those exponents until the total output vector equals one. All of the probabilities should add up to one. The loss function for such a multi-class classification problem is frequently cross entropy loss. Softmax is frequently used as the final layer in image categorization networks. As seen in the figure (Figure 1), the emotion with the greatest softmax score is then overlayed on the camera stream.

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Figure 1: The emotion overlayed on the camera stream (own figure).

We have modified the main fragment of the code (Figure 2). Every time a face is detected, the image is cropped and is used in the model to classify the emotion. The classified emotion is then added to an object that is sent as parameter in a request to a specified URL.

```
for (x, y, w, h) in faces:
    cv2.rectangle(frame, (x, y-50), (x+w, y+h+10), (255, 0, 0), 2)
    roi_gray = gray[y:y + h, x:x + w]
    cropped_img = np.expand_dims(np.expand_dims(
        cv2.resize(roi_gray, (48, 48)), -1), 0)
    prediction = model.predict(cropped_img)
    maxindex = int(np.argmax(prediction))
    userdata = {"emotion": emotion_dict[maxindex]}
    resp = requests.post('https://www.physcatch.sk/insertfacial.php', params=userdata)
    cv2.putText(frame, emotion_dict[maxindex], (x+20, y-60),
                cv2.FONT_HERSHEY_SIMPLEX, 1, (255, 255, 255), 2, cv2.LINE_AA)
```

Figure 2: The main fragment of the code (own figure).

The PHP script available on the URL receives the data and inserts new records to the database. Some of the inserted records can be seen in the table (Table 1).

Table 1: Sample data from the database (own table).

id	emotion	date_time
229	Surprised	2022-01-02 20:43:08
228	Surprised	2022-01-02 20:43:07
227	Surprised	2022-01-02 20:43:06
226	Fearful	2022-01-02 20:43:05
225	Fearful	2022-01-02 20:43:04

As it can be seen, on average, a new record is inserted into the database table every second, which in our context can be considered real-time monitoring of emotional states based on facial expressions. When it comes to hardware, CPU usage on our Raspberry Pi IV was 50% when only the facial recognition software was running. As it can be seen in the figure (Figure 3) 46% of CPU load was due to Python. Considering the hardware usage is also an important factor when using IoT devices, as more software could be running on the same microcomputer, therefore, we have to have an insight about the resources needed for each part of the complex solution, where the data can be acquired by doing load testing.

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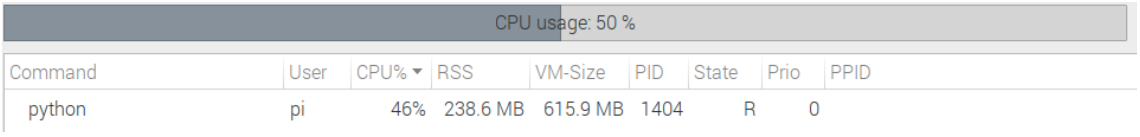

Figure 3: CPU usage while running the facial recognition software on the Raspberry Pi IV (own figure).

CONCLUSION AND FUTURE WORK

Several emotion classification solutions based on facial expressions have been reviewed, which are summarized in the table (Table 2). We consider the conclusion of this work the overview of currently available facial recognition tools with their accuracy and information about whether the code is open-source or not. As it can be seen from table 2, the most accurate facial recognition tools are commercial products, where the source code is not modifiable by the developer community. Since only the facial expression recognition software created in Python language and tested on Raspberry Pi was open-source, it was selected, and the code was modified, so we could automatize the data transfer of the classified emotions into database table, where they can be analysed and visualised.

Table 2: Overview of the mentioned emotion recognition solutions
(own table created based on the information from the Related work section).

Facial Recognition Solution	Accuracy	Open-source
Xpress Engine by Quantum Labs	91%	no
FaceReader by Noldus	99%	no
Affectiva Affdex	39%	no
Neurodata Lab Emotion Detection	53%	no
Amazon Rekognition Facial Analysis	49%	no
Microsoft Face Emotion Recognition	62%	no
Facial Expression Recognition in Python	63.2%	yes

The classified emotion will be used as a reference value in future works to find correlations between the emotion classified by the model using facial expressions and measured physiological functions that will be monitored simultaneously. The aim will be to gain knowledge about how physiological functions increase or decrease during specific emotions. Later, the measured physiological functions be will be used as features, while the classified emotion from the model will be used as a target attribute to train a machine learning model. A functioning machine learning model will be able to predict the emotional state of the users based on their physiological functions without the need to use a software that detects emotions based on the facial expressions of the user and the solution can be used in many environments.

One of the environments, where such a solution could be used is education, where based on the physiological data we could recognize the emotions of students. Monitoring the emotional state of students during various activities in the academic environment could help teachers identify stressful activities and a positive change in those activities could make the experience of students in school less stressful. Distance learning became very popular during the recent pandemic and the solution does not require any special environments; therefore, the students' emotions can be monitored using their webcam and as an addition, using wearable technologies, their physiological functions can be acquired as well.

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The 3D Software in Secondary School Education – Pilot Study

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Abstract

The article deals with the implementation of 3D technologies, 3D graphics and 3D software in education at secondary schools. The theoretical part outlines the issues of the above technologies. The main part of the article is devoted to research that was conducted in 2021. The research was conducted. The research was conducted among pupils at secondary schools in the Czech Republic. The research was carried out in the form of a questionnaire survey. The main goal of the survey was mapping the knowledge of the 3D software in pupils at grammar schools, secondary vocational schools. The survey aims to answer the research questions. The main result of the research is that totally 59.1% of the secondary school pupils know 3D graphics and 3D software. The research also discover that 3D software can be implemented near all educational areas. The other result of the research is that most popular 3D software is Autodesk.

Keywords

3D graphics, 3D software, secondary school.

INTRODUCTION

The 3D graphics belong to the above-standard education at secondary schools. Nevertheless, many schools are responding to current labour market demand. As part of their school curricula, some schools include 3D graphics in their teaching. By including above-standard educational programs in the regular teaching of the school, they not only respond to the current demand of the labour market, but also take into account the preferences of pupils. (Magdin et. al., 2013).

The 3D graphics are based on vectors. Based on 3D graphics the objects and scenes can be created. With the use of materials, the right lighting and camera settings, we achieve realistic images and with high-quality workmanship that is difficult to recognize from reality. (Pászto, Krišková, 2018).

The 3D graphics are created in 3D tools. The 3D space is only a virtual surface, which is based on the Cartesian coordinate system, a geometric spatial map developed by René Descartes.

The 3D space is defined in three axes - *X*, *Y*, *Z*, which means width, height, depth. A numerical grid is built from them, in which these points are defined by their coordinates. The zero point is the intersection of all three axes and is called the origin (0,0,0). The axes themselves are called World Axis, they are fixed. Each object has its own axes, which is called Local Axis. The local axes enable movement or rotation of the (Derakhshani, 2006).

The 3D graphics is supported by 3D software. The use of the 3D software develops spatial imagination, spatial thinking (Trojovska, 2019, Nemec, Vobornik, 2018, Nemec, Vobornik, 2019). The 3D software can be used as learning tools in many subjects. Within the research we have found out the use of 3D software in the learning in the secondary schools in the Czech Republic. The usage of 3D graphics develops pupils' imagination, and it has influence to development of cognitive function and creative thinking (Kohutek, Turcani, 2020).

The presented research maps the knowledge and usage of the 3D technology, mainly 3D software in secondary schools. The research results support implementation of the 3D software in different area of the education

RESEARCH

The aim of the survey is to map the knowledge of 3D software in pupils at grammar schools, secondary vocational schools. Based on the survey, a proposal for the implementation of 3D graphics and 3D tools in selected educational areas at secondary schools will be implemented in the future.

The survey aims to answer the following research questions.

1. What percentage of pupils know 3D software?
2. Do pupils use 3D technology in their learning? If so, in which subjects?

The research methods

A questionnaire survey method was chosen to verify the above assumptions and to meet the aim of the survey.

The questionnaire was different for each respondent. The length of the questionnaire varied according to the answers. A pupil who did not know 3D technology had 2 compulsory and 2 optional questions. The pupil, who knew 3D technology and used 3D software during the lessons, answered 9 questions. A pupil who did not know 3D software, did not meet him in the class, but would like to meet him, answered 5 questions about 3D technology.

The questionnaire was created using Google Forms. The questions were then processed in Microsoft Excel.

The survey was conducted among the addressed secondary school and vocational school pupils from all over the Czech Republic. A total 349 pupils from the grammar school and the secondary vocational schools answered.

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The survey in form of link to Google Forms was distributed to directors of the schools and they distributed it between pupils.

Data analysis, survey results and their interpretation

The first question

The first question that divided the respondents was "*Have you encountered 3D software?*".

Totally 59.1% answered the question about knowledge of 3D software in the negative and 40.9% answered positively. This question divided the respondents into two groups.

I don't know 3D software – 59.1%

If the respondents did not know 3D software, they were asked if they would like to get acquainted with 3D software. They had three answers to choose from:

- "*I don't want to meet*";
- "*Yes - I will meet myself*";
- "*Yes - I want to meet in class*".

The results are shown in the Table 1.

Table 1 – The question answers

ANSWER	PERCENTAGE
I don't want to meet	47.3%
Yes - I will meet myself	33.9%
Yes - I want to meet in class	18.8%

The most common answer was "*Yes - I want to meet in class*", this is how 47.3% of respondents answered, 33.9% of respondents said that they are not interested in getting acquainted with 3D software and 18.8% of pupils want to get acquainted with 3D software, but alone. It is possible that this is due to the fact that pupils generally do not want to educate themselves.

For the respondents who answered that they would like to get acquainted with 3D software during learning, the open question " *In what subjects do you think the 3D software could be used?*" The results are part of the results shown in the Table 3.

I know 3D software – 40.9%

The first question found what specific types of 3D software the respondents know. It was an enumeration question, and they had a choice of thirteen types of software with the possibility of writing other software. This option was used and most often the software was written 3D Rhinoceros and one respondent wrote Archicad. The results are shown in the Table 2. The sum of the percentages is not equal to 100%, because this was an enumeration question.

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Table 2 – The 3D software knowledge

ANSWER	PERCENTAGE
SketchUp	23.5%
Blender	23.4%
Cinema 4D	20.1%
Autodesk AutoCAD	14.1%
Autodesk 3DS MAX	8.0%
ZBrush	7.9%
FreeCAD	7.8%
SolidWorks	7.7%
Autodesk MAYA	5.7%

The most well-known software includes SketchUp (23.5% respondents), Blender (23.4% respondents) and Cinema 4D (20.1% respondents). This is followed by AutoCAD (14.1% respondents), Autodesk 3DS MAX (8.0% respondents), ZBrush (7.9% respondents), FreeCAD (7.8% respondents), SolidWorks (7.7% respondents) and Autodesk MAYA (5.7% respondents). Fewer respondents already knew the following software (less than 5.7% respondents): Autodesk TINKERCAD, Inventor, Fusion 360 and REVIT.

We were also interested in whether pupils ever encountered 3D software during learning. Totally 46.5% pupils answered YES, and 53.5% answered NO.

These 46.5% pupils who know 3D software from the learning were asked in which subjects the 3D were used. The results are shown in the Table 3.

Table 3 – 3D software in the subjects

SUBJECT	PERCENTAGE
3D modelling	63,6%
Art	40,9%
Technics	37,9%
Medical subjects	25,8%
Robotics	15,2%
Computer graphics	10,6%
Designing	10,6%
Subjects related to game creation	3,0%
Animation	1,5%
Photographic design	1,5%
Informatics	1,5%

These 53.5% of respondents who know 3D software but did not meet it during the teaching were asked if they want 3D software used during learning. Almost three quarters (72.3%) would like 3D software used in the lessons.

These 72.3% of the pupils were asked the question: "*In what subjects do you think the 3D software could be used?*" The results are in the Table 4.

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Table 4 – 3D software in the subjects

SUBJECT	PERCENTAGE
Informatics	79,6%
Biology	27,8%
3D modelling	25,9%
Medical subjects	24,8%
Physics	20,3%
Chemistry	12,8%
Mathematics	12,0%
Animation	9,8%
Technics	8,6%
Art	8,6%
History	6,4%
Programming	4,1%
Economics	4,1%
Geography	3,4%
Gym	2,3%
In all subjects	2,3%

3D software in learning

Only those who encountered the software during the learning answered the questions in this section. The questions were "*What software did you use during the lessons?*". The results are shown in the graph in the Table 4.

Table 4 – The use of 3D software in the learning

3D SOFTWARE	PERCENTAGE
Autodesk AutoCAD	37,9%
SketchUp	25,8%
3D Rhinoceros	22,7%
Blender	18,2%
Cinema4D	15,2%
Autodesk Inventor	9,1%
Autodesk TINKERCAD	7,6%
Autodesk 3DS MAX	1,5%

The answers from the questionnaire show that pupils and pupils most often used Autodesk AutoCAD (25 answers), SketchUp (17 answers), 3D Rhinoceros (15 answers), Blender (12 answers) and Cinema4D (10 answers) during the lessons. This was followed by Autodesk Inventor (6 answers), Autodesk TINKERCAD (5 answers) and Autodesk 3DS MAX (1 answer). None of the respondents used Autodesk Maya, REVIT, Fusion 360, Zbrush, FreeCAD during the course.

The last open-ended question was, "*What subjects did you use 3D software for?*" The answers are expressed in Table 5.

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Table 5 - Answers to the question " *What subjects did you use 3D software for?*"

SOFTWARE	SUBJECT	PERCENTAGE
Blender	Informatics	9,1%
	Medical subjects	7,6%
	Photographic design	1,5%
	Subjects related to game creation	1,5%
	Designing	1,5%
	3D modelling	1,5%
	Computer graphics	3,0%
	Animation	1,5%
SketchUp	Informatics	7,6%
	Technics	13,6%
	3D modelling	3,0%
	Computer graphics	3,0%
	Art	1,5%
	Robotics	1,5%
SolidWorks	Technics	10,6%
	Computer graphics	1,5%
	Informatics	3,0%
3D Rhinoceros	3D modelling	19,7%
	Designing	7,6%
	Informatics	3,0%
	Technics	9,1%
Cinema 4D	Animation	13,6%
	Computer graphics	9,1%
	Informatics	1,5%
Autodesk Inventor	Computer graphics	3,0%
	3D modelling	1,5%
	Technics	6,1%
	Informatics	1,5%
Autodesk AutoCAD	Computer graphics	4,5%
	3D modelling	15,2%
	Designing	9,1%
	Technics	24,2%
	Informatics	4,5%
Autodesk 3Ds Max	Computer graphics	1,5%
Autodesk TINKERCAD	Informatics	6,1%
"I don't remember the name"	Photographic design	1,5%
	Medical subjects	3,0%
	Informatics	1,5%

The surprising answer was a 4th grade secondary school pupil who answer the question "*What subject did you use 3D software for?*" "*The school didn't teach me anything*". And this pupil knew and used the most types of software of all respondents.

CONCLUSION

The aim of the presented survey was to find out whether pupils of grammar schools and other types of secondary schools know 3D software, whether they use 3D software in

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learning and in which educational areas 3D software can be used. The research results show that 3D software is used in the education, but only in some subject, that we assume the 3D software can be used. The results also show, that the pupils would like to use the 3D software more and near in all subjects.

Based on the survey, a proposal for the implementation of 3D software in the education will be prepared.

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How to use Educational Software in Teaching Chemistry: The Qualitative Insight into Opinions and Attitudes of Czech Chemistry Teachers

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Abstract

The role and importance of information and communication technologies in education are continuously increasing, going hand in hand with the emphasis on the digital competency development. The implementation of educational software is one of the possibilities to achieve how to reach better results in chemistry teaching. However, the appropriate use is substantially related to teachers' opinions and attitudes. Therefore, qualitative research was conducted using semi-structured interviews with 12 teachers representing different types of educational software users and having various lengths of teaching practice. The analysis of the semi-structured interviews was based on the interviews' transcript and open coding by the "pen and paper" method; then, the codes were categorized and the technique of "reading the cards" finalized the process. The results of the analysis show that teachers who use the educational software in chemistry teaching point to its positive impact on learners' results in learning. However, the absence of teacher-learner communication and interaction is considered a negative factor that can result in the fact that learning content is not fully acquired by the learners, as well as the learner´s oral performance is not supported and developed. Furthermore, teachers are afraid of learners 'careless' approach when working with educational software, or consequent overloading of learners with technologies. Insufficient equipment in schools with hardware and software, lack of external support, personal characteristics of teachers, insufficient time load for teaching chemistry, and inappropriateness of the educational software available belong to the most frequently mentioned constraints on the use of educational software.

Keywords

Educational software, Teachers attitude, Chemistry education, Learning Technologies.

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INTRODUCTION

The role and importance of information and communication technologies (ICT) in education are continuously increasing, changing the hardware and software used, as well as teaching methods, ways of learning content presentation, and search for and sharing information among teachers (Frýzková, 2008). Nowadays, in the Czech Republic, this trend is supported by the document Strategy for the Education Policy of the Czech Republic up to 2030+ (Faberová and Kohoutová, 2020) and relating revisions of the Framework Educational Programmes (FEP). Innovations in learning content and expected outcomes in the area of Informatics are part of the document, including a new definition of the digital competency that is expected to be developed in all areas and fields of education within their context of learning content.

One of the ways how to integrate ICT in chemistry teaching and thus support digital competency development is to use educational software defined as a learning tool predetermined for teaching and self-learning by using educational technology with learning as the end product (Januszewski and Molenda, 2013). Educational software in chemistry teaching can serve to substitute or supplement chemistry experiments, not only those that are time-demanding and equipment-unavailable (Kupatadze, 2013; Turcani and Mudrak, 2020) but mainly when the macroscopic, microscopic, and semi-microscopic levels of the chemical experiment are to be displayed at the same time, which enables better understanding of the chemical process and emphasizes to show deeper inter-relations (Díaz et al., 2008; Marson and Torres, 2011; Solomonidou and Stavridou, 2001; Tatli and Ayas, 2013). Educational software also provides support to the connection of theory and practice (Fialho and Matos, 2010), enables shortening the length of study, and provides individualized teaching (Serban and Savii, 2011).

When any new technology supporting teaching is introduced, new research questions appear. The impact of ICT in teaching has been researched for more than half of the century, but as e.g., Endrizzi (2012) states without any clear and convincing result. Various constraints may appear that impede the implementation of educational software into chemistry teaching, mainly insufficient readiness of teachers, or inappropriate use that is not in accordance with teaching objectives (Eichler and Del Pino, 2000; Fialho and Matos, 2010; Mondeja González and Zumalacárregui De Cárdenas, 2009). Problems may be detected even when we work with quality educational software because of the complexity of the process (Altun et al., 2010; Balogh et al., 2014; Perry and Schnaid, 2012). These reasons led us to conduct a deep insight into the opinions and attitudes towards the use of educational software by Czech chemistry teachers; opinions and attitudes form the starting point for real, and meaningful implementation of educational software in the teaching process.

RESEARCH DESIGN

Chroustová et al. (2017) conducted a research that focused on the use of educational software among Czech chemistry teachers. They discovered significant differences between *current users* and *non-users*, as well as between three types of non-users: *former users*, who had had experience in using educational software but they did not use it later on, *non-planning non-users*, who had not used educational software and were not going to use it

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later on, and *planning non-users*, who had not used educational software at that time but they planned to do so after the research.

In this research, the identical typology of Czech chemistry teachers was applied. Data were collected via semi-structured interviews where the predefined questions serve as the structure of the interview (Švaříček et al., 2007).

The main objective was to detect the opinions and attitudes of Czech chemistry teachers towards the use of educational software in chemistry teaching, that is, to discover factors that make impact on teachers' decision to implement (or not) the educational software in lessons, including their preferences for some teaching methods and organizational forms in chemistry teaching. To gain deeper understanding of teachers' opinions and attitudes, interviews were conducted with teachers of different types (Švaříček et al., 2007).

The questions were structured into four parts: introductory, main, identifying, and final (Švaříček et al., 2007). In the first part, respondents were informed about the research objective, the method of recording the interviews, data processing, and about the way in which data will be kept anonymous through informed consent. Consent was repeated before each interview started. The introductory questions (Q1, Q2) focused on the school equipment of the respondent with ICT and their attitude towards the ICT use in teaching. The main questions (Q3 – 13) dealt with educational software: the definition, availability at school, respondent's opinion on the efficiency and contribution of the educational software to teaching, optimal conditions for implementation in chemistry lessons, and optimal features of educational software. The introductory and main questions are listed below:

- Q1. *Would you tell me what the ICT equipment is at your school? What technologies can be used or do you use to support the chemistry teaching?*
- Q2. *Do you think that the use of ICT in chemistry teaching is beneficial?*
- Q3. *In the literature, there is more than one definition of educational software. What is your definition?*
- Q4. *Do you understand the definition or would you comment on it?*
- Q5. *What is your experience with using educational software in chemistry teaching?*
- Q6. *What is your opinion on the statement that using educational software in chemistry teaching results in better knowledge of the learners?*
- Q7. *Under what conditions do you consider the use of educational software in chemistry teaching to be meaningful and contributively. Imagine the optimal state and describe it.*
- Q8. *What are the main differences when comparing the optimal state with the current situation?*
- Q9. *Would you describe the optimal educational software for chemistry teaching?*
- Q10. *In your opinion, what are the main advantages and disadvantages of using educational software in chemistry teaching?*
- Q11. *In what way would you implement the work with educational software in chemistry lessons?*
- Q12. *Do your colleagues use educational software in chemistry teaching? / Have you had the opportunity to learn about the work with educational software in chemistry teaching from your colleagues?*

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Q13. *Would you recommend the work with educational software in chemistry teaching to your colleagues? Why?*

Identifying questions focused on the respondent's teaching practice and degree. The final questions provided the respondent with the opportunity to add more information.

Semi-structured interviews were conducted at the respondent's workplace; they were 15 to 35 minutes long. However, only the first two interviews were 15 minutes long; the others lasted more than 19 minutes, probably due to the increasing experience of the researcher in interviewing, consequent modification of questions, and experience in transcribing of the recordings.

To analyse the interviews, first, a verbatim transcription of the recordings was made (Hendl, 2005). Then, the analysis followed that applied open coding by the method "pen and paper". Finally, the technique of "reading the cards" was used (Švaříček et al., 2007).

RESEARCH SAMPLE

Purposive sampling was applied to form the research sample (Gavora, 2000). It consists of 12 chemistry teachers who met the criteria presented in the table below (see Tab. 1) and recommendations of other teachers. We aimed at having respondents from the group of users/non-users of the educational software as defined by Chroustová et al. (2017), but also teachers – *beginners* (1-5 years of teaching practice), *experienced* teachers (6-25 years of teaching practice), and *conservative teachers with fading motivation to learn new things* (25+ years of teaching practice, Průcha (2005). And, one teacher with less than one year of teaching practice was included in the sample (*absolute beginner*). Most absolute beginners are characterized as "shocked by the teaching reality", their professional skills are being developed and they are step-by-step adapting to the professional environment (Průcha, 2002, 2005).

Table 1: Characteristics of the research sample.

Teacher code	Teacher category	Teaching practice (years)	Expected user type	School type
A	Experienced	12	current user	G
B	Conservative and fading	32	non-planning non-user	G
C	Experienced	7	current user	G
D	Conservative and fading	33	non-planning non-user	G
E	Experienced	19	planning non-user	G
F	Experienced	24	current user	L
G	Experienced	19	planning non-user	G
H	Experienced	16	planning non-user	G
I	Absolute beginner	1	former user	L
J	Experienced	25	current user	V
K	Experienced	23	former user	G
L	Beginner	5	current user	LS

Note. G – General upper secondary (grammar) schools, L – Lower-secondary school, V – Vocational (technical) school

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RESULTS AND DISCUSSION

ICT in schools; the use in chemistry teaching

Introductory questions about ICT served to induce a positive environment for conducting the interview, to map how the school is equipped with ICT, and how teachers can use them.

The responses clearly show that the level of school equipment varies. All schools had one or two computer classrooms, but the number of computers in them differed. In general, they used computers bought more or less in the past, which means that their quality was not the same: "*Sometimes, it lasts ten minutes before the computer starts working, and when it finally starts, after a few minutes, it collapses*…" (teacher L). This fact can be supported by data from the Czech Statistical Office 2018; they state that most computers were in service for more than three years (Wichová, 2019). Classrooms equipped with a PC and beamer were considered standard. They are available in almost all schools, sometimes in combination with the interactive board. However, there are still schools where this ICT equipment is not available, or the equipment for laboratory lessons is missing, and only selected chemistry lessons can be held in the labs. This fact increases the mental strain of the teacher when scheduling lessons and organizing shifts of learners to the specialized classroom: "*… I must reconsider planning the lessons according to the classrooms available in the schedule, for example, we cannot run an experiment because the ICT lab with special equipment needed for it is not available at the time of the lesson.*" (teacher L). It is rather common that there are three interactive boards per school. It results in the fact that chemistry teachers are those who frequently and regularly use interactive boards. Teacher L and teacher G have the interactive board in the chemistry lab, which is rather exceptional. In some schools, notebooks, tablets, iPads, dataloggers, or sensors are available for chemistry lessons.

Regardless of whether teachers have the ICT available in every lesson or have to book the lab in advance, they all use ICT in chemistry teaching to some extent. They are either sure that it increases learners' motivation and attracts their attention, or they consider it to be a necessary response to ICT development in general. An interesting reason for ICT implementation was given by teacher K: "*…there is something like an interrelation, right? The teacher works with computer, presents something interesting, so learners are also interested in the teacher, aren't they? I can see how it works, so I can go along with it.*"

Chemistry teachers use ICT for lesson preparation, that is, for making presentations, digital learning materials, electronic and printed worksheets, for the search for new information, for example, via YouTube, they can also engage learners, and the information is exploited to support their lessons. ICT can also be used to support experimental activities as an alternative to real chemical experiments: "*…it enables me to present what cannot be shown in reality, …*" (teacher J), or for the preparation before the laboratory experiment is conducted, for example, teachers can project a video-recording showing the technique for the work. From the viewpoint of phases of the process of instruction in which the ICTs are implemented, they can be used to support the illustrativeness of the explanations, or practising the newly acquired learning content. Furthermore, learners' presentations can be implemented, which besides others leads to the development of learners' presentation skills.

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Teacher's view of educational software in chemistry teaching

Chemistry teachers expect to detect a **positive impact** of educational software on the process of instruction and learners' results when implementing it in lessons, and they also express similar reasons as they mentioned with ICT implementation: "… *but I think it is necessary these days, and it is different work, at a higher level*…" (teacher E). They emphasize that learners are interested in working with educational software because it mediates the learning content through technologies they have a positive relationship with: "…*and, I think learners like the lessons more if the software is implemented..*." (teacher E). Teachers consider the use of educational software more acceptable compared to printed materials: "*And, learners do not like reading, they do not like printed materials, so I would 100 times rather tell them the fact; to let them read – it does not work.*" (teacher I).

Teachers understand the educational software as a tool that makes the lesson more varied, as a possibility that widens the portfolio of teaching methods and organizational forms. Educational software that provides new ways of learning content presentation brings changes into the lessons: "*Well, I think, it's another viewpoint on the subject…*" (teacher B) or makes learners more active: "*I have experience in using it (educational software), so I know that learners are more interested and active...*" (teacher J). Another contribution of educational software for chemistry teaching is that it supports learners' autonomy: "*…then, when the program interacts with, they blink it's good, it's bad, it forces them to try to invent independently, just why it didn't work*" (teacher L). Leading towards autonomy in learning is another reason, why teachers use educational software: "…*this is like I gave them instructions how to practise the learning content autonomously, without me*…" (teacher F). Educational software also makes teacher's work easier because it replaces them in providing feedback, they do not speak, they save the voice, and time for lesson preparation: "*…if I am going to liven up the explanation of a learning content, not only to speak monotonously and tediously, and use a marker only, I search for the Internet… the search also takes time but if the material is well-designed and fits my purpose, it makes the preparation for a lesson easier and time- and work-saving.*" (teacher H). If teachers use online tests, learners are provided with immediate feedback. Further advantages include, for example, a user-friendly environment, support to individual or team work, creativity and competitiveness, visual support that enables to understand demanding topics etc. (Stoica et al., 2010).

Questions about how efficient the use of educational software in lessons is have not been clearly answered, neither from the viewpoint of the teaching method, "*…the efficiency…, well, I think it closely relates to the teacher explanation and answers to learners' questions, and in these fields, the role of teacher is irreplaceable, but in practising, educational software is in the lead.*" (teacher F), nor regarding the quality of learning content presentation: "*The choice is important because… I can have high quality software but if it does not attract learners' attention, because of the graphics, colours, pictures they do not like, it is no good, useless. On the other hand, I can have common, non-attractive at first sight software that can have other, user-friendly features, and learners will like the work with it. This is the problem – how to discover which aid is the most attractive from learners' viewpoint. Then, their activity will arise and the use of educational software can be considered.*" (teacher L). Principles of visual design of electronic learning objects in relation to the results of the teaching process were investigated in works, for example, by Plass et al. (2009a; 2009b) and Adams et al. (2008a; 2008b).

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All teachers unanimously agree that the role of educational software in chemistry teaching is primarily to support lessons, they do not consider it to be a tool to replace teachers or to be used in every lesson, but to support efficiency if used appropriately: "*If it (educational software) is used as a tool supporting the teaching. If it is not the 'leitmotiv' of chemistry teaching because the role of the teacher is irreplaceable, in my opinion. And if it is implemented at the right moment to support teaching, it enlivens the lessons, helps practise the learning content…*" (teacher J). Similar conclusions were discovered, for example, by Mondeja González and Zumalacárregui De Cárdenas (2009) who said that educational software does not replace the teacher but serves to support reaching learning objectives.

Contrary to the above mentioned, a **negative impact** was also detected when educational software was used in chemistry teaching. Missing teacher-learner communication belongs to those features that are most frequently mentioned: "*I think that learners, when using the software, cannot ask questions to the software … the only possibility is to express their own opinion…*" (teacher B). The absence of direct interaction with the teacher may result in non-understanding of the information provided by the software: "*…children are used to work in a way how we communicate in lessons, and if the materials are prepared by another person (author, teacher…), they may not know the needed facts but questions are asked in another way, and this may cause problems*…" (teacher C). And oral performance of the learners is not sufficiently developed when working with educational software: "…*the benefits often do not prevail the loss of time and teacher-learner contact; learners should not express themselves in digital way only. In school-leaving exams, oral performance is evaluated.*" (teacher D).

Other teacher concerns are connected with learners' careless approach to learning lessons supported by educational software: "*They (learners) consider working with educational software to be effortless, as random thoughtless clicking on what they are interested in at that time*…" (teacher K), "*I think, most of the learners were mindless clicking only, they do not think whether the answer is correct or not, it is the ´select one of the proposed choices´ approach, they do not think much about the answers, but the same can be found when they work with printed materials. So, the problem is the multiple-choice format, it is not the dis/advantage of the software.*" (teacher C). It is also necessary to change aids, teaching methods, and organizational forms so that learners are not overloaded with technology: "*…when using the software, learners are back in the environment of computers where they spend three quarters of the day, I guess, and they do not know the reality.*" (teacher K). As recommended by Bell and Smetana (2008), digital learning objects should supplement, not replace, other teaching procedures.

Constraints on the use of educational software in chemistry teaching

As mentioned above, **insufficient equipment in** schools with ICT belongs to the constraints on the use of educational software in chemistry teaching. Based on interviews, commonly, chemistry teachers cannot count on the use of ICT labs: "*Of course, we have two IT labs at school. However, I cannot use them because IT lessons are scheduled there first*…" (teacher A), "*…I cannot use educational software because there is no space for chemistry lessons to be taught in IT labs.*" (teacher B). Thus, chemistry teachers are to work in another classroom with the equipment available there: "*The schedule is overloaded, there is hardly any possibility to change rooms, so I have to work with the equipment available in the classroom scheduled for my lesson …*" (teacher A). This fact strongly limits the use of

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educational software: *"…I discovered that I have them (interactive simulations of experiments) available but my lessons are not scheduled in classrooms equipped with an interactive board, so it makes no sense…*" (teacher I). And, even if the teacher has the technology available in their classroom, they cannot 100% rely on it, not only on the computers: *"…I usually go to the classroom during the break, before the lesson starts, and check whether everything works, passwords etc., (…) so that the lesson did not lose speed and time was not wasted. Because – if something does not work, it is no good, right?*" (teacher E). As for the use of mobile technologies, for example, tablets: "*…when we used tablets for the first time, it took so much time to start, to log in, we wasted so much time, and the lesson plan was destroyed…*" (teacher H). Insufficient hardware equipment, the necessity to check everything before, mainly during the break, and despite all this not knowing whether it will work or not, it may result in giving up technologies in lessons (Perrotta, 2017). In some schools, commercial educational software is not available, or they do not have the latest version: *"…only a few schools have educational software, or the version is outdated...*" (teacher H).

Other constraints were detected in the field of **insufficient external support** from school management, colleagues, a decision-making sphere, or educational software developers. Financial sources for buying hardware equipment are often covered from projects, resp. Developmental programmes (for example, The Operational Programme Education for Competitiveness). However, this support was considered low and too complicated to reach by one teacher: "…*I would expect the state to help more in getting the equipment. Of course, we have some projects but it takes a lot of time and work to synchronize them.*" (teacher F). Another problem is insufficient support from school management; they do not provide a positive environment for educational software implementation or new technologies in general: "*If the work is expected to run individually, every learner must have their tablet, but there is no will to teach this way*." (teacher G). In other schools, teachers are not informed about school equipment: "…*these days, we were reinformed what equipment is available because some teachers did not know what we really have*…" (teacher I).

Teachers often fight against misunderstanding from colleagues: "…*we considered whether children could use smartphones in lessons, but the use of smartphones at school is prohibited by headmaster, regardless the purpose*" (teacher F). Consent could be a key moment in using educational software in lessons: "*And, it also depends on other teachers – if, for example, the interactive board or computers are used in most lessons, then, it is more interesting for the learners to have the lessons not supported by technologies … it will be easier to engage them without a computer, right?*" (teacher I).

The most frequently mentioned constraint on using educational software in chemistry teaching is that teachers are not sufficiently informed, further education fails and teachers do not have enough channels to receive latest information: "…*the speed, the rapid the development appeared so fast that people are not qualified, they are not used to exploiting software from the time of university studies, and many of the things – I learned them by myself, it is rather demanding to acquire the software and find the advantages which can be used in teaching.*" (teacher D). And the presentations of the software from the producers are also missing: "*First, I think we did not receive any offer from the producers, I would appreciate this, how the software works…*" (teacher G). Referring to this comment, there is no continuous and updated list distributed among teachers that summarizes information on available educational software. Otherwise, teachers lose much time when searching for the

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information: "…*I was interested in how applications work on Android on mobile phones … you cannot get information if you do not google 'chemistry' every year … and then you read whether there is new information because there is no one to send you such a list. (…) … simply said, there is nothing like this … it is clicking on links … and you hope that you will find something useful*." (teacher I). Teacher may find that there is nothing useful for their lessons, or even discovers some mistakes: "…*I was annoyed … they focus on practising nomenclature, and then, there are compounds that do not exist, it is evident that it was computer-generated and cannot exist in reality, … when I found, say, two mistakes, I was demotivated to continue.*" (teacher I). Finally, teachers become tired of such results and will not continue.

The personal 'setting' of the teacher may work as another constraint. The unwillingness to search for educational software may arise from the personal characteristic of the teacher; it is mainly expected in conservative ones: "… *this is human inertia that prevents me from using the software; we as older teachers have worked without the knowledge and skills*." (teacher D). Some teachers are aware of this characteristic: "…*I have become conservative, I think. I do not use new things any more, I use what we have created, or I have had experience with*…" (teacher J).

Insufficient amounts of lessons (time load) were frequently mentioned: "…*considering the amount of learning content, in particular in grammar schools – we have three lessons of chemistry per week – simply said, if we are to go through all the content, it seems to me that it is rather time-consuming to use the educational software.*" (teacher G). "… and, *we have 'Didakta' and other educational software, and it takes a long time, I do not have so much time during lessons.*" (teacher I). "…*I think it is a good thing, learners develop the knowledge when using software compared to teacher explanations but I cannot teach everything I am expected to do, so quantity goes to the detriment of quality, you know.*" (teacher H).

Optimal conditions for the use of educational software in chemistry teaching

There are two main limits when using educational software in chemistry teaching.

First, optimal ICT equipment, which means teaching in the IT lab, or having enough computers or notebooks in the chemistry lab: "*Well, we could use educational software if each of the classrooms, I teach in, had, let's say, five computers and groups of learners could take turns, we could work in groups (solving different tasks), ... or if we had the IT lab for the lesson, each learner could work with one computer, it means they all could work simultaneously.*" (teacher A). From the current viewpoint, having one tablet per learner seems to be more practical: "*… if using tablets, you are not bound with the interactive board, each learner could work individually, and try experiments with sensors…*" (teacher I). "*Optimal equipment is functional and can be adjusted to the situation, for example, having slats to darken the room with computers, the mobile and adjustable interactive board, etc.*" (teacher E).

Second, quality educational software, which means a complex tool that includes parts for motivation, explanation, practising, and testing, visualization of the learning content, video-recordings of experiments; these features are appreciated in works by Bilani (2007), Le Maréchal and Robinault (2006), and Beaufils and Richoux (2003). Of course, the explanatory part should be short and structured into several parts. Immediate and concretized feedback is a must. Teachers would appreciate the possibility of adjusting the

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content, mainly the text formulations. The basic and optimal features of the educational software from the user view are: "*The software is expected to provide sources, links, so that the teacher could select some of them and the learners could work with the others. It means that the software should be available to learners, not too expensive but responsive and working on mobile devices without any limits. Furthermore, the school administrator is not expected to be engaged in; sometime, it is hard work to register the users. So, easy and user-friendly registration for the learners to register themselves. Colourful, illustrative, with appropriate size of font for easy reading. Well, this is what I remember … and without mistakes, of course.*" (teacher F). Similar criteria are listed, for example, by Leacock and Nesbit (2007).

How educational software can be implemented in chemistry teaching

As mentioned above, chemistry teachers consider educational software to be a tool that should be implemented appropriately to the learning content. However, currently, it is used rather exceptionally if there are good conditions. According to the function of educational software, teachers have experience in using the software in frontal explanation to the class/group, when it supports teachers presentation with illustrative examples, in team and group work: "*I would pick up some topics for autonomous learning and educational software, and then, I would test their knowledge without software, or vice versa I would explain the topics and the learners would practise and test knowledge using the software.*" (teacher A). Identically, teachers consider educational software helpful in frontal work with interactive board, and in individual work with computers or tablets: "*Of course, learners would work autonomously to wider extent because I think there is nothing more helpful than trying something out for themselves. For example, by the trial – error method, if they try and make a mistake, they will remind of this did not work, and to use another way will be better…*" (teacher L). Similar conclusions were discovered by Gallerand (2011).

One teacher regularly uses educational software and states that learners prefer individual use of the software to frontal work. However, chemistry teachers also consider educational software suitable for homework. It may help solve the problem with a lack of time in chemistry lessons and provides learners with immediate feedback in practising new knowledge. "*Sometimes, all learners work with the software, but I mostly rely on that they will do practising in the school Internet club after lessons.*" (teacher F). The way how educational software is implemented in lessons is impacted by IT equipment in the school and by the abilities of the learners.

From the viewpoint of learning content, educational software mostly supports practising the nomenclature: "*I frequently use it to practise nomenclature, because it is based on an algorithm; first, I explain to learners the principles of nomenclature creation, because the software does not provide any explanation, then, we go through it in the software, and finally, they practise it individually....*" (teacher F). Furthermore, educational software can also be used to calculate chemical equations, particle content of substances, types of chemical reactions or historical interests, overview of important chemists, etc. "*Well, and it could be used for equations, how to add single elements to chemical equations, …and for explanations in organic chemistry…*" (teacher D). There are hardly any topics that cannot be taught with the support by educational software; however, teachers realize that, for example, chemical calculation could be difficult: "*I think that all topics could be taught with the support of the software but, for example, calculations of chemical equations could*

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be difficult…" (teacher F), or teachers do not recommend the implementation of educational software to present difficult learning content: "…*especially the classification of hydrocarbons, I would not like to entrust it to the computer…*" (teacher D) and, if possible, to show the subject matter in a realistic way.

CONCLUSION

When we consider teachers' responses in semi-structured interviews, we find out that all teachers, regardless of whether they use educational software or not, agree that the software plays a supportive, not the main role in chemistry teaching, just from the reason it is not able to fully replace the teacher. Teachers consider educational software to be a learning aid that broadens the portfolio of possibilities on how lessons can be conducted. With regard to the possibilities that the educational software brings to chemistry teaching, teachers consider it a tool that makes lessons more varied.

As stated by Chroustová et al. (2017), if teachers think that educational software makes lessons more entertaining and interesting and that this approach suits the teacher, they tend to use it. The problem is that in some cases teachers had not had the possibility to gain own experience in using the software before the interview was held. This results in the fact that they had not required knowledge and financial means to use the software before. Respondents (with some exclusions) do not show complex knowledge about available educational software because, first, it did not exist at the time of their university studies, second, such training was not offered within further education, and they do not have time to search for information individually. In some schools, conditions for more frequent and regular use of educational software are not sufficient. But what is even worse, teachers do not have enough awareness about it. Under these conditions, institutions responsible for teacher training in cooperation with commercial producers should provide presentations of teaching aids, in particular educational software, for each subject. An updated list of the latest products informing about the main features should be provided to chemistry teachers.

Furthermore, it was also found out that teachers are limited by the large volume of learning content and the small number of lessons, which restricts them to experiment with didactic means that do not provide a scientifically verified effect. As one respondent stated, we still prefer quantity to quality. It could be helpful if compulsory learning content was reduced as a result of curriculum revision because we cannot expect that the amount of chemistry lessons will be increased under current conditions of information explosion and consequent cognitive overloading of learners.

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Integration of Digital Competences in the Context of Pedagogical Practice

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Abstract

This article deals with the issue of digital literacy, the level of which needs to be raised due to the constant growth of technologies around us. Digital literacy is no longer just about working with a computer, thus increasing digital literacy affects several aspects. Although we are surrounded by technology on a daily basis, we often fail to use it efficiently enough, therefore raising the level of digital literacy affects everyone, including educators and their pupils. The article presents the results of research aimed at analyzing the views of primary school teachers on their relationship to digital technologies and their implementation in school practice. In addition, it summarizes the whole issue of digital literacy, i.e. what digital literacy is about, why is it necessary to foster it and how it relates to the integration of digital competences into curricular documents and the educational process itself. The article also presents a proposal on how to foster developing digital literacy in future teachers at faculties of education during their preparation for their future profession. The outputs of this article will be used for further research purposes, such as verification of created educational materials used for the development of individual digital competences in primary school pupils. All of this can help current teachers improve their digital skills and get rid of the fear of using digital technology in their teaching.

Keywords

Digital technologies, Education, Digital literacy, Digital competences, TPACK.

INTRODUCTION

The interest in digital technologies in today's generation of children is growing steadily. That does not come as a surprise as children encounter the Internet and digital technologies at every turn and digital technologies accompany them in their daily lives. Nevertheless, there is no need to immediately perceive this fact as negative, because we live in modern age. We should not avoid technology, but rather learn to work it efficiently, which is the precise goal of digital literacy. However, digital literacy is not just about working with a computer, but also includes a number of digital competences. With their inclusion in curricular documents comes the obligation of teachers to foster their development in pupils. Although we are surrounded by constant progress in digital technologies, teachers often lack practical guidelines to help them properly grasp the individual competences and to make further use of them.

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The purpose of this research was to map the current state of integrating digital competences into teaching in primary schools, and therefore we posed the following research questions:

- What is the current state of integrating digital competences into teaching?
- What is the teachers' opinion on the integration of digital competences into school practice?

Digital literacy

The expansion of modern media and the transformations associated with them have affected the way society functions. Changes related to the constant presence of media affect many aspects of human life. The way we live and perceive the reality that surrounds us has changed. The modern technology revolution affects everyone, both young and old, and that is why modern education faces a huge challenge. Its task is to prepare everyone, regardless of age, for working with digital technologies and for developing digital literacy.

Basic literacy means reading and writing. However, the concept of literacy stems from a context within a particular socio-cultural environment. Rather than one literacy, there are multiple literacies to emphasize that literacy is a social practice, and therefore there is not just one single literacy that everyone needs. Instead, we all need (and use) different literacies depending on what social or professional group we belong to (nurses, academics) or what kind of activities we do (dealing with authorities, studying, etc.) (Mallows, 2017).

The ICT sector has developed enormously and, with the advent of the Internet and globalization, a certain section of the population has moved forward and is motivated to develop their digital literacy. The digital world offers us all huge benefits. It provides platforms that allow us to connect, interconnect and collaborate. It presents opportunities to learn about new topics and enables innovation in a way that was unimaginable a few years ago.

Today, technological progress permeates all areas of our lives. Employers expect their employees to posses the skills needed to live, work and grow in today's digital society. Digital literacy is therefore essential for preparing students for their future profession and practice.

The term "digital literacy" first appeared around 1997, when Paul Gilster introduced it as a set of skills for working with the Internet, searching, managing and editing digital information, the ability to participate in online information and communication networks, the ability to properly use and evaluate digital resources, tools and services and apply them to lifelong learning processes. Over decades his concept has been modified and supplemented. Martin (2008) understands digital literacy as the ability to successfully perform digital activities (the ability to work effectively with digital technologies) in a variety of life situations, which may include work, learning, leisure and other aspects of everyday life. Janssen (2013) states that digital literacy involves more than just knowledge of using devices and applications. The sensible and healthy use of ICT requires specific knowledge and attitudes regarding legal and ethical aspects, privacy and security as well as an understanding of the role of ICT in society and a balanced approach to technology.

Digital literacy includes a wide range of competences: knowledge of the basic principles of computer devices and skills in using computer networks; problem solving using basic programming; managing personal information in the online world; working with data;

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security in cyberspace; awareness of digital footprint; advanced critical thinking in order to analyze reliability of information presented on websites; creating and sharing media content and much more (Neumajer, 2017).

Digital literacy is essential for teachers. They have the main responsibility for passing on information to their students and thus preparing them for life in modern society.

Today's generation of young people is drawn into the digital world at a very early age, therefore it is important that they learn to navigate it properly. Through combination of a smart device and an Internet connection, they can find answers to all kinds of questions, whether simple or complex. However, they may not always understand the answers and they will not always be aware of the authenticity of the obtained information or information source. It is the job of a digitally literate teacher to encourage students to think about: which resources are authentic and which are regularly updated, what other useful links about the given topic exist, and whether the written information is biased or objective.

Just as young people are brought up for citizenship and responsibility in the real world, they are also expected to honor the same values in the virtual world. In the digital space, just as in reality, there is a good chance that they will encounter various dangerous and illegal activities. The students themselves can also be involved in these activities – either as victims or the perpetrators (due to the lack of knowledge). Here, too, the teacher plays a major role. Teacher can encourage and motivate pupils to become responsible digital citizens.

On the one hand, pupils are very familiar with various applications and websites, but on the other hand, they are in many cases not able to understand and grasp the potential of the application. It is up to the teacher to help and guide his pupils to do that.

Using a variety of available applications, a digitally literate teacher can distribute better and more sophisticated educational materials to his or her pupils. Based on the learning style of an individual pupils, the teacher can design different forms and methods of teaching and focus on individualism. To an easily distracted pupil, he can offer visual content, to an auditory pupil, he can provide audio recordings.

Teachers are in charge of the comprehensive development of pupils, and therefore they should constantly learn and follow new trends. As part of their professional growth, they should focus not only on deepening and expanding knowledge in their subject, but also on increasing their digital literacy and improving general pedagogical skills.

The TPACK framework

Over the years, a number of frameworks, models and platforms have been developed to assist educators in their efforts to foster the development of students' digital competences, with an emphasis on involving and working with digital technologies. In general, these frameworks focus on enhancing skills when using "educational" applications and digitally acquired information, or on effectively interconnecting pedagogical, contentual and technological knowledge.

The TPACK (Technological Pedagogical Content Knowledge) framework, as described by Mishra and Koehler (2006), was built on Shulman's (1986) idea of the PCK (Pedagogical Content Knowledge) framework by adding the technological component as a separate area.

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The framework describes the knowledge that teachers need to effectively integrate technology into their specific areas in terms of content and level (Niess, 2008).

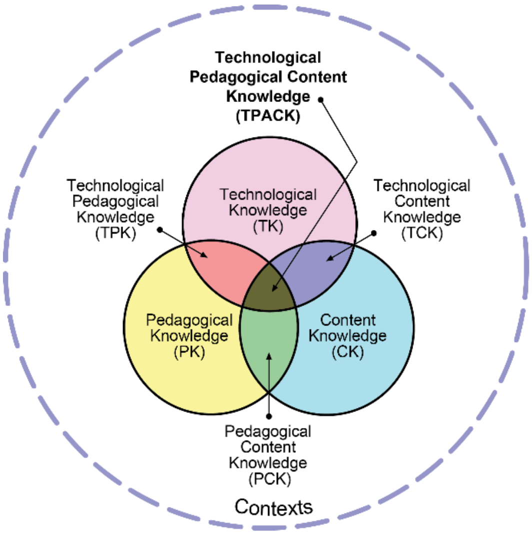

Figure 3: The TPACK model

The seven knowledge areas described by the TPACK framework include (TPACK ORG, 2012):

- technological knowledge (TK): knowledge of different ways of working with technologies, tools and resources,
- content knowledge (CK),
- pedagogical knowledge (PK): knowledge of pedagogical theories, processes, procedures and methods of teaching and learning,
- technological content knowledge (TCK): knowledge of how technologies and content interact and limit each other, which specific technologies are best suited to be used in their teaching,
- pedagogical content knowledge (PCK): knowledge needed to develop and provide effective teaching focused on specific content, various options for interpreting the curriculum, adaptation of teaching materials to previous knowledge of students,
- technological pedagogical knowledge (TPK): knowledge of how technologies can support teaching and learning,
- TPACK: knowledge that supports the teacher's ability to integrate the content of pedagogy and technology in a specific context (subject, level of education, teachers, school aspects, demography, culture, learning environment, etc.).

METHODS

We already know that digital literacy does not only involve working with a computer, but also a range of digital competences, such as information and media literacy, digital

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communication and cooperation, digital content creation, responsible use of digital technologies or problem solving using digital technologies.

At present, teachers in the Czech Republic are struggling with integrating digital technologies into teaching. Although teachers and their pupils encounter digital technologies daily, they often fumble about in them or are unable to manage them effectively enough. If we want digitally literate pupils, we need digitally literate educators. Thus, individual schools are taking various steps in this situation not only to equip themselves with new digital technologies, but also to increase the level of digital literacy of their teachers.

In order to find out what phase of implementation the individual school facilities are currently in, we designed and compiled a questionnaire survey which aims to find out the views of primary school teachers on the implementation of digital competences into school practice.

Using an electronic questionnaire, which consisted of 21 questions, we addressed teachers from various primary schools throughout the Czech Republic using targeted e-mails and social networks. The first 4 questions covered basic information about the respondents, such as age and the length of teaching experience. Subsequently we asked 10 closed, 3 semi-closed and 4 open questions to determine the teachers' relationship to digital technologies or their views on the integration of digital competences into school practice.

RESULTS

The total number of respondents was 94, of which 80 were women and 14 were men. Respondents of all ages participated in the survey, ranging from recently graduated teachers to pre-retirement or already retired teachers, most of whom, almost 70%, had more than 10 years of teaching experience.

Through the questionnaire we tried to assess the teachers' relationship to digital technologies. Therefore, we asked them for opinions on the integration and use of digital technologies and subsequently about ways of fostering the development of individual digital competences in pupils.

Based on the available data we can state that primary school teachers have a predominantly positive attitude towards digital technologies. On a given scale, most chose a positive answer, see Figure 2.

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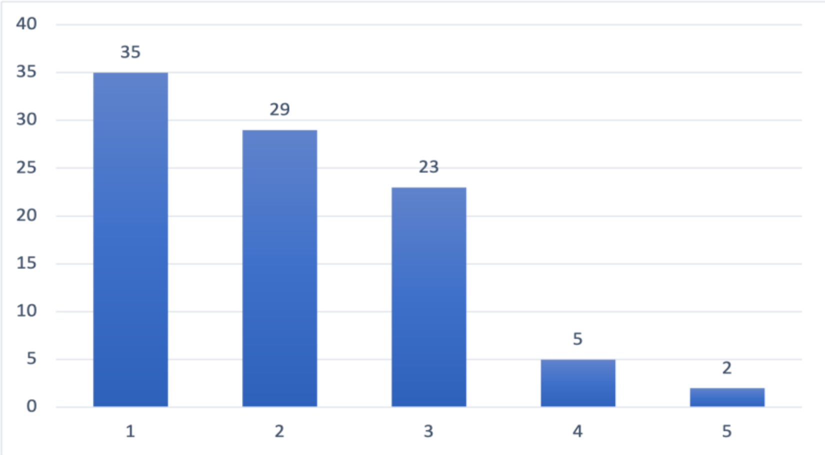

Figure 4: How would you rate your relationship to digital technologies? (where 1 means great and 5 means bad)

Interlinked with the teachers' attitude towards digital technologies is their effort to further educate themselves in the field of digital technologies. As the answers show, more than 70% of teachers want to continue to improve their knowledge in digital technology. Another 23% of teachers responded that they did not know because they had not yet discovered their own limits and only 5% of respondents are satisfied with their knowledge and consider further education unnecessary.

The following two questions concerned the teachers' view on the integration of digital technologies in education and the integration of new key digital competences in the FEP (Framework Educational Programme). When asked to rate the integration of digital technologies into education on a scale of 1 to 5 (where 1 means great and 5 means poor), most teachers gave a grade 1 to 3. Only 3% of respondents chose grades 4 and 5.

The chart in Figure 3 shows that most teachers welcome the integration of a new digital competence and consider it necessary. However, as we can see in the chart, some teachers still do not have a firm opinion or consider the integration of this competence meaningless.

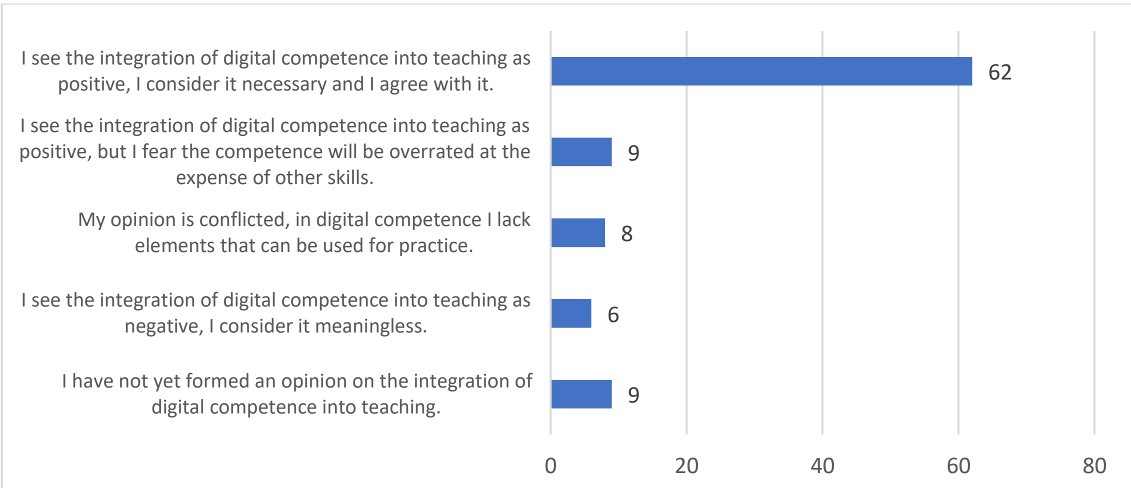

Figure 5: What is your view on the integration of a new key digital competence in the FEP?

The opinion concerning the integration of digital competences into teaching is certainly influenced by the school's digital equipment and the level of digital literacy of individual

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teachers. Therefore, we asked what measures regarding digital competence has the school implemented or is currently implementing. Most educators stated that their school had purchased new digital technologies, provided training for educators in digital literacy, and innovated the school curriculum while incorporating digital competences.

Next, we were interested in the actual use of digital technologies in teaching. In the chart below more than a half of teachers responded that they use digital technologies in their classes often or even very often and at the same time think about using them meaningfully. Other educators stated that they try to use digital technologies from time to time but need to increase their knowledge further.

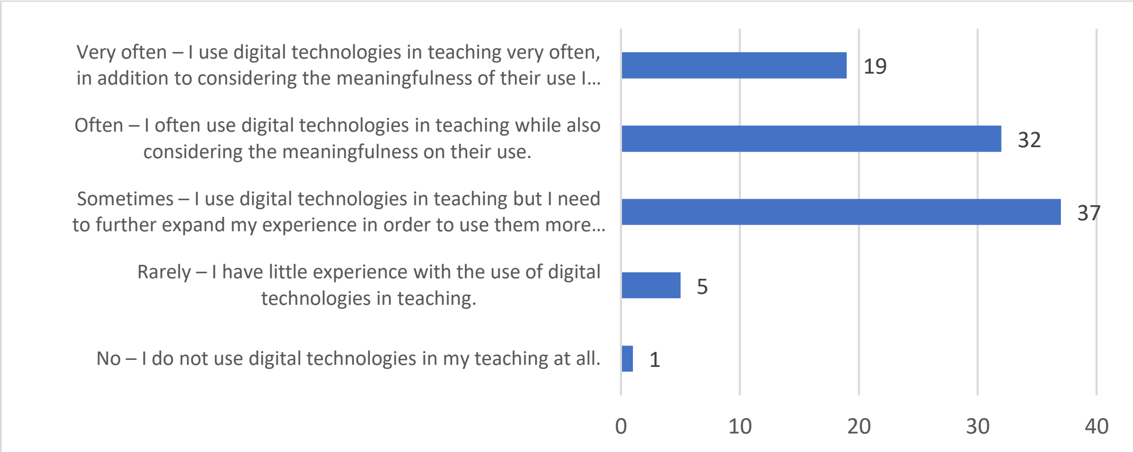

Figure 6: Do you use digital technologies as a teaching support and support for the pupils' learning process?

Most often teachers use digital technologies in activities such as presenting the curriculum, motivating and testing pupils or recording pupils' performance. On the contrary, technologies are very rarely used to create digital content, for practicing or repeating curriculum or during project days. The data obtained from the questionnaire also made it clear that teachers most often use laptops, projectors, interactive white boards, desktops, tablets and mobile phones for their work. Other types of technology, such as robotic toys, kits or 3D printers, are used rarely or not at all. Even though the used applications and programs are very diverse, the respondents agreed on the most common use of the following tools: G Suite (Google Classroom), MS Office, Wordwall, Kahoot, Padlet and Liveworksheets.

The authors were pleased that educators are aware of the possibility of using digital technologies in almost all subjects, which is shown in the chart below.

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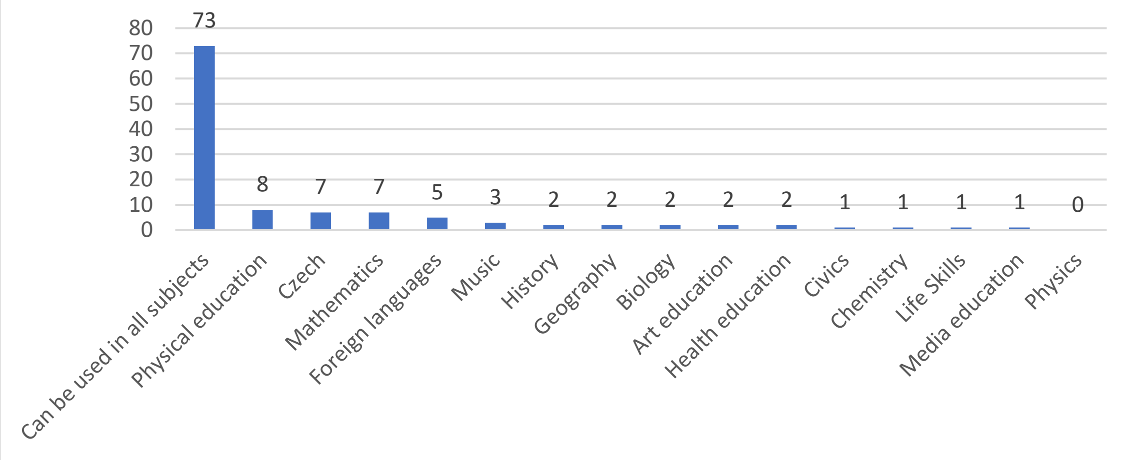

Figure 7: In which subjects, in your opinion, is it not possible to use digital technologies?

The following questions dealt with specific digital competences and their integration into teaching. As shown in Figure 6, almost 50% of teachers encourage their pupils to search for information on the Internet and to also evaluate their authenticity, while 37% of teachers say they do not encourage their pupils to search for information or require verification of resources.

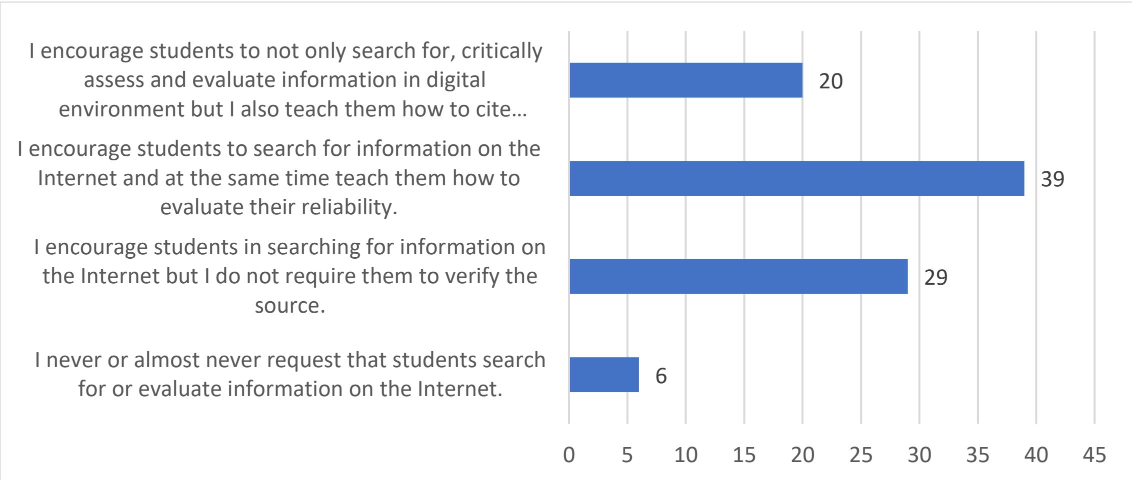

Figure 8: Do you encourage pupils to search for and evaluate information in a digital environment?

More than half of the teachers said that they encourage their pupils to communicate using digital technologies in teaching and at the same time, teach them to choose appropriate communication tools for different type of communication.

Given the answers shown in Figure 7, which deals with the creation of digital content, it is clear that almost 70% of teachers encourage their pupils to create digital content in their lessons. On the contrary, almost 30% of teachers stated that their pupils do not create any digital content.

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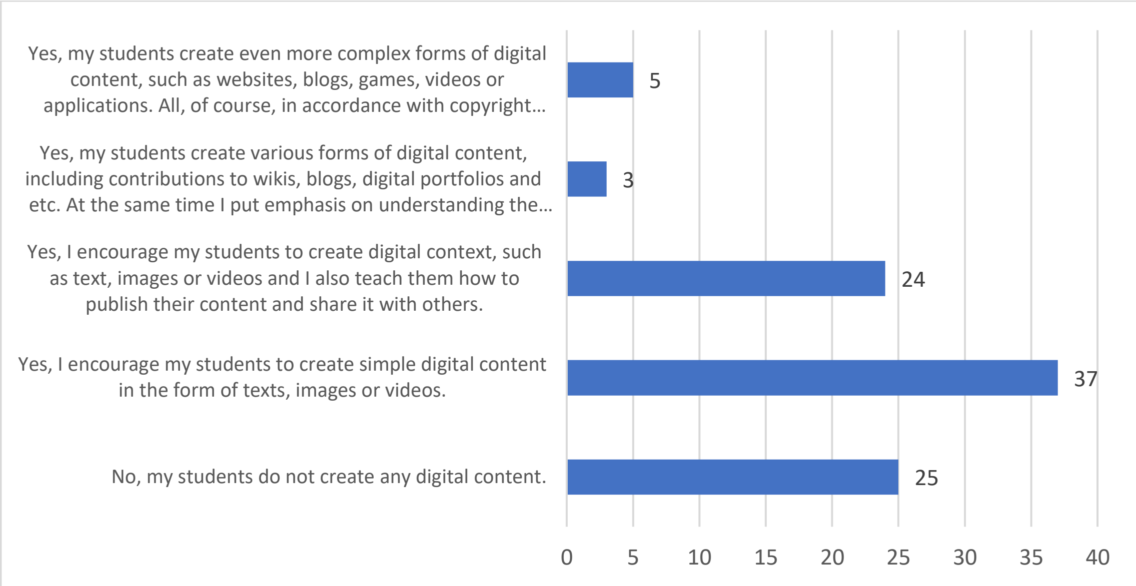

Figure 9: Does your teaching include educational activities that aim to create some digital content?

The following chart shows that the vast majority of teachers, approximately 95%, pay attention to the safety and health of pupils when using digital devices.

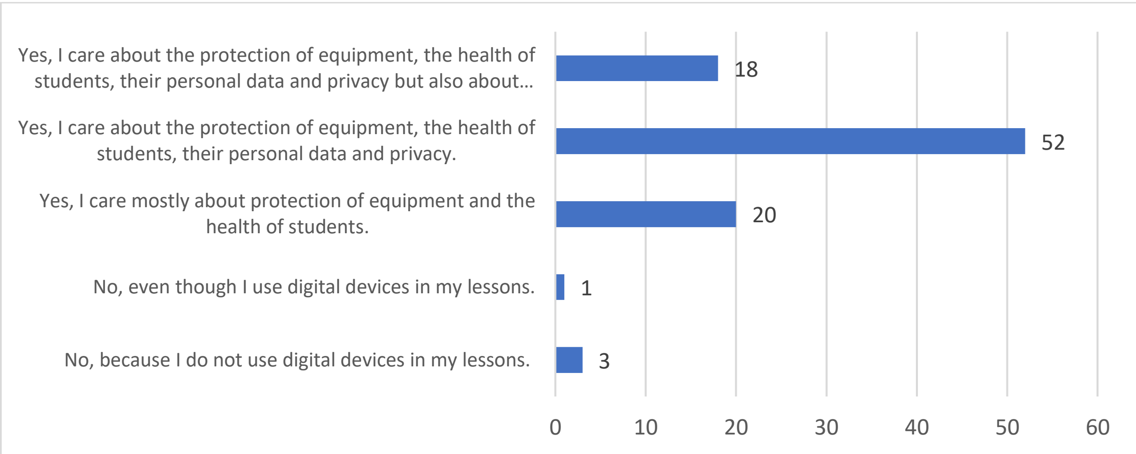

Figure 10: Do you emphasize security when using digital devices?

The last question targeted problem-solving through digital technologies. More than half of the teachers answered that they encourage their pupils to solve problems using digital technologies. Only 30% of respondents stated that they do not encourage their pupils to solve problems with digital technologies.

CONCLUSION

The aim of this paper was to determine the opinions of teachers on digital technologies and their integration into the educational process. In the introductory part of this paper we asked questions that we are now able to answer after completing the survey and analyzing the data.

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The results showed that the integration of digital competences into school practice is in full swing. Schools are taking various steps to provide teachers with the appropriate equipment but also to foster the development of their digital skills. Some of the schools are already taking practical steps concerning pupils, like innovating school curricula or using digital technologies directly in teaching.

Most educators welcome the integration of the new digital competence and consider it necessary due to life in modern society. Nevertheless, there are a few individuals who consider this competence unnecessary. Therefore, we deem advisable for them to cultivate their creativity. This could help them discover new ways of using digital technology both in teaching and across disciplines.

Finally, we would like to give an example of how digital literacy can be cultivated in future teachers and thus prevent possible complications during employment. At the Faculty of Education at the University of Ostrava we require every student of pedagogy to take a microlearning course that has proved to be an effective tool for increasing the level of digital literacy of future teachers. The course supports development in the following areas:

1. Work with text and creation of worksheets.
2. Work with images and graphics.
3. Multimedia.
4. Online tools and sharing.
5. Mobile technologies and applications.

The course is implemented on the LMS Moodle platform. Each chapter contains video tutorials, interactive H5P elements and text materials. All the parts of the course were created according to the basic principles of microlearning.

The effect of the course can be documented by already published results (Polasek, Javorcik, 2020; Javorcik, Havlaskova, 2021), where we dealt with students' study results and their activity in the course in comparison with the previous e-learning option. In addition to the obtained data, the efficiency of the microlearning course can also be documented through evaluation questionnaires, where the students praise the course and they state that it suits them.

It is interesting that the results concerning the integration as well as the use of information technologies in school practice are received with a positive response. Whether the fact that all teachers had to deal with online teaching during the pandemic contributed to this could be a subject of further research and help refine the findings of this survey. In order to further our research a set of tasks designed according to the principles of microlearning will be prepared to help primary school pupils advance in digital competences. Microlearning is still an unexplored area in the Czech school environment, and these tasks should provide teachers with practical resources and advice that will hopefully help them stop being afraid of digital technologies and start using them effectively and with joy.

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Improvement of the Effectivity of Education Process Through Mmorpg Games

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Abstract

Nowadays, information technologies offer new possibilities to make teaching much more appealing for students. Interactive educational portals can provide a solid ground for teaching activities by using information technologies as well as for studying and for homework. However, in many situations, they do not focus on the motivation of the students. There are some ideas that are trying to motivate students through the use of graphical materials, interactive tests, etc. One such idea to motivate students is to connect the boundaries of games and education. Enhancing the effectiveness of teaching by using gamification certainly has the merit of choosing the right game type that students will enjoy and will be suitable for their abilities. In this paper, we focus on the selection of game mechanics, which can increase the efficiency of the portal and the education itself.

Keywords

Interactive education portal, Game development, MMORPG, Educational games, Phaser3.

INTRODUCTION

Nowadays, computer games are one of the most common forms of free time spending. This may be confirmed by modern market research (M. P. J. Habgood, 2011). According to them, the video game industry is more profitable than other industries working in digital entertainment, whether it is sports, movies, or music (D. Eglesz, 2005).

The combination of video games and web browsers became popular, especially at the beginning of the 21st century, when other web technologies also progressed. The popularity of web games is still growing, even though they do not offer such possibilities as games created for different platforms. But why are web games so popular? Web games are a form of fast entertainment these days. The player can type the address into the web browser window and play the game. You can play with friends online or alone and, in most cases, for free. In addition, web games do not have as high hardware requirements as classic computer games. Most popular web games can be also played on mobile devices. Combining the popularity of games and education could create an effective form of teaching, especially in a telepresence form. This idea is a base of implementation in the development of an interactive educational portal. The interactive educational portal was developed as a part of project teaching at the Faculty of Management and Informatics of the University of Zilina

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in Zilina (Fig. 1). It builds on the existing system of an educational portal with the support of games (J. Kostolny, 2018).

Figure 1: Educational portal game world environment

In the game world, learners choose a character and enter the individual games assigned to the subjects themselves. Then, the teacher can select these games in the portal settings and sets of questions for the game itself. Then, after the test is available, the learner can enter the contest and answer questions while playing.

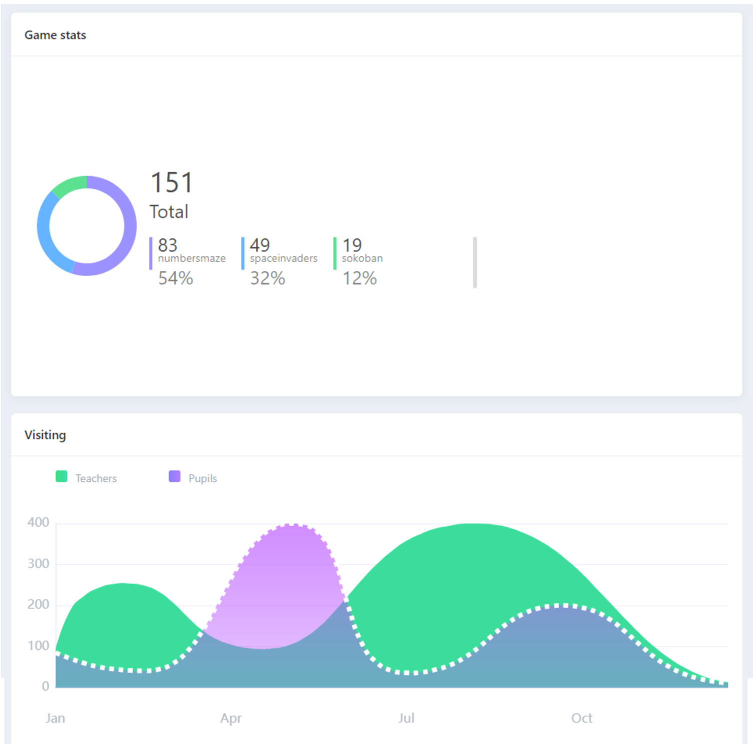

Figure 2: Monitoring the traffic of a given game and game statistics

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In addition to playing games, the portal also supports the display of statistical data on the playability of a given game and the status of answering individual questions (J. Cachovan, 2020) (Fig.2).

SELECTION OF GAME TECHNOLOGY

MMORPG style

MMORPGs combine aspects of RPG games with multiplayer support. Players take on a fictional character set in an imaginary world in RPG games, often in fantasy or sci-fi style. In this world, players can move freely, fight monsters, complete tasks or have dialogues with other unplayable characters.

MMORPG games differ from classic single-player RPG games in that there are a large number of players on one server and one game world (J. Lu, 2019). These players know how to work together on common goals or, conversely, they can compete against each other. In addition, the gaming world is constantly evolving, changing, and expanding over time with newer functionalities.

Thanks to this, MMORPG games are characterized by a very long length of game time or time that players spend without exhausting all the possibilities that the game offers. This is one of the main reasons why, even after more than 15 years, one of the most popular games is in the MMORPG genre and overall, in the online games market, game World of Warcraft. Other popular games in this genre include Runescape, Guild Wars 2, Final Fantasy XIV, Black Desert Online, The Elder Scrolls® Online, and EVE Online (PCGamesN, 2021).

The main elements of MMORPG games include:

- games are typically set in a fantasy or science fiction style environment.
- development of game characters.
- interact with other players.
- each player takes on a fictional character with specific characteristics that the player can modify or improve while playing.
- games are built on client-server architecture.

Designation of MMORPG game properties

In the interactive educational portal, students can choose individual games by entering the buildings themselves. Each building presents a specific subject of teaching. As mentioned earlier, it is possible to divide the types of game characters into several classes in the games. Classes available for players are Knight, Mage, Stalker, and Hunter. Mage and Hunter classes represent game characters with ranged attacks, and Knight and Stalker are game characters with melee attacks. Each class has a different layout of game attributes and a specific set of abilities that player can unlock by gradually completing given tasks.

The player can accept tasks by interacting with characters distributed throughout the game world. Fulfilling these tasks usually involves killing a certain number of monsters or collecting game items that fall out of the dead monsters. After completing the job, the player is rewarded with experience points, game currency, or learning a new ability.

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After creating a character, the player will appear in the game world. The character's movement can be controlled using the keyboard or by clicking on the marked area in the game window, which users with touch screen devices can use. You can also use the keyboard and mouse to control other game elements, such as opening.

Other prominent features of the game include: game inventory, improving skills, game chat that is used to communicate between players and display various information about the player's and the game status, ability to join a group of players and perform game tasks together, new object creation system, object and ability improvement system, combat PvP system, support for various Minigames, large world with many zones, different types of enemies and bosses, stores where the player can buy weapons, equipment, or food and elixirs.

The main features of this game include a skill system that allows the player to collect various game items, increasing skill levels, inventory function in which the player can store the collected game items, system for creating new game items, fulfilment of tasks, different game zones that are available to players after reaching a certain level, duel with monsters and players in certain game zones, game chat showing communication between players and information about various game events, game leader board, ability to join groups of players and perform various game activities with them, helps are distributed throughout the game world in the form of signs, which is helpful for new players, lots of weapons and clothing, ability to build your base.

CHOOSING A TOOL FOR CREATING GAMES

Nowadays, there are countless web technologies, and often, it is challenging to become familiar with them and choose the right one for your project. The same, of course, applies to game engines used to create web games. In the following subchapters, we will look at some known engines and list their functionalities and pros or cons. We will focus mainly on engines used primarily to create 2D games.

Kiwi.js

Kiwi.js (Kiwi.JS Documentation, 2022) is a freely available, open-source engine for developing games for web browsers and mobile devices.

One of the advantages of this engine is its easy usage in practice even for beginning programmers, which follows the simple syntax and good documentation that the developers of this engine offer. On the official Kiwi.js website, we can also find several instructions that is very useful for developing games. One of the main things that shows user-friendly approach for developers are templates for different types of games. Some features are already pre-programmed in these templates depending on the game genre that the user chooses to program. Another advantage of Kiwi.js is its speed of rendering textures using hardware acceleration and WebGL technology.

However, Kiwi.js also has several disadvantages that make it a relatively unsuitable engine to use in 2021. The first such disadvantage is its obsolescence. The latest version of Kiwi.js, according to the official website on the GitHub portal, was released in November 2015. Another of the many disadvantages associated with the obsolescence of this engine is the relatively small developer community that still uses Kiwi.js. Therefore, it can happen

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that if we encounter a problem in the code that we can't fix, it will be much harder to find a solution to it. We could add to the disadvantages the unavailability of some official sites, which is probably also caused by developers' already mentioned obsolescence and negligence about this library.

MelonJS

MelonJS (melonJS API documentation, 2022) is a freely available gaming framework that allows you to develop games for web browsers. MelonJS, like most game frameworks mentioned in this chapter, is an open-source project. The community of developers working with this framework is not that big, but the library is regularly updated and well documented on the official website. MelonJS is less robust compared to other similar tools. It is characterized by relatively small size and a small number of files (below 3MB and the number of files is around 100). Of course, this will be reflected in functionalities, which are lower compared to more robust tools.

Pixi.js

Pixi.js (kittykatattack, 2022) is a freely available open-source engine used to render 2D graphics. It is primarily used in creating animations on websites and the development of 2D web games.

Pixi.js is characterized by high-speed rendering of graphic objects using hardware acceleration and WebGL technology. It is used by companies like Google, Adobe, Disney, Spotify, and others.

As far as game development is concerned, it does not offer as many functionalities as the already mentioned libraries. Its functionalities are mainly connected with the fast rendering of graphics. Therefore, it is not suitable for programmers looking for an engine that fully supports game physics simulation or collision detection. However, it is practical and often used in the development of specific game engine.

Construct 3

Construct 3 (Construct 3 Online Manual, 2022) is a tool that allows you to create games for web browsers and mobile devices. Games in this engine are developed directly in the editor on the website, or it is possible to download a desktop application. Engine in Construct 3 can also run on mobile devices that meet system requirements.

The most significant advantage of Construct 3 is that it does not require knowledge of any programming language, but it supports scripting in Javascript. This feature makes it the most suitable tool, among all those mentioned in this chapter, for beginning programmers or people who are not so interested in programming.

Disadvantages of this tool include a higher usage fee, which is paid every month. Also, this tool does not provide as much freedom in creating a game as traditional programming.

Phaser3

Phaser (E. Feronato, 2018) is an open-source framework used to develop 2D games for web browsers and mobile devices with the Android or iOS operating system. Games made in the Phaser framework are developed in JavaScript or TypeScript. In addition, Phaser uses WebGL or HTML canvas technology to render graphics, supported by most modern web

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browsers. Regarding physics simulation, Phaser supports several engines to support game physics simulation (Game Development Envato, 2022). These engines include Arcade and Matter.

Arcade is the fastest and easiest to use. In Phaser, all objects to which physics is applied have the points attribute. On the other hand, the point attribute has several parameters, including dimensions and position information within the playing area, based on which, for example, object collision checking can then be performed. However, the Arcade engine only supports rectangular or circular objects.

The Matter is more challenging to use and slower in terms of performance. On the other hand, it supports objects of different shapes and also allows different interactions between these objects.

Phaser's most significant advantage is its popularity in the game developer community. For this reason, there are a large number of resources on the Internet from which it is possible to draw during development. Phaser also offers excellent documentation, tutorials for beginners, and demonstrations of many functions on practical examples directly on the official website. Phaser is regularly updated, and with new versions, new functionalities and bug fixes from previous versions are released.

GAME DESIGN AND IMPLEMENTATION

In this part, we will focus on the main functionalities and components of our game. Then, we will gradually analyze the player's mechanics, unplayable characters, and the system of tasks.

The player joins the game by accessing the interactive educational portal. In the portal settings, you can set a nickname. After confirming the nickname, the user is moved to the player character type on the selection screen. The player has a choice between three game characters, which differ in the current graphic display. After selecting a character, the player is moved to the game world (Fig. 3). The player controls the game character using the arrow keys and, on mobile devices, a virtual joystick on the screen.

Figure 3: Character in the game environment.

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NPCs are characters in the game world that the player does not control. We divide these characters into two categories in our game: Characters giving tasks and Enemies (Fig.4).

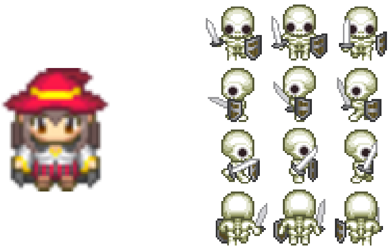

Figure 4: Player character and demonstration of enemy movement.

Characters of first type are used to enter tasks and reward players for their successful completion. The teacher sets the choice of answers when configuring the set of questions for a given game. (Fig.5) In the game world, we recognize them by the fact that they do not move. Another distinguishing feature is the exclamation mark or question mark icon that appears above these characters. If the player's role assigned to this character has not yet begun, an exclamation mark is displayed above it. When the task is accepted, the exclamation mark disappears. Likewise, as soon as the player completes the job, a question mark that appear above the character, disappearing after the task has been handed over.

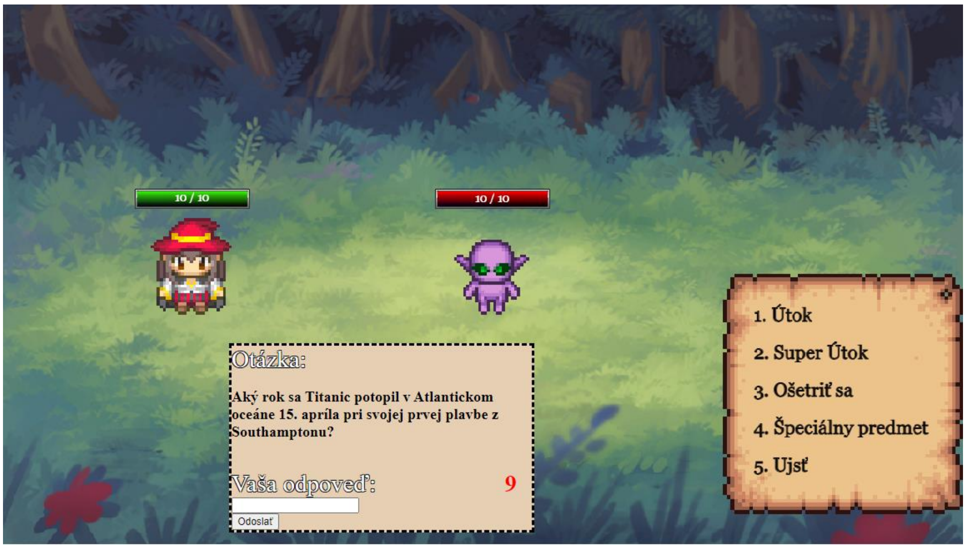

Figure 5: The character fights in the form of answering questions.

As for the enemies, we divide them into two groups: enemies attacking from a distance and enemies attacking at close range. Enemies are controlled by a simple artificial intelligence that detects whether a player is near them. If a player is at a certain distance from the enemy, the enemy will attack him. As soon as the player moves away, the enemy enters a state where he randomly moves in the defined zone.

Creating a game map

The first step in creating a game map in the Tiled Map Editor is to choose a map size. In our case, we chose a size of 150x100 squares (Fig. 6). Next, we select the size of one square 32x32 pixels. The size of the square depends on the size of the images that will make up the map. The most common manifestations are 16x16, 32x32, or 48x48 pixels.

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Then, we need to load the Tileset that the map will consist of. A tileset is one large image that contains several smaller images of a given size. Click New Tileset to add a new Tileset and set the size of one image. Based on this size, Tiled knows how many parts Tileset will divide me into.

After we have the Tileset loaded, we will create the layers to make up the game map. In our case, we will use two types of layers. The first type is the Tile Layer, which defines the very appearance of the map. The second type is the Object Layer, in which we set the initial positions of the enemies of other NPCs.

Lastly, we need to export the map in a suitable format. We will save the map in JSON format as our application is implemented in Javascript.

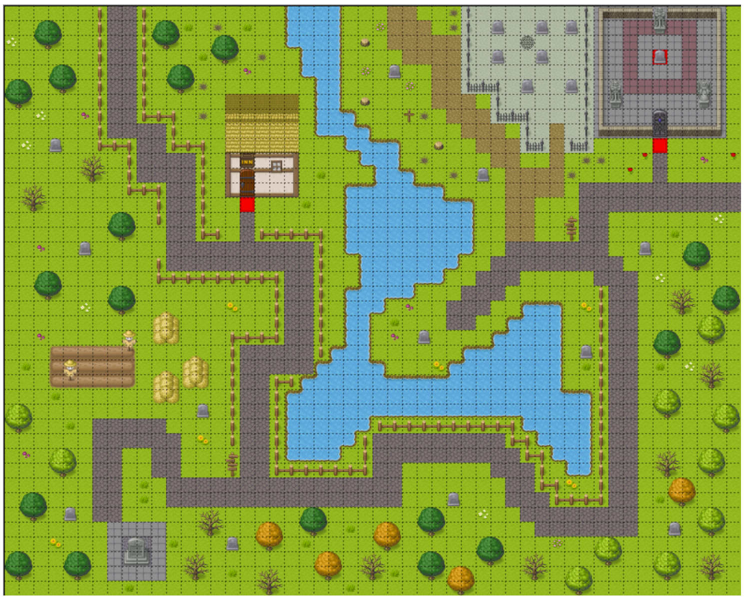

Figure 6: Preview of the created prototype map of the game world

CONCLUSION

In this article, we described a creation of a 2D web game for an interactive educational portal that will support multiplayer connectivity. In the individual phases of the project, we became acquainted with the importance of collecting and analyzing user requirements. We then used the results of the requirements analysis in the design and implementation of our applications.

We chose MMORPGs as the genre of the game. However, during the implementation, we encountered several difficulties associated with developing games of this genre and multiplayer games in general. MMORPG games are quite possibly the most extensive and complex games of all game genres. Which in turn, can be considered a disadvantage as it is necessary to implement a large number of functionalities. That is associated with debugging a large number of errors. Portal games could be more improved by increasing the number of characters and their properties.

The presented game makes it possible to use various collections of question, which the teacher can configure for his subject. Learners simultaneously, when playing games, can be

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gradually tested from several topics, and all their answers are recorded for further evaluation (J. Kostolny, 2021).

This evaluation will be solved using data mining algorithms (E. Zaitseva 2016, E. Zaitseva, 2017). Applied the results of the review can improve the teaching process. For example, it will be possible to identify gaps in student's knowledge, or it will be possible to locate poorly understood curricula and improve their interpretation.

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The impact of ICT on Comprehensibility of the Chemistry Education

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Abstract

The presented study focuses on the pupils of the 8th grade of the lower secondary school. It deals with the question of whether ICT tools implemented in the teaching of inorganic chemistry can support the comprehensibility of the matter taught in this field. The research was carried out during two academic years in the period of 2020-2022. It was conducted as a pedagogical experiment aimed at observing the study success of control and experimental groups. The study success was determined by the results of non-standardised test prepared especially for the experiment. The test focuses on the knowledge acquired in the first half-year of 8th grade focused on the topic of inorganic chemistry. The content validity of the test had been performed by competent experts; its reliability is Cronbach's alpha of 0.909. The teaching of the control group was carried out in a conventional way using a chemistry textbook, while for the experimental group, teaching was carried out via ICT tools: interactive whiteboards, interactive programs, PASCO sensors, iTRIANGLE educational kit. The results regarding each of the mentioned tools showed a statistically significant difference in the pupils' study success in favour of the experimental group. Considering gender, the benefit of implementing ICT tools in teaching chemistry was only evident in the study results of the boys in the experimental group. The study achievement of girls in both groups was comparable.

Keywords

Chemistry education, Interactive whiteboard, Interactive programs, Educational kit iTRIANGLE, PASCO sensor.

INTRODUCTION

Pupils' attitudes towards a subject are influenced by their success in the subject. In their research Weinburgh (1995) and Salta and Tzougraki (2004) mention that the value of correlation between attitudes towards science subjects and achievement of elementary school students is more than 0.50. Further authors such as Glasman and Albarracín (2006) point out that students' views on a given subject predispose their subsequent choice of future occupation. Many new science, technology, engineering and math (STEM) related positions have been emerging in recent years, and employees and workers have to face new demands of these new job positions that require more science, technical and mathematical capability than the previous ones (cf. Uttal and Cohen, 2012; Wai, Lubinski and Benbow, 2009).

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Chemistry is classified as a science subject. According to the international comparative study PISA (Programme for International Student Assessment), there has been a downward trend in the assessment of students in science literacy in the Czech Republic. And regarding the popularity of chemistry among elementary school pupils, according to several research papers, the chemistry subject is repeatedly near the bottom of the list compared to other subjects taught in elementary school. For example, Höfer and Svoboda (2005) discovered, based on the questionnaire in which they inquired the subjective "level of liking" of individual subjects, that only physics ranked worse than chemistry in popularity among the science subjects.

In contrast, information and communication technologies ranks among the very popular subjects. According to the research mentioned above (Höfer and Svoboda, 2005), based on the answers from 2182 pupils, the ICT subject is most popular subject in elementary school.

Thus, it has become increasingly more common in education to use various ICT tools, see recent papers (Shanaka Pivatissa, Johar and Tarofder, 2018; Fussell and Truong, 2021; Tiwari et al., 2021; Morris and Rohs, 2021). For students' self-study, various virtual environments, learning games and multimedia applications are available to increase their motivation and understanding of given learning material.

The above-mentioned findings led authors of the article to the idea of including appropriate ICT tools in the teaching of chemistry at elementary school, where the pupils encounter the subject for the first time, which could raise the general interest in chemistry and increase understanding of the matter taught in the subject.

The purpose of the presented research is to explore the process of teaching chemistry and to detect the influence of information and communication technology used in this subject.

The Materials and Methods section presents the ICT tools used in our research, and then it presents the research process. In the Research Results section, the quantitative data analysis is presented. The research findings and our further research plans in the explored field are discussed in the Discussion section.

MATERIALS AND METHODS

The presented study focuses on lower secondary students. It deals with the question of whether ICT tools used in teaching inorganic chemistry can support the comprehensibility of the matter taught in this field.

The collection of in the article presented and discussed data has been taking place since the school year 2020/2021. Before the data collection began, the following was done:

- The appropriate ICT tools for the inclusion in chemistry subject for the eighth grade of elementary school were selected.
- For every topic taught, a syllabus detailing the procedure of integrating ICT tools into teaching a given topic was created.
- To determine the level of knowledge acquired by the eighth-grade pupils in the first half of the year of the subject of chemistry, half-year test was set up.

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The content validity of the half-year test had been performed by competent experts. The test has excellent internal consistency (*Cronbach's alpha* of 0.909).

For inclusion into the lessons within the presented study following tools and their interconnection were selected: an interactive whiteboard, suitable interactive programs, PASCO sensors, educational kit iTRIANGLE.

Interactive programs

The following Czech interactive programs were included in the lessons through the utilisation of an interactive whiteboard:

Chemie obecná a anorganická – euroDidact

The program was used during these topics: Introduction to chemistry, properties of substances, solutions, the periodic table, individual chemical elements and important personalities of chemistry. The program includes a number of worksheets suitable for practising a given topic. The program also features illustrative videos, which help students understand the given topic.

Chemie 1 – Zebra do školy

This program is older than the aforementioned one. It does not even feature an opportunity to practise or watch videos. Despite this, it was suitable for use in lessons on chemical utensils, chemical mixtures, the structure of chemical compounds and the structure of an atom.

Studiumchemie.cz

Within the subject matter of our research, this website was used to project a detailed procedure of various experiments on an interactive whiteboard.

PASCO sensors

PASCO sensors are a set of sensors connected to a computer and with the help of which data are collected on the computer. The data collected were afterwards discussed with the students in class. We used the individual sensors in the following way: the pH sensor was used in lessons to compare the pH of particular substances, for example, lemon, soda, soap, juice, and also for teaching the topic of neutralization. The conductivity sensor was used for electrolysis and measuring ions' concentration in various beverages. The sensor of gas state O2 and CO2 were used in lessons with the topic of air; the CO2 sensor was also used for observing the reaction of soda with vinegar.

In the lessons with PASCO sensors, the *Projektui.cz* website containing materials not only for chemistry but also for other subjects, both for the second grade of elementary school and the first grade of elementary school, was also used. In the chemistry field, the website provides 100 files in which the theory of the topic is clearly explained, and the exercises are devised for the purpose of practising the topic in a playful way. The tasks involve matching, completing or linking concepts related to a given topic.

Educational kit iTRIANGLE

We also used the sensors in connection with the educational kit iTRIANGLE to review and reinforce the knowledge acquired in the topics of density, solubility and attraction of

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matter, or water (hydroelectric power station). The task for the pupils was to assemble the apparatus according to the instructions, connect the sensor to it and measure given parameters. Students worked in groups to create their own protocol and reach conclusions. This way, they discovered the properties of substances and other information by themselves.

RESEARCH STUDY

The presented research was conducted as a pedagogical experiment. The gathering of data from the experimental and control group of 8th grade students of elementary school happened during the first half-year of the school years 2020/21 and 2021/22.

The research has been processed within the framework of a dissertation thesis and in line with the ethical code of the University of Hradec Kralove. At the beginning, pupils were informed about the research study intended to be carried out in their chemistry lessons. All pupils included in the research agreed on their participation.

Research objectives

The research objective was to investigate and analyse the impact of information and communication technology in the teaching of inorganic chemistry in the 8th grade of elementary school on the level of understanding of the taught topic.

Sub-objectives were:

- to investigate and analyse the impact of interactive programs
- to investigate and analyse the impact of PASCO sensors
- to investigate and analyse the impact of the educational kit iTRIANGLE

Considering the research objectives, the following null hypotheses were proposed:

H_0: Study success does not depend on implementing ICT in the teaching process.

H_{ip}: Study success does not depend on implementing interactive programs in the teaching process.

H_{ps}: Study success does not depend on implementing PASCO sensors in the teaching process.

H_{iT}: Study success does not depend on implementing the educational kit iTRIANGLE in the teaching process.

H_F: Study success achieved by girls does not depend on implementing ICT in the teaching process.

H_M: Study success achieved by boys does not depend on implementing ICT in the teaching process.

The study success was determined by the results of the half-year test.

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Research sample

The research participants were 100 pupils of the 8th grade from the elementary school in Humpolec. In the first year, 50 pupils took part in the research, and the same number of pupils took part the following year. The ratio of girls and boys was equal; see Table 1.

Table 1: Research sample.

	boys	girls	total
school year 2020/21	25	25	50
school year 2021/22	25	25	50
total	50	50	100

In each year, pupils were sorted into two groups, the control and the experimental. The control group followed the standard approach using a chemistry textbook, while the experimental group was taught using ICT tools (see above Materials and Methods).

Limitation

Pupils from the elementary school in Humpolec were involved in the research. Therefore, the research results are valid only for this specific area. Considerations about potential generalisations of the results gained within the research framework are discussed at the end of the paper.

Data analysis

The NCSS Statistics Software was used to statistically analyse the collected data. The normality of the data was tested via standard tests that are in the NCSS (see thereinafter). Considering that it was revealed that the monitored data had not a normal distribution, Mann-Whitney non-parametric test was used to test the hypotheses.

RESEARCH RESULTS

Based on the Shapiro-Wilk, Anderson-Darling, Martinez-Iglewicz, Kolmogorov-Smirnov, D'Agostino Skewness, D'Agostino Kurtosis, and D'Agostino Omnibus it was revealed that the monitored data had not a normal distribution. That is why the Mann-Whitney non-parametric test was used to process other results.

Considering the fact that in the 8th grade of elementary school, students encounter chemistry for the first time, and considering that the average scores of students in both groups in other science subjects (mathematics, physics, and biology) at the end of the 7th grade were comparable, we regard the level of knowledge of students from the control and experimental groups at the beginning of the research as comparable.

Descriptive statistics

Results of the half-year test for both groups (control and experimental) are presented in Table 2. First, the results of the whole half-year test are presented, followed by those questions of the half-year test that are related to: implementing interactive programs, PASCO sensors, and the educational kit iTRIANGLE in the teaching process. Finally, the results relating to girls and boys individually are presented in the same manner.

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Table 2: Results of the half-year test.

		mean	standard deviation	min	max	median
whole test	control	19.42	8.06	4	32	21
	experimental	23.37	7.16	6	32	25.25
interactive programs	control	10.84	4.45	2	18	11
	experimental	13.01	3.57	4	18	13.75
PASCO sensors	control	4.64	2.84	0	9	5
	experimental	5.78	2.97	0	9	6,5
iTRIANGLE	control	3.94	1.43	1	6	4
	experimental	4.58	1.1	2	6	5
whole test - girls	control	21.62	7.02	6	32	23
	experimental	22.14	7.64	6	32	25
interactive programs - girls	control	12.26	3.87	3	18	13
	experimental	12.5	3.86	4	18	14
PASCO sensors - girls	control	5.16	2.65	1	9	5
	experimental	5.36	3.06	0	9	6
iTRIANGLE - girls	control	4.2	1.36	1	6	4
	experimental	4.28	1.11	2	6	4
whole test - boys	control	17.22	8.43	4	32	17
	experimental	24.6	6.43	11	32	27
interactive programs - boys	control	9.42	4.54	2	17	9.5
	experimental	13.52	3.15	8	18	13.5
PASCO sensors - boys	control	4.12	2.94	0	9	5
	experimental	6.4	2.76	1	9	7
iTRIANGLE - boys	control	3.76	1.42	1	6	4
	experimental	4.88	0.99	2	6	5

Hypothesis Testing

The results of the Mann-Whitney test are presented in the table 3.

Table 3: Hypothesis testing.

null hypothesis	prob. level	reject null hypothesis (α = 0,05)
H_0	0.014120	yes
H_{ip}	0.017699	yes
H_{ps}	0.046204	yes
H_{iT}	0.035818	yes
H_F	0,778111	no
H_M	0,002069	yes

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With the exception of the null hypothesis H_F, the results of the Mann-Whitney test, Table 3, show that all the null hypotheses are rejected, and thus we can accept the alternative hypotheses, i.e. study success (of all pupils) depends on implementing given ICT tools in the teaching process. The experimental group achieved significantly better results than the control group.

In terms of the results of girls in the half-year test (hypothesis H_F), we do not reject the null hypothesis; we consider the performance of girls in both groups to be comparable.

The results of the half-year test were also statistically analysed with respect to the sub-questions separately for both girls and boys. In all cases (implementing interactive programs, implementing PASCO sensors, implementing iTRIANGLE educational kit) we do not reject the null hypotheses for girls, and we reject them for boys.

DISCUSSION

The paper aimed to clarify the importance and the positive impact of the implementation of appropriate ICT tools into the teaching of inorganic chemistry in the 8th grade of elementary school on the level of understanding of the taught topic.

The research objectives were successfully reached. An exploratory analysis indicated that the pupils from the experimental group (who used the ICT tools) demonstrated significantly better results in the half-year test than the pupils of the control group in both the test as a whole and its individual parts regarding particular ICT tools.

The results of our research, which were analysed separately for girls and boys, showed that it was mainly boys who contributed to significantly better results in the half-year test of pupils in the experimental group. This is probably due to their stronger relationship with ICT related to a more positive attitude towards the subject of chemistry (Weinburgh, 1995; Salta and Tzougraki, 2004; Glasman and Albarracín, 2006).

Subject popularity

As mentioned at the beginning, Svoboda and Höfer (2005) studied the popularity of science subjects among primary school pupils. The findings were carried out using a simple questionnaire, which they presented to 2182 pupils. In the questionnaire, the students recorded their subjective "level of liking" for particular subjects on a discrete scale of 0 to 6 (0 = "extremely unliked", 6 = "very liked").

We too presented the students participating in our research with such a questionnaire related to chemistry. The average value of their answers corresponds to the results obtained for all our six hypotheses (H_0, H_{ip}, H_{ps}, H_{iT}, H_F, H_M). The popularity of the chemistry subject of the students as revealed from the questionnaire is as follows:

- In terms of all pupils, there is a significant difference between the control and experimental groups (for the control group, the popularity of chemistry = 3.42, for the experimental group = 4.08).
- For girls in both groups, the value of liking chemistry is comparable (control = 3.64, experimental = 3.8), whereas for boys it is once again significantly different (control = 3.2, experimental = 4.36).

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Activity and activation

Learner activity could be defined in various ways. According to Maňák (1998), it is an intensive effort of a pupil that is based on and arises from their inner emotions, interests, or life needs. The pupil uses effort in order to acquire knowledge, habits, attitudes or to get good grades. The teacher's aim is to elicit, stimulate and develop the pupil's activity by appropriate means.

Students' activity can be effectively measured using the Flanders Interaction Analysis System (FIAS), see, e.g. Chadimova et al. (2019). The FIAS method was developed in the 1970s and belongs to the microanalytic research techniques. It uses predefined behavioural categories to describe the teacher's lesson management or teacher-student interaction. Every three seconds a record is made in the pre-established categories of what is happening in the classroom at that time.

The resulting data can be processed and evaluated in various ways and based on a detailed analysis to determine whether it was the pupil or the teacher who was more active in the lesson, what was given the most space in the lesson or in a certain part of the lesson, etc.

The FIAS method is also used in our research. From the data obtained so far, we were able to observe that in the lessons, the pupils of the experimental group, in contrast to the pupils of the control group, were more active than the teacher. This finding corresponds with the results of our previous research on pupils' performance in the half-year test and supports the view that better results are achieved by pupils who are more active in class.

Referring to the obtained data, we assume that our future research activities will focus on continuing in investigating both the study success and the activity of pupils from the 8th grade of the elementary school in the lessons focused on inorganic chemistry. The students will also be examined on the long-term sustainability of the acquired knowledge in the field of inorganic chemistry. All data obtained will be subjected to a thorough analysis from various perspectives.

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Comparison of Programmable Drones Used in Education

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Abstract

The aim of this article is to compare programmable drones that are used in education. Drones, or unmanned aerial vehicles, are not just for free flying using a remote control. There are also drones that can be programmed. This can be used to teach programming in schools. Its a programming teaching in which not only two axes but also a third axis has to be considered. This is more interesting and challenging for students. Four programmable drones were compared in the article. These drones can be programmed via computer or smartphone/tablet. They offer programming using block programming or more advanced programming languages such as Python. An important parameter in the comparison was the availability in the Czech Republic and the price affordability. Only one drone offers all of these options, the DJI Ryze Tello. The other drones can be programmed either on a computer only or on a smartphone/tablet only. Moreover, they are not even available in the Czech Republic. The DJI Ryze Tello drone is therefore the ideal drone for learning programming in a three-dimensional environment.

Keywords

Drones, Unmanned aerial vehicles, Programming, Block programming, Education.

INTRODUCTION

Drones, or unmanned aerial vehicles, have experienced a major boom in recent years. Nowadays, these are mostly quadcopters or multicopters that are remotely controlled. They are used for both entertainment and commercial purposes. Drones may not only be piloted by remote control, but they can also be programmed. It is the programming of drones that can also be used in education. (Hubálovská, Hubálovský, 2016; Hubálovský, 2013; Voborník 2019, 2020; Coufal et all., 2021, Musílek et all., 2018). The Czech Republic is currently undertaking a revision of its Framework Education Programme for the subject of computer science. This revision is very much focused on computational and algorithmic thinking. There are many ways to teach algorithmic thinking. The advantage of programmable drones is that they are not only programmed in two axes, such as programming cars, but with drones, a third axis has to consider as well. The third axis here is regarded as the up and down direction. This brings new and interesting programming possibilities.

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PROGRAMMABLE DRONES USED IN EDUCATION

Programmable drones that can be used in education should have an affordable price and also have the option to be programmed. They should not just be used as a toy. It is also important that the drone is programmable on a computer and at the same time on a smartphone/tablet, preferably using block programming. However, there are not many such drones.

Description of research

The aim was to find programmable drones that could be used in education as well as to compare them in a visual way. Several conditions were adopted to find such drones. The main condition is the prospect of programmability. Under the condition of programmability was the means on which the drone is programmed. The means is understood to be a computer or a smartphone/tablet. Another sub-condition of the programmability was the option of block programming. Another sub-condition was the cost of the drones. Price is an important parameter for purchasing equipment for schools. This is because the purchase of larger quantities must be taken into account. The larger number of pieces of equipment is due to the availability of the equipment for each pupil in the classroom. The last adopted condition was the availability of the drone in the Czech Republic. In some cases, the school can purchase from abroad, but it is usually better to purchase within the country. For example, due to a refund. However, there are also searches for drones available only abroad.

The following table gives an overview of programmable drones according to the selected parameters (Table 1).

Table 1: Programmable drones

Programmable drones							
	programmability					**price (approx.)**	**Availability in the Czech Republic**
	Computer	**Smartphone / tablet**		**Block programming**			
Drone		**Android**	**iOS**	**Computer**	**Smartphone / tablet**		
DJI Ryze Tello	yes	yes	yes	yes	yes	3 000 CZK	yes
MJX HEXA X series	no	yes*	yes*	no	no	from 3 000 CZK	no
Airblock	no	yes	yes	yes	yes	3 000 CZK	no
CoDrone	yes	no	no	yes	no	5 800 CZK	no

*just drawing the flight plan

As is clear from the table, the only drone that meets all the conditions is the DJI Ryze Tello. This drone will be discussed further. However, the other drones will also be analysed and compared.

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DJI Ryze Tello

The DJI Ryze Tello is a very affordable drone from DJI (Figure 1). The company collaborated with Ryze Techs and Intel to develop it. The DJI Ryze Tello is a small drone for children and adults, designed for instant flying and will do well to help develop skills and awareness of drones in general.

Figure 1: DJI Ryze Tello (Tello, 2022)

The DJI Ryze Tello drone is programmable in several programming languages. Probably the biggest advantage is the block programming language Scratch, which is widely used in education. Scratch allows both children and adults to learn to program in a fun way (Figure 2) (Tello, 2022).

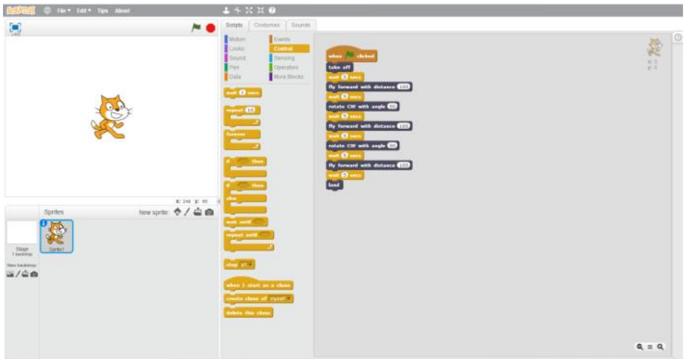

Figure 2: Programming the DJI Ryze Tello (Coding with the Ryze Tello, 2022)

A great advantage is that this drone can be programmed in another programming language besides Scratch. It is the DroneBlocks programming language (Figure 3). Programming on a computer is then done using a Google Chrome extension. The programming principle is identical to the programming in the Scratch programming language. Block programming is used here as well (DroneBlocks Chrome, 2022).

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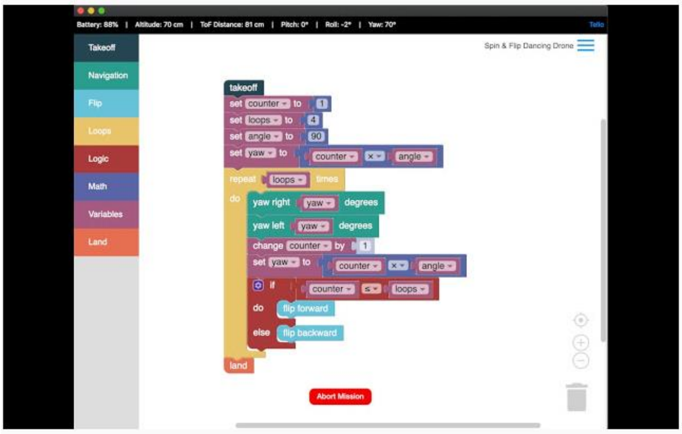

Figure 3: DroneBlocks (DroneBlocks Chrome, 2022)

Very advanced students can also connect the DJI Ryze Tello drone to Geogebra and use Python programming (Figure 4) (DroneBlocks Facebook, 2022).

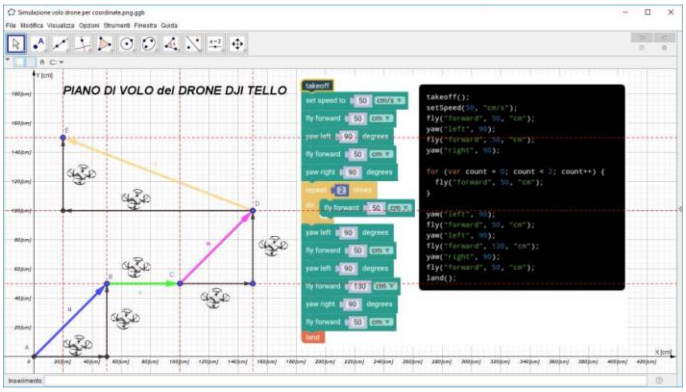

Figure 4: DroneBlocks Geogebra (DroneBlocks Facebook, 2022)

In addition to computer programming, the DJI Ryze Tello can be programmed via smartphone/tablet. This brings a great advantage in mobility with the drone. It is possible to program a flight in a larger space, for example in a gym. There are several applications in which to program. These include Tello Edu (Figure 5), Go Tello (Figure 6) or DroneBlocks (Figure 7).

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Figure 5: Tello Edu – block programming (Tello Edu, 2022)

Figure 6: Go Tello – block programming (Go Tello, 2022)

Figure 7: DroneBlocks – block programming (Drone-Blocks App, 2022)

All mobile applications are in the form of block programming. Although the Go Tello app is different, the principle is the same.

MJX HEXA X series

The MJX HEXA X series is a drone that is only partially programmable. For example, this is the MJX X800 HEXA drone, a 21 cm hexacopter (Figure 8). Programming the MJX HEXA X series drones involves drawing a flight path on a smartphone/tablet. The drone then flies

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around the plotted route. This is not conventional programming, but on the other hand it is not just ordinary piloting either. It is only possible to draw a flight path on a smartphone /tablet. It is not possible to draw a flight path via computer. (MJX X800 HEXA, 2022)

Figure 8: MJX X800 HEXA (MJX X800, 2022)

Airblock

Airblock is a drone that consists of modular parts that interconnect with each other. It is a hexacopter with a size of approximately 23 cm (Figure 9). Programming is done using the Makeblock App (Figure 10). Therefore, it can only be programmed using a smartphone/tablet. It cannot be programmed via computer. (Airblock, 2022)

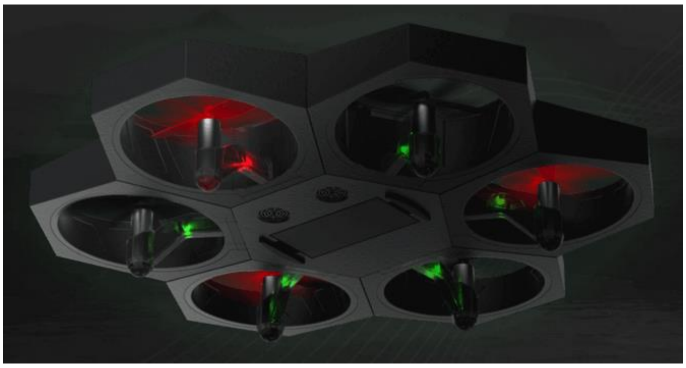

Figure 9: Airblock (Airblock, 2022)

Figure 10: Airblock - block programming Makeblock App (Airblock, 2022)

CoDrone

The CoDrone is a programmable quadcopter approximately 13 cm in size (Figure 11). (CoDrone, 2022) This drone can be programmed via computer. The big advantage of this drone is the option to program via block programming, using a plug-in for the Google

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Chrome web browser (Figure 12). Another programming option is via the Python programming language. Programming using the Python programming language is suitable for more advanced programming (Figure 13). There is also an option to program via Arduino. The remote control is assembled, and then the interfacing as well as the response to the sensors is programmed (Figure 14).

Figure 11: CoDrone (CoDrone, 2022)

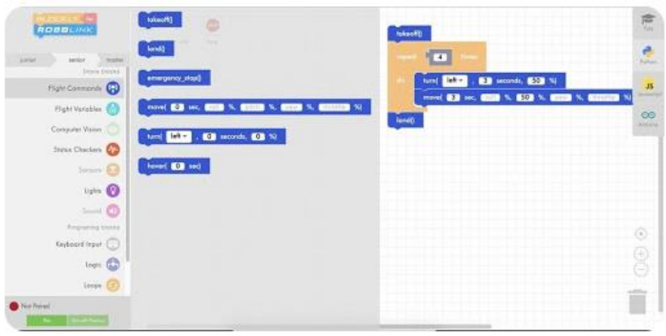

Figure 12: CoDrone - Google Chrome block programming (Introduction to Blockly, 2022)

Figure 13: CoDrone – Python programming (Pair and Fly!, 2022)

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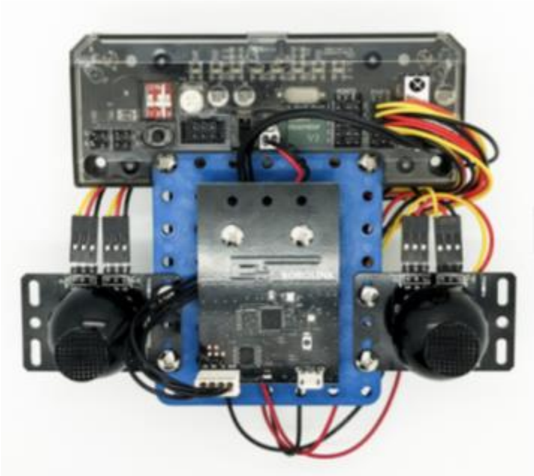

```
#include <CoDrone.h>

void setup() {
    CoDrone.begin(115200);
    CoDrone.pair();

    CoDrone.takeoff(); //goes up and hovers for 3 seconds
    CoDrone.hover(2); //hovers for 2 seconds
    CoDrone.land(); //lands the CoDrone
}

void loop(){
    byte bt8 = digitalRead(18);
    byte bt4 = digitalRead(14);
    byte bt1 = digitalRead(11);

    if(bt1 && !bt4 && !bt8){
    CoDrone.emergencyStop();
    }
}
```

Figure 14: CoDrone – Android programming (Building the Remote, 2022; Flight Events, 2022)

CONCLUSION

From the review and comparison of available programmable drones, it is clear that the options are limited. The DJI Ryze Tello programmable drone wins by a landslide. It is available in the Czech Republic and can be programmed both via computer and smartphone/tablet. The other drones either have the option to be programmed only via computer or only using smartphone/tablet, and at the same time the drones can be found only abroad. The disadvantage of all tested drones is also the inability to set protection (safe distance) to accident occurs during testing. The winning drone will be further researched and will be used in teaching in the future.

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Teachers' Opinions on Information Technology Integration Into University Education

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Abstract

In the education with the support of information technology (IT), teachers fulfil educational goals and, in addition, motivational and consulting tasks. Digital tools are changing the form of education and consequently the educational content requires study materials available in modern electronic applications. The Covid-19 pandemic has accelerated the digitization and virtualization of education, but its availability is conditioned by technical and software equipment on the part of both teachers and students. In addition, digital competences are obligatory basis for the implementation of distance learning. In these conditions, we were interested in the process of distance learning and its support using modern IT tools. The main goal of the paper was to analyse the experience and attitudes of teachers towards full-time education and distance learning. We present the results of a questionnaire survey, which took place in 2021 among teachers from universities and secondary schools. We verified hypotheses focused on the form of education, comparison of time requirements in teacher preparation for education, and the implementation of distance learning using the MS Teams. Obtained results showed that teachers successfully mastered the implementation of new digital tools needed for distance learning. The answers show that a combined form of education is preferred and, moreover, teachers consider preparation for distance learning to be very time consuming. The Teams meeting tools are used as a substitute for full-time teaching, as these tools allow the teacher to communicate directly with students during online lectures and seminars.

Keywords

Education, Information technology, Distance learning, Digital tools, MS Teams, Questionnaire survey.

INTRODUCTION

The main task of university education is the professional and scientific training of students because the future of the knowledge and information economy is determined by the quality of education. University graduates and their professional knowledge and competencies will represent a competitive advantage for companies and organizations in the digitization of production processes and the introduction of the necessary innovations.

Digital technology transforms companies, therefore, the development of key competences of graduates is the principal goal within the European education system. Need

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for digital competences became even more pronounced during the pandemic, when mastery of information technology tools was necessary to realize the process of distance education (Strategy of digital transformation of Slovakia 2030, 2019). University education in the distance form is associated with the quality electronic study courses, training of teachers and course creators, the provision of technical support and the established evaluation system (Malik, 2015). The quality of distance education and its evaluation belongs to the current topics of research studies, in which evaluation systems are presented based on established indicators of the educational process (Yang, 2018).

Slovak universities have access to created electronic educational courses via University Portal in the module "Database of e-Learning Courses" and via this portal there are collected actual opinions of university students and teachers (Tothova et al., 2019). Digital applications are useful educational tool used in many subjects in the phase of explaining knowledge and methods, during the acquisition and development of knowledge and finally, in assessing knowledge. Education through LMS MOODLE is also provided by Slovak universities and faculties, and in many study subjects teachers use created educational courses (Cápay & Tomanová, 2010; Tothova, 2018).

Information technologies enable innovative approaches to the implementation of education with the support of digital applications (Országhová, 2018), such as Office 365 and its applications (the most popular are standard applications such as Word, Excel, Power Point). Teachers and students have become accustomed to using MS Teams during online education (a collaboration application built for hybrid work) and MS Forms (an application that allows to create fillable forms quickly, collect responses in real time, and visualize data using automatic charts, as well as other).

Online education has forced teachers to use other innovative approaches, especially in the group teaching. The use of "private channels" in the lesson became a popular means, where groups of students solved special assignments, and afterwards presented results in a general channel. The advantage is that students are not disturbed at work by another group, whereas a teacher can move from one channel to another, still be available for students, answer any questions, respectively guide them. By creating a standard channel, we will again allow open access, which can be used for "learning groups", where students can move from one group to another for inspiration. Another innovative approach is to use a "whiteboard" in MS Teams (Microsoft 365 Digital Screen for collaboration for effective meetings and engaging learning) or a "graphics tablet". We cannot miss the effort of the Faculty of Economics and Management to support hybrid teaching by technical equipment (purchasing cameras for all classrooms, upgrading of computers, or buying new ones) and in these conditions students in the quarantine could participate in the education from the home environment.

In the presence form the seminars on accounting are realized with software and students solve tasks individually. During distance learning video tutorials allowed students to work in a demo version with the teacher as a tutor who comment applied procedure (Váryová, 2021). During distance learning, it was necessary to prepare new electronic teaching materials for mathematical subjects, e.g., in the form of word documents, animated and spoken PowerPoint presentations, using mathematical lectures freely available on the Internet (Pechočiak, 2021). Information technology and new digital tools, software products, access to free software on internet provides new possibilities even in solving mathematical and application problems where a graphical interpretation is required

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(Hornyák Gregáňová, 2015). University teachers have experience in assessing students' knowledge in the distance form. Assessment of students' knowledge through IT tools has certain specifics in terms of the number of the tested group, the creation of variations of test assignments, or to ensure the authenticity in solving tasks in the e-test (Misut & Misutova, 2017; Tomanova & Capay, 2010).

The technical equipment of classrooms and lecture halls at the Faculty of Economics and Management SUA in Nitra is adapted to the requirements for online education. At present, the faculty has 4 lecture rooms with a capacity of more than 160 seats, one with a capacity of 60 seats. Auditoriums S-01 (Figure 1), S and AS-31 are equipped with Smart Podium, a system for unified auditorium management with an interactive touch screen with installed software identical to the software for interactive whiteboards. All seminary rooms have modern equipment with structured cabling, ecological boards, data projectors, interactive boards.

Figure 1: AS-01- auditorium for the hybrid form of lectures. Source: authors.

The Faculty of Economics and Management has long tradition in the teaching with the support of IT and creating electronic study courses. In the education, it is possible to use materials directly from the computer network, from the local network, in addition to the popular file repositories Dropbox, Google Drive, OneDrive and others. Teachers can use for study materials repositories in the local network, in the created Exercises Directory on the faculty server or in the file storage in the university LMS Moodle, WWW servers, or from various international databases.

METHODS

The main aim of the presented research was to analyse the experience and attitudes of teachers towards full-time (presence) education and distance learning. The questionnaire method was applied, and primary set of data was summed up via anonymous questionnaire survey conducted in year 2021 through the Google form. In the survey participated 102 teachers from universities and secondary schools. Answers of respondents were evaluated by quantitative methods and graphical presentations were performed via tools of MS Excel.

The questionnaire contained 14 questions, of which 4 questions were classification (age, workplace, gender, type of school: university, secondary school). The aim of the

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questionnaire was to find out teachers' opinions on the use of IT tools in the presence and distance education. In the first phase, we sent a questionnaire to the teachers of the Faculty of Economics and Management (SUA in Nitra) and selected teachers at secondary schools. In this paper we present opinions of this research sample of teachers.

The topic of the questionnaire was “Distance learning versus full-time learning”. Respondents/teachers were asked to express opinions towards the forms of teaching, the time-consuming for individual educational forms and the technical support of the teaching process. To evaluate conditions and requirements for presence and distance form of education we have been verifying following hypotheses:

- Hypothesis H1: Teachers prefer full-time (presence) teaching.
- Hypothesis H2: Distance learning requires more teachers´ time to prepare materials than the full-time form of education.
- Hypothesis H3: At least 70% of teachers implement distance learning using the MS Teams meeting tool.

RESULTS

Outputs of questionnaire survey

In this part we present the analysis of respondents’ answers to the selected questions from the questionnaire survey about "Distance learning versus full-time learning". The questions were focused on tools and digital applications used in the process of education. In the context of distance learning respondents (teachers) were asked to express their opinions on the quality of realized e-learning and preferences according to the form of education. Via open question respondents could formulate suggestions for improving the quality and the process of education with the support of IT. Figure 2 shows answers for classification questions that characterise the research sample.

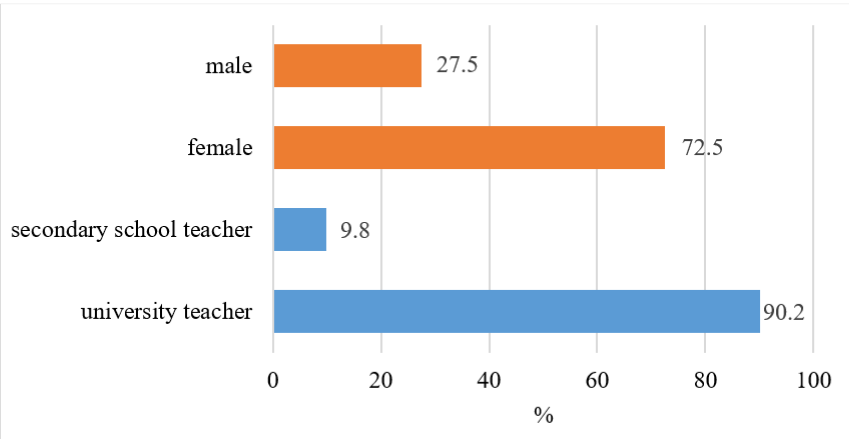

Figure 2: Characteristics of respondents' sample. Source: authors.

We see that the group consisted of 102 teachers, of which 90.2% were university teachers and 9.8% were teachers at secondary schools. The distribution of respondents by gender was as follows: 72.5% women and 27.5% men.

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Figure 3 confirms that in the survey participated teachers of all age categories. The lowest representation of teachers was in the age category up to the age of 30 (6.9%). The largest share of teachers was represented in the age category from 30 to 40 years (33.3%).

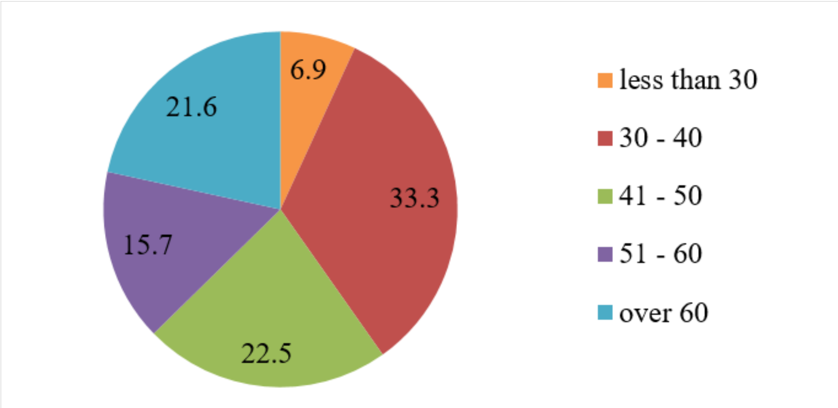

Figure 3: Respondents according to age (%). Source: authors.

Question 1: Which form of teaching do you prefer (if you could choose)?

Results show (Figure 4) that the combined form of teaching (full-time teaching with the support of created electronic courses) was chosen by the most respondents: 35.2%. In the second place it is the full-time form of teaching (presence: 32.4%). Online learning using video conferencing systems declared 22.3% of respondents. Hybrid teaching (some students are full-time at school and some students join online) has 5.2%. The fewest number of respondents chose the distance form of teaching (the student learns regardless of place and time, with the agreed date and time of consultation), only 4.9%.

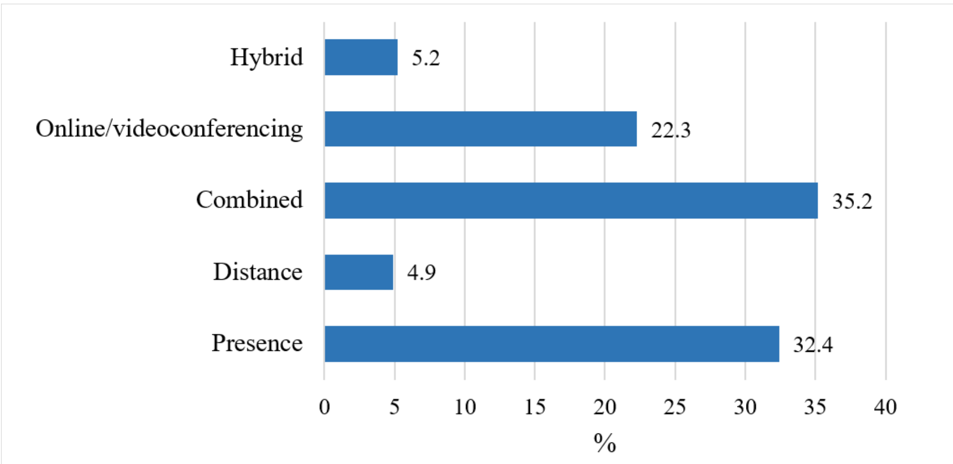

Figure 4: Preferences according to the form of education. Source: authors.

According to results we conclude that Hypothesis H1 has not been confirmed. In the research sample teachers did not prefer the full-time form of teaching. Moreover, from analysed opinions follows that teachers consider distance learning as more difficult for students because they must learn some topics individually. At the same time, they consider the hybrid form of education as less suitable because students do not participate in the teaching process. Students connected online often do not answer the question; they argue that they have bad signal, problems with connection, etc.

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Question 2: Does the distance form of teaching require more time for preparation than the full-time form?

The responses obtained about time requirements for teachers' preparation are shown in Figure 5. We see that no one respondent chose the answer "no". As many as 83.3% of respondents stated that the distance form of teaching requires more time for preparation. This confirmed Hypothesis H2 on the more time-consuming preparation for distance form of teaching for teachers.

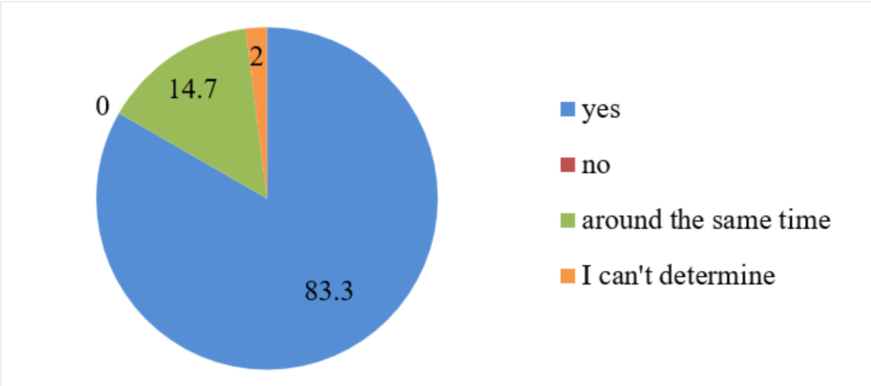

Figure 5: Time requirements for teachers' preparation for teaching. Source: authors.

We have chosen from the respondents' suggestions for improving distance learning: there are no determined rules for online learning, each teacher uses own method; students are less concentrated on teaching; there is no collective solution of problems and tasks as during the presence teaching; information for students must be repeated several times, even if they are available in files in repositories and applications.

Question 3: What didactic technique do you use in the full-time teaching form (you can mark more than one option)?

In the Figure 6 we see mostly use technical equipment for the full-time teaching. PC/notebook obtained 90.2% and data projector 69.6%, which indicates good technical equipment for teaching. PC and notebooks are used in seminary classrooms where students solve tasks during lessons. Interactive board is used by about a quarter of respondents (25.5%). Smart podium is a special tool placed in the auditoriums for lecturing (9.8%). The visualizer is displayed with 3.9% of responses. Other technical tools had the stated use of only 1%. In the lecture and seminary rooms the technical equipment is supported by the finance of a faculty, university or secondary school.

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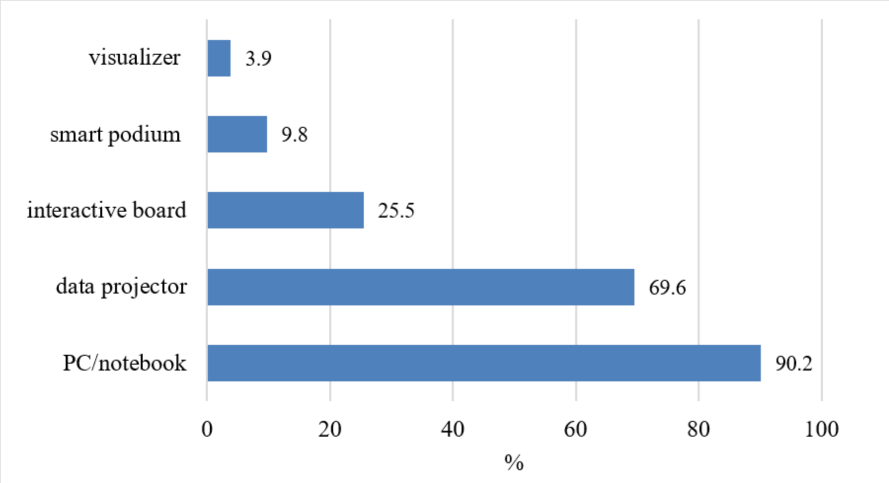

Figure 6: Usage of technical equipment for the full-time teaching. Source: authors.

Question 4: What applications do you mostly use in the distance learning (you can mark more than one option)?

The implementation of digital applications for online face-to-face teaching has started to a greater extent during the corona crisis caused by Covid-19. MS Teams – meeting allows the teacher to create an interactive online meeting environment where all participants can share audio, video, or electronic study content. According to results on Figure 7, respondents declared usage of MS Teams – meeting at the first place (81.4%). MS Teams - live event (53.9%) enables to create webinar-style online meetings; it can be shared study content, video, and audio. Participants can view the content, but cannot share their own audio, video, or other content. Projects and assignments have 55.9%; sharing video presentation (20.6%) (these applications are used in individual study). Self-study via created and shared study materials was declared by 44.1% of respondents. Application of Zoom is used by 9.8% of respondents and application of EduPage by 7.8%. The latter two applications are used in online education in secondary schools.

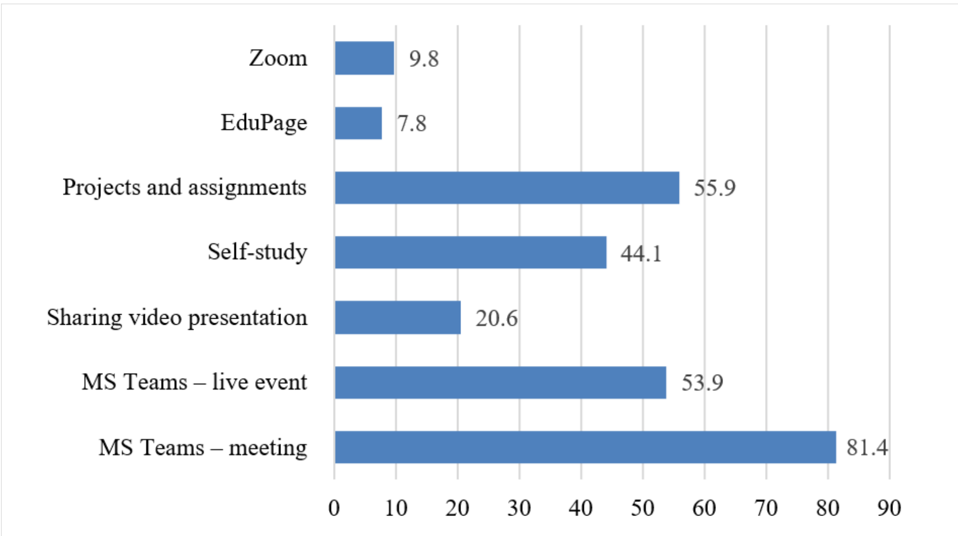

Figure 7: Digital applications mostly used in the distance learning. Source: authors.

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Answers of respondents approved the formulated Hypothesis H3: At least 70% of teachers implement distance learning using the MS Teams meeting tool. The most used tool in the distance learning is MS Teams - meeting tool. However, it requires proper hardware and internet connection. Students at university sometimes declared technical problems with this application.

Other applications and tools suitable for distance learning had only 1% of responses, e.g., LMS MOODLE, Testmoz, E-mail, consultations, graphic tablet, Discord. In this question, only 1% of respondents (teachers) stated usage of a graphics tablet. Tablet can be directly used for writing and presenting examples with mathematical expressions, sketching graphs and for presenting other topics during online teaching. We assume that teachers in this research sample have not this technical equipment.

The current wide way of using IT in every area of life requires to acquire and develop skills for digital environment by all ages. Hence, information and communication technologies are important for school education, where e-learning methods are changing study forms and educational methodology at all levels. Moreover, skills revolution also changes the job content and create new professions with the support of IT.

DISCUSSION AND CONCLUSION

Information technology in the 21st century brings new tools that have effective usage in online education. The contemporary educational work of university teachers combines various forms of communication with students, therefore contact through IT tools requires teachers prepared for blended and online learning (Almpanis & Joseph-Richard, 2022). Many studies explore the possibilities of using IT applications (like Zoom, Google Meet, Kahoot, and Google Classroom) in the teaching in relation to the quality of educational outcomes, However, experience in teaching some subjects shows that it is necessary to continue developing new applications, e. g. for foreign language teaching, as stated by Vadivel, Mathuranjali & Khalil (2021). The blended learning is the form of education which integrates a combination of online activities with personal learning. Authors of the study (McKenzie et al., 2020), state that in this form of education it is important to clearly define the roles of the teacher and the student, as well as the approach to classroom communication and effective ICT integration.

In the paper we presented research focused on the attitudes and opinions of teachers to the different form of education and IT support of the teaching process. From obtained opinions follows:

- Teachers prefer combined form of the teaching (H1 not confirmed).
- Preparation of teachers for distance teaching takes longer than preparation for presence one (H2 confirmed).
- Around 80% teachers prefer MS Teams – meeting for online teaching face-to-face (H3 confirmed).

Important findings and discussed questions on the distance learning among teachers:

- Teachers concern how students will master the curriculum without direct participation in school if it is necessary the reduction of the study curriculum.

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- Technical support for education in the digital environment brings new applications and creates better conditions for the hybrid form of education.
- By seminary projects and individual assignments teachers want to activate and motivate students for the systematic study.
- More time-consuming activities for teachers as creation assignments and assessment of knowledge via electronic tests (each student has individual test).
- Co-operation of teachers in the creation of variety of assignments to satisfy the authenticity of homework and to avoid cheating and copying solution of problems by students.
- After the enthusiasm from the online teaching there was exhaustion, mainly because of the reduction of social contacts and the lack of direct communication between students and teachers.
- For students, the distance form of education resulted in requirements for increased activity in independent study, for the development of communication competencies and responsibility for learning outcomes.
- Consequence for teachers: During the distance learning it is necessary to apply methods proper for students and find effective way for gaining professional knowledge and digital competences.

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Incorporating Mobile Technology into the Process of Developing Communication Skills of Primary School Pupils

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Abstract

The paper is aimed at using mobile technology for developing communication skills of primary school pupils, focusing on upper primary school pupils. The authors present the current state of their long-term research. In the initial part of the paper the research problem is defined. Then the authors introduce the topic, along with the theoretical foundations on which the second part of the paper is based. The authors focus on communication skills and the use of mobile technology in education. The paper also mentions a pedagogical experiment aimed at determining the impact of mobile technology on developing communication skills. The paper introduces specific activities and methods that help develop communication skills. Research is currently at the stage of proposing and realizing pilot research. The authors describe the course of the pilot research, including methods and individual steps.

Keywords

Communication skills, mobile technology, pedagogical experiment, primary education.

INTRODUCTION

Mobile technology is an integral part of today's world; it also has a special place in education. Today's generation of children lives in a digital world, with mobile technology being a natural part of their lives. In his previous research, the authors have learned that mobile technology can help improve knowledge retention (Tran, 2018; Tran, 2019). Taking these findings into account, the authors then set out to determine whether or not mobile technology could be used to develop communication skills. The authors' research is aimed at finding the answer to that question.

In the initial part of the paper the authors define the research problem, questions, objectives and expected outputs. The authors then summarize the current status of research on the topic, which they were able to determine by analyzing published papers and studies on the topic. They also define theoretical foundations on which the research part of the dissertation plan is based. The second part of the paper is dedicated to the current status of both pilot and main research. Research is currently at the stage of proposing pilot research. The authors describe in detail the pilot research project, including the methodology and methods for developing communication skills. The paper concludes by

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outlining the planned continuation of research. The paper centers on one particular part of research.

DEFINING RESEARCH PROBLEM

The research objective is to determine whether or not mobile technology could be used to develop communication skills of primary school pupils, and to design, create and verify a teaching model that uses this technology as the main tool for developing the aforementioned skills. Based on this notion the authors defined the research question, which consists of the following two sub-questions:

- What kind of impact does mobile technology have on improving communication skills of primary school pupils?
- In what ways could this technology be used to help improve the aforementioned skills?

The main objective is to determine to what degree mobile technology may help improve pupils' communication skills in the proposed teaching model. The main objective covers two significant areas – the pedagogical-psychological and technical. From the technical point of view, it is the active use of mobile technology (tablets) in the education process; studying this technology, its possibilities (tools and applications), and how it could be used to aid the development of communication skills. Moreover, the term mobile technology needs to be defined in order to be able to make full use of the possibilities it offers. From the pedagogical-psychological viewpoint, it is the development of communication skills, one of the key learning competencies in the majority of countries. Communication as such is deeply rooted in psychology; there are communication disorders that are often related to mental disorders.

Based on the research question and the research objective, the authors formulated 3 research hypotheses:

- H1: Targeted use of mobile technology will have a positive impact on pupils' communication skills.
- H2: Targeted use mobile technology will spark pupils' interest in improving their communication skills.
- H3: Targeted use of mobile technology will have a positive impact on pupils' participation in class discussions.

The authors intend to determine whether or not the proposed teaching model, which uses mobile technology as the main or the supporting tool for developing communication skills, will succeed in doing so. This model includes methods that will be verified in the classroom and therefore available for use in instruction. The authors will also try to discover all the problems that may arise during the process of developing communication skills, as well as the possible risks associated with the use of mobile technology in education. The authors expect that using mobile technology to help develop communication skills will have an impact on pupils' participation in class discussions (pupil-teacher communication).

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Current status of research on the topic

Based on their personal experience, from everyday life as well as the school environment, the authors believe that today's generation of children (between the ages of 12 and 15) has poor communication skills. They are often not at the level required by the society. Children are often not able to express their ideas and/or formulate their opinions, which can have a negative effect on both their school and personal lives.

Having analyzed published papers and studies on the topic, the authors learned that the development of communication skills is not being paid much attention to at the primary school level. The majority of studies focus on universities and secondary schools (far less often). In those studies, communication skills were developed through conventional methods, i.e. without information technology. The remaining authors used information and communication technology, computers in particular, to develop communication skills (Taillefer, 2014).

When the authors began analyzing the available sources on the topic, there was no study aimed at using mobile technology for developing communication skills. In 2021, however, a study was published that takes mobile technology into account (Backman, 2021). Taking the current status of research on the topic into account, the authors intend to develop a methodology for using mobile technology to develop communication skills, focusing on particular mobile applications.

Communication skills

Competencies are the basis of modern education. The term competency has a variety of meanings. The basic definition of competency is practical application of knowledge and skills acquired in school (Chvál, 2014). The so-called key competencies form the basis of the education system in the Czech Republic. The curriculum document titled Framework Educational Program defines the term key competency as a "set of knowledge, skills, abilities, attitudes and values important for personal development and success of all members of society". The importance of individual competencies depends on generally accepted values and the shared views on which competencies an individual needs to have to be able to lead a happy and successful life, and which competencies are important from a societal standpoint (Framework Education Program for Primary Education, 2021).

From analyzing published papers and studies on the topic the authors learned that communication is one of the key learning competencies in the majority of European countries (Kocourková, 2011). This proves that communication is an important skill that should be developed in school. Pupils should be taught to develop their communicativeness. Communicativeness is an individual's ability to communicate in a conscious way, i.e. to talk to others about themselves in a clear and cohesive way, to listen to others, to be able to distinguish between relevant and irrelevant information, to meet the needs of others and be able to understand non-verbal signals. It is worth noting that communication skills include not only verbal (oral or written) communication, but also non-verbal signals, such as body language, object language or place language (Belz, 2011).

Let's focus on communication skills as viewed through the lens of the Czech educational system. As has already been mentioned, this competency is defined in the Framework Educational Program that introduces skills that a pupil should master during primary

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education. In their research the authors only focus on the following skills (Framework Education Program for Primary Education, 2021):

- The pupil formulates and expresses their ideas and opinions in a logical sequence, expresses themselves in a concise, coherent and cultivated manner both in written and verbal form.
- The pupil listens to what other people say, understands them, responds appropriately, participates in the discussion, is able to defend their opinion and present their arguments.

MOBILE TECHNOLOGY IN EDUCATION

Since its inception, mobile technology has undergone gradual change into its current form. That is why there are many different definitions of and approaches to mobile technology in the literature. One can argue that today laptops, tablets and smartphones are the most common devices. In their research the authors focus exclusively on mobile touchscreen devices, tablets in particular. On the global computer market there are hybrid devices that can be classified as both laptops and tablets (as they feature a touchscreen). Despite this fact, the authors focus exclusively on tablets. That is why the authors use the IBM definition of mobile technology, which says that "mobile technology is technology that goes where the user goes. It consists of portable two-way communications devices, computing devices and the networking technology that connects them. Currently, mobile technology is typified by internet-enabled devices like smartphones, tablets and watches" (Mobile technology). Tablet is characterized by a touchscreen, a variety of sensors, features and applications.

According to the Czech Statistical Office, 6,724,100 (76.6 %) Czech citizens over 16 years of age use a smartphone (Use of Mobile Phone and Mobile Internet, 2021). Tablets are used by fewer people; 2,201,400 citizens over 16 years of age (Use of Computers and Other Device to Access the Internet, 2021). The above data shows that today's children use mobile technology every day, which is why it comes more naturally to them than other information and communications technology. The figure below presents the data regarding mobile technology use across all age categories (over 16 years of age).

The statistics show that smartphones are most used by people between the ages of 25 and 54, who are the parents of today's primary school pupils. This confirms the notion that today's children encounter mobile technology every day (Use of Computers and Other Device to Access the Internet, 2021).

With the incorporation of mobile devices into education comes a new term: "mobile learning". One of the oldest definitions of the term defines mobile learning as "a type of learning facilitated by mobile devices" (Hyman, 2014). Another definition of mobile learning considers not only the mobile device, but also the internet or other networks and their role in learning. However, accessing the internet from a mobile device remains the most important factor (Pedro, 2018).

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METHODOLOGY

Research focuses on pupils between the ages of 13 and 15. It will take place in a primary school. Research subjects will be selected through available sampling (Gavora, 2000). An educational experiment will be used in this quantitative-qualitative mixed methods research. Since the authors are planning on monitoring only one independent variable, it will be a single-factor experiment. The independent variable will be monitored using a parallel group design – the authors will be working with a control group, which will be developing communications skills without the use mobile technology, and an experimental group, which will have mobile technology at its disposal. Therefore, the use of mobile technology will serve as the independent variable.

A variety of data collection tools will be used during the course of the experiment, the main of which is a questionnaire survey. Gavora defines a questionnaire as "asking questions and receiving answers in written form" (Gavora, 2000). These will be specialized questionnaires aimed at selected aspects of communication – they will be rated on a scale. Cohen's Kappa coefficient will be used to estimate reliability of the questionnaire. Questionnaires will be used in two stages of research:

- Before the start of the experiment – a questionnaire for teachers – assessment of the pupils' communication skills – selecting 5-10 pupils on whom the teacher will focus their attention, and a questionnaire for pupils – self-assessment of their communication skills.
- After the experiment – a questionnaire for teachers – final assessment of the selected 5-10 pupils.

Semantic differential will also be used to determine the level of communication skills. Another method for collecting quantitative data is scale evaluation of pupils' performance in class. During selected activities scale evaluation will be used – the teacher will focus on preselected aspects of the pupil's communication and evaluate them.

Observation will be used as a qualitative method of data collection. Observation will take place during every session of both the control and experimental groups. It will be a long-term educational observation. It will be direct and structured (Chráska, 2016). The authors will be monitoring the control and experimental group outputs, comparing the quantitative data. Based on the data and the outputs, the author will draw conclusions.

RESULTS

Based on the existing results, the authors proposed specific methods for developing communication skills of pupils in both the control and experimental groups. For each group 6 specific methods were designed that should help pupils develop a particular aspect of communication.

Control group

The control group will not be able to use mobile technology in class. Their communication skills will be developed through available methods that have been used in the past.

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As far as developing verbal communication is concerned, there are a variety of games that help improve verbal communication skills, from the simplest expressions (use of words) to the more difficult and significant skills (argumentation). Such games can be divided into various categories (Staníček, 2020):

- Introductory games;
- Classification games;
- Games for two and more players;
- Games for more players.

During the activities one can focus on the individual communication skills (asking questions, presentation, problem-solving and negotiation) and how to use them (group presentations, group discussions, experiential learning). However, in control group classes the teacher should focus not only on communication skills but also on other important aspects of education, as the goal of education is the complete development of the pupil.

All the proposed control group activities have already been used in class and published in textbooks, books or other academic sources. The following 6 activities have been proposed for the control group:

- Stones;
- Finish a story;
- Learn to say "no";
- Comics experience;
- I will have the last word;
- Contemporary dialog.

Experimental group

The experimental group will be using mobile technology (iPads in particular) for developing communication skills. In experimental group classes the teacher and the pupil will have identical roles, which are defined in the control group chapter, with digital competencies playing an important part. In order to be able to efficiently use iPads in experimental group classes, appropriate mobile tools and applications needed to be defined first. Research began in the summer of 2019 and continues to this day (it is an ongoing project). The first results were published at the 2020 DIVAI conference (Tran, 2020). The authors focus only on the applications available in Apple's App Store. The applications can be divided into three categories:

- Applications for the target group (pupils between the ages of 13 and 15);
- Educational applications (in the Education category);
- Applications that the authors are familiar with.

During the first stage, approximately 80 applications were analyzed, 35 of which were selected and further examined. Of those, 10 applications were determined to be appropriate for developing one or more aspects of communication, making them suitable for this research project (Tran, 2020).

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Mobile applications are still being analyzed (every 2-3 months) in order for the authors to stay up-to-date with the latest additions. Today the list includes approximately 20 different applications that could be used in the experiment. However, not all of the applications will be used during the course of the project. The following are the ones that will be used:

- iMovie;
- ChatterPix;
- Speech Blubs;
- Chanti;
- Nearpod;
- Vuforia Chalk;
- WallaMe;
- Word clouds (Slido, Mentimeter);
- Group chat apps;
- Augmented reality apps.

The experimental group will be using mobile technology in classes. The authors wanted the activities to be mobile technology-based version of the activities used in the control group, i.e. the activities are identical, with the only variable being mobile technology. The following 6 activities have been proposed for the control group:

- Stones with the ChatterPrix app;
- Finish a story with the SimpleMind app (mind maps);
- Learn to say “no” with the SLIDO app (word clouds);
- Video experience with the iMovie app;
- I will have the last word with the SimpleMind app (mind maps);
- Contemporary dialog with the MS Teams app.

DISCUSSION

During his research, the authors have discovered a number of important facts. By analyzing the published literature on the topic, he has learned that mobile technology is not being paid much attention to. He also discovered that communication is one of the key learning competencies in the majority of European countries, which means that communication is an extremely important skill. The literature describes various methods for developing communication skills. However, those methods use neither mobile technology nor any other information and communications technology. If one wants to use mobile technology for developing communication skills, there are a variety of applications that facilitate it. Even though those applications were not primarily designed for this purpose, they are often used for educational purposes. Therefore, it is extremely important to focus on how such applications can be incorporated into the education process. What the authors

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also found very helpful were the tools for determining the level of communication skills, i.e. questionnaires (which have already been designed and used at universities abroad).

The results of this research can contribute to the field of mobile learning, development of communication skills, and can be used as the basis for further research. Research outputs can also help improve digital literacy in education. As far as practical contributions are concerned, methodological sheets for the individual activities will be created, which teachers can then use in their classes.

CONCLUSION

The paper proposes a research project that will be carried out in the near future. Pilot research will take place in the spring of 2022. Afterward, the results will be analyzed and the main experiment will be modified. The main experiment will take place no later than early April 2022. In June 2022, the main experiment results will be analyzed and conclusions will be drawn.

Despite the fact that this paper only focuses on upper primary school pupils, the development of communication skills is a lifelong process, which starts in pre-primary education and continues in lower primary school, secondary education and at the university level. The proposed methods (with slight modifications) can be used at all education levels.

Many teachers can be discouraged from using mobile technology for developing communication skills because they do not know how to incorporate it into their classes. That is why the authors present mobile app-based activities and explains how they could be incorporated into classes.

In the coming months pilot research is going to take place. Its results will be analyzed and the research proposal might be modified. The main objective, however, will remain unchanged.

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XR Applications for the Education and Entertainment of Hospitalized Children

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Abstract

Applications based on virtual, extended, or mixed reality are rapidly gaining momentum in the sector of education worldwide because they have the potential to allow new forms of education and transform educational experiences into a new quality. Their use is expanding from commercial games and services to various science-research areas (healthcare, economy, space) as well as to the area of education at the universities, high schools and nowadays also to primary schools (mainly due to low hardware prices). In this article, we focus on primary school children, who are being hospitalized due to various health problems. We pilot-created an experienced laboratory for them with the necessary hardware, in which they have the opportunity to use our applications, adapted to their needs and requirements, among other activities. In the paper, we deal with the use of VR, AR, and MR in various areas of education and present selected applications that we make for children in primary school (located in a hospital area). Regarding the protection of the health of hospitalized children during the Covid -19 pandemic, we have only found opinions on the success of our applications among teachers, students, and students in primary schools. We present the results of the questionnaire in the discussion part of our article.

Keywords

Virtual reality. Augmented reality. Extended reality. Game-based learning. Primary education.

INTRODUCTION

Due to the pandemic situation of Covid-19, our daily social routines changed completely - our communication and education moved mainly into the online environment. Teachers, as well as pupils and students, were forced to adapt to changed conditions and quickly learn to work with new technologies. However, many technology visionaries expect that this is not the last change that has meet us. In the future, we probably will not miss most of the work and leisure meetings in the Metaverza environment[1], which will allow us to replace our own physical avatars with artificial intelligence in the form of a digital assistant. It relieves us by automating the exchange of information, managing tasks and deadlines, and helping to make education more fun, interactive, and therefore more interesting. Young

[1] Metaverzum is basically a digital world full of digital duplicates of people, cities and things. It is a version of the Internet where people's avatars can be virtually gathered to communicate, collaborate and share information on any device. This could lead to the adoption of VR headsets that would become as common as smartphones are now. (Metaverzum, 2022).

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people between the ages of 18 and 25 (Z Generation) attach more importance to their digital self, but at the same time, virtual interactions suit them better than they do in real life. Dissatisfaction with their physical appearance, as well as a number of complex problems and "uninteresting" life, they solve by escaping into a virtual world where no restrictions and laws apply, where everything is allowed, more beautiful, more perfect, and more fun. There is nothing easier than putting on virtual reality glasses and escaping from the problems of our planet into a world of endless possibilities.

The world of virtual reality is described (Sherman and Craig, 2002) in 'Understanding Virtual Reality' as a medium consisting of computer simulations, giving the user a sense of presence in the simulations. Other authors (Carter and Potter, 2016) claim that it is the completely virtual world made by a computer in which the user interacts only with virtual objects. The Virtual Reality technology has traditionally consisted of cumbersome created environments and has often required complex sensors worn on the body for an individual to interact with the environment. The emergence of head-mounted virtual reality devices is shifting the technology into the commercial consumer area. The number of users who experience the feeling of being immersed in the virtual world is growing rapidly.

Users experience similar impression with an unconventional feeling of augmented reality AR. It is due to interactive digital elements such as pictures, 3D models, sounds, and text, by which our perceptions of the real world are enriched in real-time. The difference between these two technologies (VR and AR) is that virtual reality requires special headsets that allow the user to feel immersed in another - digital world, while augmented reality offers interaction with digital objects in the real world. Hardware of AR is more available because the most popular applications require just a mobile device (tablet or smartphone with a camera, which inserts digital content into the captured image).

The use of web platforms to share virtual environments and user interaction is possible thanks to a high level of network infrastructure and technologies. In this way, systems to support global virtual collaboration are rapidly formed, where users can access a common virtual space. (Hudák and Sobota, 2021)

We have already dealt with the unifying concept of the mentioned technologies in the article (Horváthová et al., 2020). This term refers to all combined real and virtual environments and human-machine interactions generated by computer technology and wearables. It includes representative forms such as AR, MR, and VR (Gownder et al., 2016) and the areas interpolated among them. It is called eXtended Reality (XR). The levels of virtuality range from partially sensory input to immersive virtuality. XR is a superset that includes the entire spectrum from "the complete real" to "the complete virtual" in the concept of reality–virtuality continuum introduced by Paul Milgram (Milgram and Kishino, 1994). Still, its connotation lies in the extension of human experiences, especially relating to the senses of existence (represented by VR) and the acquisition of cognition (represented by AR). With the continuous development in human–computer interactions, this connotation is still evolving. XR is a rapidly growing field being applied in a wide range of fields, such as entertainment, marketing, real estate, training, and remote work (Hui-Wen, 2018).

All these realities have huge potential and in many cases prove to be successful in the context of education (Douglas-Lenders, et al., 2017), (Shen, et al., 2017) a (Fotaris et. al., 2017). In Slovakia it is very successful, for example, Human Anatomy VR application (Brngál,

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2020), used since 2016 and spread to more than 140 countries around the world. A similar example of the use of AR in biology is Arlearning (Arlearning, 2022). Other examples point to the possibilities of using XR in military training (Pallavicini, et. al., 2016), teaching astronomy (Yen, et. al., 2013), chemistry (Nechypurenko, et. al., 2019), history (Barreau, et. al., 2015) (Nicolas, et. al., 2015), (Persofoni and Tsinakos, 2016), geography (Shall, et. al., 2011), languages (Shih and Yang, 2008), mathematics (Yingprayoon, 2015), or Pocket tutor - Math Help (Augmented reality, 2022) and many others. These applications serve not only to train and teach, but also to observe and discover.

New XR technologies are also a challenge for us teachers, didactics, and application developers, to know how to use them to make teaching more attractive. We should turn our attention to where the whole world is headed. We should prepare not only teachers, university and high school students for another form of information interaction, but also primary school children for a new phenomenon that they are likely to encounter soon. With the effort to introduce XR technologies into education, the weaknesses of this process also appear, which are mainly related to the insufficient technical equipment of schools, as well as the reluctance of teachers to solve unknown challenges and accept new technologies into their teaching process. Another disadvantage can be the creation of addiction to mobile devices or headsets, leading to many health problems. In any case, by gradually overcoming these obstacles, the implementation of XR can be very beneficial for both students and teachers.

In this paper, we present our efforts, which began several years ago with the creation of a new VR subject, gradually building a VR and UX laboratory, and finally focusing our attention and efforts on creating XR applications, especially in education. At our department, in cooperation with the Rotaract Club and the Rotary Club in our city, we focused on primary school children who are hospitalized due to various health problems. Last year, we created an experiential laboratory at this school, which allows such children to break away from their illness, immerse themselves in a completely different world, cheer up, and play in educational games through the modern virtual and augmented reality technologies, as well as 3D pens and various games. We want the children to learn something new and forget, at least for a moment, why they are where they are.

In cooperation with the teachers of the Primary School at the medical facility, which is located in the Children's University Hospital with a polyclinic in our city, we have created several applications that are aimed at repeating and expanding knowledge in various subjects (Slovak Language and Literature, English, Homeland Studies, Natural Sciences, Chemistry, Mathematics, etc.) as well as to entertain and cheer up sick children, to engage and detach them from an often serious illness or immobile condition. The applications are adapted to the hospital environment, different ages of children, their limitations in movement, or sad mood. At the mentioned primary school, a very large number of children have attended during one school year, so the idea of getting children acquainted with modern technologies and the virtual world is spreading very fast.

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METHODS

Hardware for VR/AR

We decided to use a headset, Oculus Quest 2, for the development of our applications. This headset was released at the end of 2020 and is therefore a relatively new VR kit that uses software based on the Android 10 mobile operating system and will have a guarantee of long-term support from the manufacturer in the form of updates. The glasses themselves have a Qualcomm Snapdragon XR2 processor, which provides high performance in conjunction with 6 GB of RAM and an Adreno 650 graphics chip. The display is provided by two LCD displays with a resolution of 1832x1920 and a refresh rate of up to 120 Hz. The glasses also have built-in speakers directly in the glasses. Two Oculus Touch controllers are used for control, with each controller having its own 4 programmable buttons. There are 4 built-in cameras directly in the glasses to capture and control the motion in the room, so the user does not have to install various auxiliary cameras in the motion capture room as with other VR kits. Due to this, the use of Oculus Quest in various spaces is a very practical and pleasant experience. It could therefore be said that this is one of the most portable VR kits on the current market. One of the best features is the ability to use glasses without controls, so the user's hands will be used directly with the help of cameras, which almost 100% reliably monitor every single finger on the basis of visual contact.

Another hardware component that we use to create AR applications is the Merge Cube, which was introduced to the market in 2017. The cube itself is nothing special. It is made of durable foam material. What makes this cube interesting is its unique shapes on each side of the cube, which, in conjunction with the right hardware and software, can turn the cube into a hologram. This requires powerful cameras in devices such as mobile phones, tablets, computer cameras, etc.

RESULTS

VR and AR applications

QuizBow (VR)

The first created application is used to learn students' new knowledge using a playful form. After turning on the application, the user grabs the bow and uses an arrow shot to select the area in which he wants to check or expand his knowledge. Subsequently, a quiz is run in which the user gets a question and must choose one correct answer from among the other 3 incorrect ones. After successfully answering and hitting the question, the user is rewarded with a positive point. Otherwise, the correct answer is displayed, and the user has the opportunity to see the answer in front of him within 5 seconds. This whole thing is repeated until all the questions for the given category are missed. Finally, the user will see the earned points and can choose another category.

Each time you select a category, all questions and answers are shuffled to change their display order. This will prevent the manual reselection of responses, and the user must be careful. A huge advantage of this application is that it uses .csv or .json files to work with issues. This means that every time the application is turned on, the current questions are loaded, and thus the application itself is a system that is very easily extended by new

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categories, questions only with the help of a pre-created question template. This can make it very easy to work with the application, especially for laypeople and primary school teachers, and it creates a reliable extension for possibly downloading questions directly from the cloud.

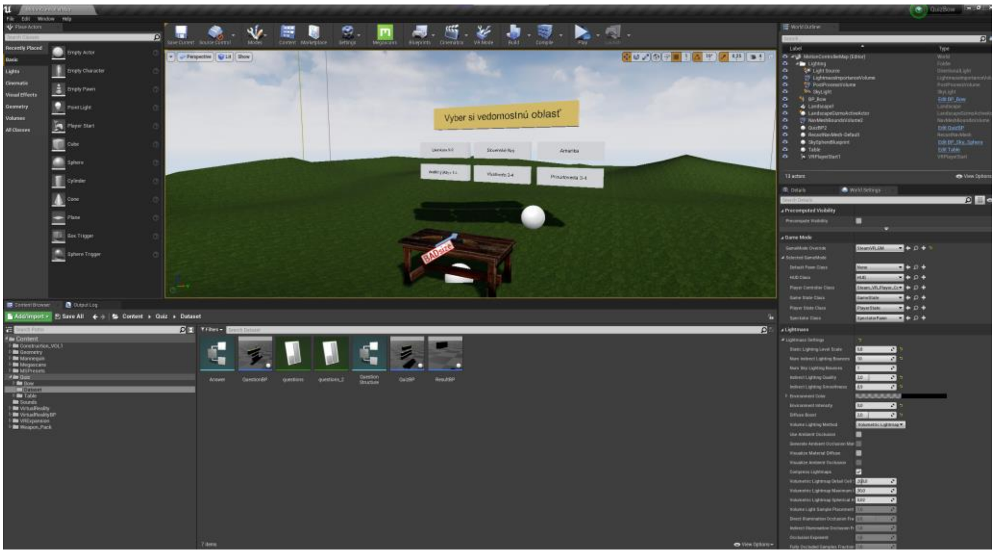
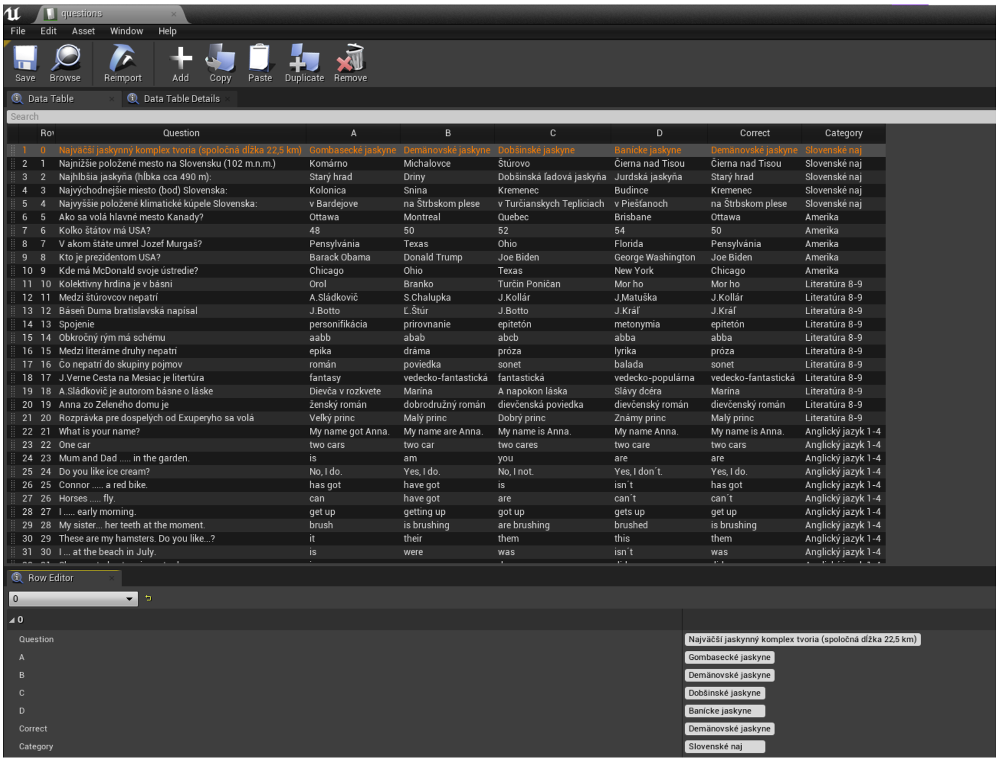


Figure 11 Demonstration of creating a QuizBow application in the environment Unreal Engine



	Ro	Question	A	B	C	D	Correct	Category
1	0	Najväčší jaskynný komplex tvoria (spoločná dĺžka 22,5 km)	Gombasecké jaskyne	Demänovské jaskyne	Dobšinské jaskyne	Banícke jaskyne	Demänovské jaskyne	Slovenské naj
2	1	Najnižšie položené mesto na Slovensku (102 m.n.m.)	Komárno	Michalovce	Štúrovo	Čierna nad Tisou	Čierna nad Tisou	Slovenské naj
3	2	Najhlbšia jaskyňa (hĺbka cca 490 m):	Starý hrad	Driny	Dobšinská ľadová jaskyňa	Jurdská jaskyňa	Starý hrad	Slovenské naj
4	3	Najvýchodnejšie miesto (bod) Slovenska:	Kolonica	Snina	Kremenec	Budince	Kremenec	Slovenské naj
5	4	Najvyššie položené klimatické kúpele Slovenska:	v Bardejove	na Štrbskom plese	v Turčianskych Tepliciach	v Piešťanoch	na Štrbskom plese	Slovenské naj
6	5	Ako sa volá hlavné mesto Kanady?	Ottawa	Montreal	Quebec	Brisbane	Ottawa	Amerika
7	6	Kolko štátov má USA?	48	50	52	54	50	Amerika
8	7	V akom štáte umrel Jozef Murgaš?	Pensylvánia	Texas	Ohio	Florida	Pensylvánia	Amerika
9	8	Kto je prezidentom USA?	Barack Obama	Donald Trump	Joe Biden	George Washington	Joe Biden	Amerika
10	9	Kde má McDonald svoje ústredie?	Chicago	Ohio	Texas	New York	Chicago	Amerika
11	10	Kolektívny hrdina je v básni	Orol	Branko	Turčin Poničan	Mor ho	Mor ho	Literatúra 8-9
12	11	Medzi štúrovcov nepatrí	A.Sládkovič	S.Chalupka	J.Kollár	J,Matuška	J.Kollár	Literatúra 8-9
13	12	Báseň Duma bratislavská napísal	J.Botto	Ľ.Štúr	J.Botto	J.Kráľ	J.Kráľ	Literatúra 8-9
14	13	Spojenie	personifikácia	prirovnanie	epitetón	metonymia	epitetón	Literatúra 8-9
15	14	Obkročný rým má schému	aabb	abab	abcb	abba	abba	Literatúra 8-9
16	15	Medzi literárne druhy nepatrí	epika	dráma	próza	lyrika	próza	Literatúra 8-9
17	16	Čo nepatrí do skupiny pojmov	román	poviedka	sonet	balada	sonet	Literatúra 8-9
18	17	J.Verne Cesta na Mesiac je litertúra	fantasy	vedecko-fantastická	fantastická	vedecko-populárna	vedecko-fantastická	Literatúra 8-9
19	18	A.Sládkovič je autorom básne o láske	Dievča v rozkvete	Marína	A napokon láska	Slávy dcéra	Marína	Literatúra 8-9
20	19	Anna zo Zeleného domu je	ženský román	dobrodružný román	dievčenská poviedka	dievčenský román	dievčenský román	Literatúra 8-9
21	20	Rozprávka pre dospelých od Exuperyho sa volá	Veľký princ	Malý princ	Dobrý princ	Známy princ	Malý princ	Literatúra 8-9
22	21	What is your name?	My name got Anna.	My name are Anna.	My name is Anna.	My name Anna.	My name is Anna.	Anglický jazyk 1-4
23	22	One car	two cars	two car	two cares	two care	two cars	Anglický jazyk 1-4
24	23	Mum and Dad ..... in the garden.	is	am	you	are	are	Anglický jazyk 1-4
25	24	Do you like ice cream?	No, I do.	Yes, I do.	No, I not.	Yes, I don´t.	Yes, I do.	Anglický jazyk 1-4
26	25	Connor ..... a red bike.	has got	have got	is	isn´t	has got	Anglický jazyk 1-4
27	26	Horses ..... fly.	can	have got	are	can´t	can´t	Anglický jazyk 1-4
28	27	I ..... early morning.	get up	getting up	got up	gets up	get up	Anglický jazyk 1-4
29	28	My sister... her teeth at the moment.	brush	is brushing	are brushing	brushed	is brushing	Anglický jazyk 1-4
30	29	These are my hamsters. Do you like...?	it	their	them	this	them	Anglický jazyk 1-4
31	30	I ... at the beach in July.	is	were	was	isn´t	was	Anglický jazyk 1-4

Figure 12 Question and answer table

GuessFlag (VR)

Like the previous application, this one uses a playful form to learn new knowledge, in this case national flags. Using a weapon that shoots foam balls, the user selects the language in which he wants to learn the flags. Currently, the application has English and Slovak

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languages, but adding a new language is not a problem with similar structures as the QuizBow application. After selecting the language, the user is asked to select the flag of the country that is displayed. After the correct selection, a point is added to the user's account. Otherwise, the series of correct answers is deleted and the user starts from 0. This element is to motivate the user to learn all the flags without being mistaken. If the user answers incorrectly, the correct flag is displayed and the user can remember it.

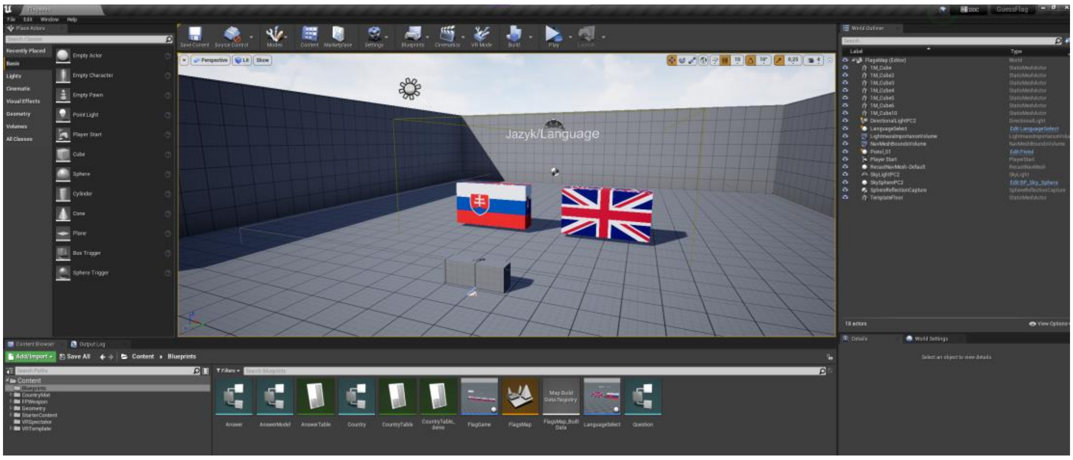

Figure 13 Demonstration of creating the GuessFlag application in the Unreal Engine environment

The generation of combinations is based on an algorithm where a four of the current bank of 44 flags are always randomly selected. The correct answer from these four random generated flags will be added in the list of used answers, and the system will use 1 flag less in the next round. If there are the last 4 flags in the system, after this round the list is reset and returned to the beginning of the count. In this way, it is guaranteed that, despite the random and mixed order, the user actually goes through each of the 44 flags, thus increasing the likelihood of comprehensive learning.

FindAndGrab (VR)

The last VR application is a focus on fun learning, it helps users orient themselves in space and at the same time improves the level of foreign language (English).

Figure 14 Children's playroom in application Find and grab

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The user finds himself in the children's playroom, where he is given the task of finding an object, while the name of this object is given in a foreign language (it is displayed on the board in front of him). As a result, he is forced to translate what he is looking for and then find this item from among the 15 randomly generated items. After successfully finding and grabbing the item, the user proceeds to the next round, where he searches for another item. In this case, the application requires movement and therefore uses one of the best ways to move - teleportation in virtual reality, which does not cause nausea like some of the other options of movement in VR. More about the comparison of individual ways of movement in the VR can be found in the article (Voštinár et. al., 2020). The user simply presses a button on the remote control and selects the place where he wants to find the object he is looking for and then moves to a new location using a blink simulation, which prevents nausea. After grabbing the correct item, another item will appear on the board that must be found in the game room.

Development tools for merge cube and our applications (AR)

Explorer an Object Viewer are official applications of MergeEdu, which offer a huge database of education materials through animate scene. All scenes and objects support the merge cube. Applications are available on common hardware, and they are categorized into areas. In addition to animated scenes, the applications are complemented by various knowledge quizzes. The CoSpace Edu application is more focused on self-creation using a comprehensive editor for augmented reality, which is accessible to the user after logging in. Other tools are Unreal Engine and Unity with Vuforia extension.

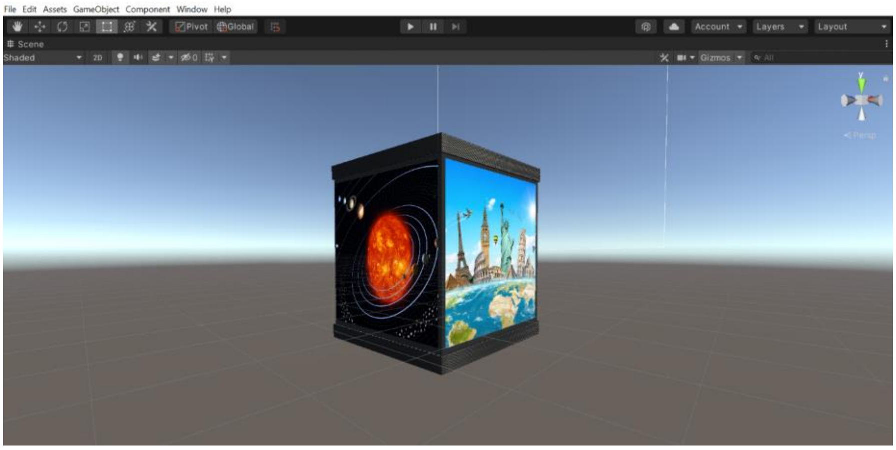

Figure 15 Demonstration of AR applications for a Merge cube (Solar System, World Monuments)

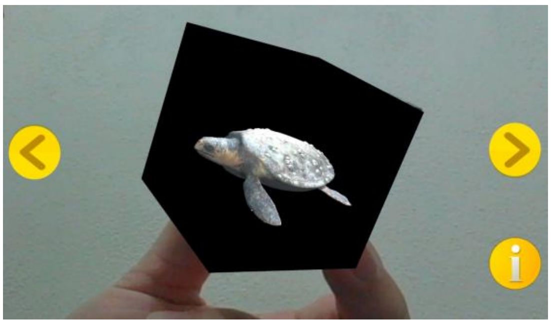

Figure 17 Merge cube animal app

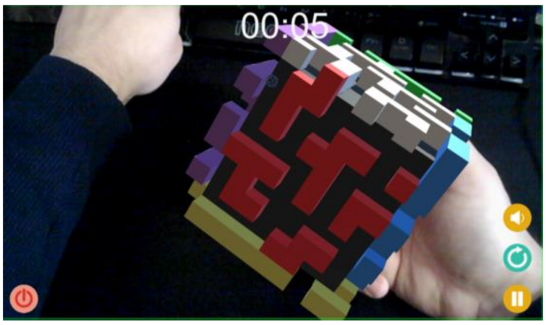

Figure 16 Merge cube application Labyrint

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Here are some examples of AR applications that use the Merge Cube to get acquainted with the solar system, some of the world's famous monuments, and sea animals. One application is used to train and rehabilitate the children's hands while watching the falling ball in the labyrinth.

DISCUSSION

Due to the Covid-19 pandemic situation, we cannot visit the pupils of primary school at the children's hospital for the second year. We could only reach teachers who had the opportunity to assess the suitability of applications for hospitalized children. Based on their requirements and input data for the quiz, the applications were modified to suit the needs of the children as much as possible. We also involved teachers and students of our department in obtaining feedback and we are still waiting for more answers. So far, more than 30 respondents have been acquainted with the applications and 22 of them have completed the questionnaire, at most at the age of 20. All respondents were already familiar with the concept of the VR, but only 64% of them already had personal experience of immersion to the virtual world. We think that the younger generation of primary school students will have even less experience with VR/AR. Although the way young people like to learn today is related to the Internet and the You Tube channel, in third place they indicate the possibility of learning through VR/AR applications and more than 90% of respondents think that this way of learning is promising mainly for hospitalized children. It was also surprising to find that none of the respondents had a problem with control in any of the applications, or with the way they moved in FindandGrab using teleportation. We believe that the limited possibility of movement in applications will be appreciated especially by children strapped to the bed, even if in a virtual environment they will be able to at least rotate, or control hand movement. The evaluation of all assessed applications was also gratifying, because in terms of fun, instructiveness or attractiveness, they passed the evaluation in a very balanced way.

Language is a major barrier in the education of young children. There are a large number of applications in the world that have been created in English and other world languages and our children do not understand them. Although the most common media element of XR applications is a 3D object that everyone understands, in communication (in the main menu, quizzes, or in other communication tools) we cannot avoid the Slovak language. This is one of the reasons why we try to create our own applications that are always tailored to the needs of hospitalized children. Another reason why we make applications for this target group is the effort to divert children's attention from their unpleasant conditions, examinations, and interventions and long-term experience with friendly medical staff and a fantastic teaching staff of our partner’s primary school.

Our applications are intended to serve not only as educational applications to expand knowledge in various fields, but also as a motivational tool to diversify education, a distracting tool to distract from illness, or for fun and entertainment. This intention of ours is also continuing. The annual topics of the bachelor's and master's theses receive a different dimension and a vision of meaningful use in practice.

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CONCLUSION

In our article, we have presented the possibilities that virtual, augmented and mixed reality technologies could bring to education. We have outlined several advantages, but also disadvantages, which must be taken into account when introducing them into the teaching process. The main part of our article was a description of tools and methods and the creation and description of applications that are designed for education and entertainment of hospitalized children in primary schools. Due to the increasing trend of using XR technologies in all areas of our lives, there is also growing interest from schools in purchasing these technologies. However, the hardware itself will not bring the expected satisfaction of their needs in the hands of teachers. More important is the targeted creation of applications that can be used in several schools at the same time. Therefore, we believe that our efforts to continue to create such applications in the future will bear the "desired fruit".

ACKNOWLEDGMENTS

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Aural Concept of Albrechtic

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Abstract

Computer-assisted teaching can be one of the creative and engaging ways to approach and practice cognitive knowledge in music theory. In practice, it is possible to find several music programs to support the teaching of rhythm or intonation. However, there is no Slovak version of any available music program that meets our requirements. Due to the fact that professional music terminology differs from Slovak music terminology, these software are not suitable for music education in Slovakia. The project KEGA 025UKF-4/2021 entitled "Development of advanced functions of music education software Albrechtic" builds on the previous project, in which the software was created according to our requirements called Albrechtic. Our task in the current project is to improve and expand the functionality of the program with new modules and finish existing modules. The instruments will be designed for advanced music theory practice. In this article we deal with the development of another module for Albrechtic software, which will focus on rhythmic exercises. We will add to the software the possibility of playing sounds via MIDI, which will serve as a sound environment for existing modules. These modules thus acquire an additional control function. The developed software will be used to support the teaching of basic tasks in music theory. The target group of the created programs will be mainly university students and secondary students of primary and basic art schools. We assume that by using Albrechtic software in the teaching process, we will develop students' aural imagination, which plays the most important component in music education and it is not possible to imagine, for example, teaching an instrument or singing without it. The software continues to be developed in RAD Studio for Windows by Embarcadero.

Keywords

Albrechtic, education software, music theory, didactic tool, MIDI,

INTRODUCTION

The development and infiltration of ICT into the educational processes of the whole society influences the importance and structure of education, as well as the competencies of university graduates. This requires the search for associations and the search for new ways of using knowledge from the issue in various fields (Balogh, Turčáni, 2009). The implementation of new technologies and practices in education currently represents the greatest support for the development of students' cognitive and intellectual abilities (Balogh, Kuchárik, 2019). In 2017, the KEGA 003UKF-4/2015 project entitled The Application of ICT in Teaching Music Theory was successfully completed. Within this project, the research team from the University of Constantine the Philosopher in Nitra developed its

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own educational software Albrechtic, which represents the function of electronic support of teaching music theory. The software includes functions exactly for the needs of teaching and consists of modules for practicing writing and reading tones, scales, chords and intervals, which were described in detail in the article from the previous year's conference DIVAI 2020 (Vozár, Čierna, Brezina, 2020). The creative team continues to improve and expand the developed software within the solution of the project 025UKF-4/2021 Development of advanced functions of music education software Albrechtic. One of the key tasks of this project is to create a sound environment for all modules that are currently included in the program. The creative team assumes that one of the inseparable parts of music-theoretical training is also the knowledge of the sound of the given tonal structures.

With the advent of modern digital teaching aids, several leading development companies have invested time in creating comprehensive educational music programs that should reflect the very idea of combining visual and aural perceptions in teaching music theory. One of the first was the Sibelius company, whose set of didactic software Musition, Auralia and Sibelius Instruments introduced for the first time the concept of music education in the virtual computer space. In particular, Musition and Auralia were an innovative way of learning intonation using computer-generated sound. Later, several music programs were created, which focused on auditory analysis training, such as EarMaster from the Danish developer EarMAster ApS. However, the primary focus on auditory analysis posed a problem, which was the lack of the possibility of deeper integration into the institutional educational process, although Sibelius has developed and continues to develop enormous activities in support of music education. (Belibou, 2018) Of the aforementioned software, only EarMaster has remained active and supported by developers. In the field of didactic software focused on music-theoretical education, the situation is currently more complicated. The research team does not have information that there is any software that would have the ability to play audio in addition to the visual side. In this respect, the superstructure of the sound module in the Albrechtic program will be an original and innovative solution not only in Slovakia, but also on a global scale.

THE STATE OF THE RESEARCHED ISSUE

The aural imagination plays the most important part in music education and it is not possible to imagine, for example, teaching an instrument or singing without it. On the other hand, the teaching of theoretical subjects and especially subjects focused on learning about the relationships and principles of music theory can primarily be taught without an auditory idea. After all, a similar approach was for many years the only one, especially in the environment of primary and primary art schools in Slovakia. The mathematical approach to deriving scales, intervals, or chords is certainly irreplaceable, but without the possibility of transforming these relationships into an aural form, it becomes self-serving (Rogers, 2004). The teaching of music theory has somehow always been necessary and not very lively, which was also reflected in the interest of pupils and students in the issue. (Čierna, 2017, Čierna, 2014/1)

From the point of view of the technical construction of the sound side of all educational software focused on auditory analysis, the use of a universal sound module was uniform. The software had to be usable on any type of computer without the need to install additional sound banks or other modules, which at the turn of the 20th and 21st centuries

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had certain limits in terms of limited storage capacity as well as the relatively low performance of microprocessors. The development companies thus reached for a guaranteed solution and took advantage of the presence of a standard sound bank present in a standard installation of MS Windows or OSX operating systems. This sound bank is General MIDI and has 128 different sounds in the basic version. Typologically, these are mostly musical instruments and several sound effects. As a standard, the use of piano sound has become established, which is processed in these banks in the most reliable way compared to a real musical instrument. However, the user has the option to choose any of the offered sounds.

One of the advantages of the General MIDI system is not only the standard incorporation of sound samples into standard operating system installations, but also the ability to use the MIDI protocol to communicate with a software sound module or external musical instrument - such as a digital piano. Here, other possibilities open up from the point of view of the sound quality of the played sound samples, as well as forms of education. At present, several digital piano manufacturers are also implementing the function of illuminating the keys after the appropriate tone. The doubling of visual perception by combining the display of a musical score in a musical program and light highlighting on a real musical instrument can thus simplify the understanding of the relationship between a "mathematical" musical notation and a real visual on a musical instrument. However, even in this case of connection, the sound form is irreplaceable and essential.

In the development of the sound module in the Albrechtic program, the creative team has not yet gone so far as to plan similar multimedia connections of several components. However, it will certainly address this issue intensively in the next few years. Currently, the priority is to connect a standard General MIDI sound module. The idea of the concept of the implemented module lies in a slightly different way of use compared to software designed to improve hearing skills. While in auditory-analytical applications, sound is the dominant component and its use is crucial for the use of the program, in the music-theoretical program Albrechtic it will serve as a complementary and controlling function. The difference is that Albrechtic software always implements the question form visually and not aurally. Therefore, the answers are entered only on the basis of a visual display. For the time being, the sound form playback function will only be linked to the control function.

In each module of the program, the sound form will be available after entering the answer. It will be possible to hear the question and the answer, but without the possibility of additional modification of the answer. This sequence is extremely important and follows from the essence of music-theoretical learning. At the same time, this prevents substitution of auditory analysis practice, which is not the intention of the Albrechtic software. For interval and chord modules, the possibilities of ringing individual tones (not in chord) during the actual answering are considered, but this possibility will have to be tested in the teaching process itself. In the first phase of development, it will be set as the default sound of a classical piano, whose sound parameters (volume, dynamics, reverberation length, etc.) will be adjusted on the basis of research in practice. The aim of the development is to provide each sound module (scales, intervals and chords) with the possibility of sound control in the simplest possible form so that the user's attention is predominantly oriented to the visual side. Again, this is also an attempt to preserve the essence of music-theoretical education.

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After completing the sound field for at least one module of practice in the Albrechtic program, an intensive phase of testing in teaching practice will follow. The members of the research team have extensive experience in testing various digital teaching aids (Čierna, 2014/2) and are aware that only in this way is it possible to set up the user environment meaningfully. Testing will take place primarily in Music Theory classes within the implementation of the teaching program Teaching Music (Department of Music, Faculty of Education, University of Constantine the Philosopher in Nitra). The research sample of students attending this study program is extremely heterogeneous, as it consists of graduates of not only music schools and conservatories, but also grammar schools and other secondary vocational schools. Thanks to heterogeneity, it will be possible to capture problem areas in the user environment, which will reflect both the approach of students with varying degrees of music-theoretical but also computer science knowledge and skills.

NEW FUNCTION OF ALBRECHTIC SOFTWARE

Albrechtic software consists of several modules, such as a module for writing and reading tones, writing and reading scales, writing and determining rising and falling intervals, and writing and determining chords. The chord module is currently only created for major chords. The research team is working on a supplemented module for reading and writing chords of moths, enlarged and reduced. Work is also underway to expand the interval module, which will be enriched with reading and writing decreasing intervals.

A new module that is currently being developed is the module for rhythmic exercises, within which it will be possible to practice rhythm reading and writing. In order for this module to work, it is necessary to program the Albrechtic software with the possibility of audio playback using MIDI (Musical Instrument Digital Interface). MIDI can be called a protocol or a standard that has become the standard for connecting and transmitting digital data from musical instruments. It is used in computers and electronic musical instruments such as synthesizers, electronic keyboards, but also electronic drums and string instruments.

MIDI procedures in the Albrechtic application

The MIDI protocol does not transmit specific sounds, but only information (a sequence of instructions for creating a sound) about the tone and instrument on which the tone is to sound. This reduces the overall data flow by several times compared to playing wav files, for example. The entire transmission takes place in real time. MIDI messages are sent as a time sequence of one or more bytes. Specifically, it is the transmission of pitch, duration, tone volume, the instrument on which the tone is to be played, and the MIDI channel number. There are 16 MIDI channels with numbers 0 to 15, which are entered in hexadecimal code for each function. Channels are used to transfer information between several devices at once, or they are used to transmit multiple data streams (playing multiple notes simultaneously, for example, when playing chords). An example of the use of channels is shown in Figure 1, where channel 0 is used for saxophone, channel 1 for piano and channel 9 for drums.

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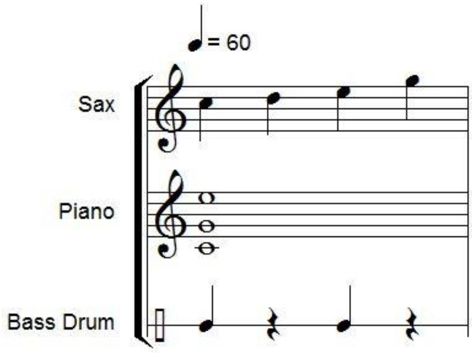

Figure 18: Example of using MDI channels.

Within the MIDI protocol, 128 standard instruments called General MIDI are defined. This ensures the identification of tools in a given order, which is adhered to within the standard on all computers and tools. For example, the first instrument is an acoustic piano, serial number 14 is for the Marimba instrument, and so on. Because they are software tools, and each developer adds their own sample tools, the sound of each tool may vary slightly from computer to computer. (The MIDI Manufacturers Association, 2022)

Albrechtic software is developed in the RAD Studio environment for the Windows platform, so it was necessary to get acquainted with and study the issues of MIDI application programming in the mentioned development studio via API (Application Programming Interface) functions. To streamline programming and clarity of the source code, a unit called *midi.pas* was created, which contains all the procedures necessary for us to work with MIDI. The principle of operation is that first you need to open a connection between the software and the device that is to play the sound. The first is the `OpenMidiOut` procedure, which uses the `midiOutopen` function with the appropriate parameters. In order to be able to verify the connection in another part of the program, we have added the global variable `MidiOpen` to the `OpenMidiOut` function. (Microsoft Windows App Development, 2022). A procedure is programmed to play a specific tone:

```
procedure TurnOnMidiNote(Note,Instrument,Volume,Channel,Panning:byte);
begin
     //tell midi device which instrument or patch to use
     midiOutShortMsg(MidiOutDev,MAKEWORD($C0 OR Channel,Instrument));
     //panning
     midiOutShortMsg(midioutdev,strtoint('$'+inttohex(panning,2)+'0AB'
                                        +inttohex(channel,1)));
     //tell midi device what note to play
     midiOutShortMsg(MidiOutDev,MAKELONG(MAKEWORD($90 or Channel,Note),
                                        MAKEWORD(Volume,0)));
end;
```

Figure 19: Procedure for playing note in MIDI

According to the `Instrument` parameter, the instrument is selected from the General MIDI list on which the entered note is played. According to the code from the `Note` parameter, it is mapped according to Table 1. Determining the note is then simple according to the formula `IndexNoty + (Octava + 1) * 12`.

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Table 1: Integer parameter for note mapping.

Octava	C	C#	D	D#	E	F	F#	G	G#	A	A#	H
-1	0	1	2	3	4	5	6	7	8	9	10	11
0	12	13	14	15	16	17	18	19	20	21	22	23
⋮												
8	108	109	110	111	112	113	114	115	116	117	118	119
9	120	121	122	123	124	125	126	127				

The value of the `Volume` parameter is from the interval 0-127 and represents the volume of the note being played. Another parameter is `Channel`, which we mentioned when defining the MIDI protocol. The `Panning` parameter is set to 63 by default, which is a mean value in the range 0 to 127. With this parameter, we can set the tone volume ratio between the left and right speakers. On music devices, this feature we call Balance.

To prevent the note from playing indefinitely, it is necessary to stop playing the note after a certain time using the `TurnOffSingleMidiNote function (Note, Channel: Byte)`. We can already recognize from the names of the procedure parameters that the playback of the respective note on the given channel will stop.

The *midi.pas* unit is supplemented by other useful procedures, `TurnOnMidiPercussionNote` and `TurnOffSingleMidiPercussionNote`, with which we can control percussion. And last but not least, the `CloseMidiOut` MIDI transmission termination procedure is an important part, which resets all channels and thus terminates all notes on all channels. We call this procedure in the `OnDestroy` event of the application form.

CONCLUSION

The creation of a sound module for the didactic software Albrechtic is an extremely challenging challenge for the research team. As similarly oriented programs are so far either absent on a global scale or only partially address the issue, many implementation difficulties will need to be addressed in original and authorial ways. In the scope and functionality of the implementation of the sound interface for individual modules, the current challenge is to set up the user environment so that it is complementary to music-theoretical education, but it does not replace auditory-analytical education. The research team is ready to solve many of these issues based on testing Albrechtic software in real educational practice. Unfortunately, due to the pandemic measures that have accompanied us for the last two years, we have not had the opportunity to test the software in teaching practice, but we do not lose hope and believe that by the end of the current KEGA project we will be able to share the results of testing teaching practice.

ACKNOWLEDGEMENT

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Section:

Learning/Teaching Methodologies, Assessment and Learning Environments

Fourth-Order Cybernetics as a Base for Smart/Intelligent Learning Environment

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Abstract

Based on our previous educational researches we discuss whether it is possible to replace a human teacher with a virtual (machine) teacher, refereeing the hidden layers of doing so, as well as considering the technological possibilities currently available explain what this means in a society. For, an adaptation of current cybernetic into cybernetic pedagogy as cognitive modelling within a compounded educational system is proposed. Since a positive answer to the question can the human mind and learning be formalised and reduced to the language of science is essential for the success, we will try to prove this by using second order cybernetic pedagogy 4.0 based on fort order cybernetics and cognitive neuroeducation approach. In this research, we try to provide a broader outlook on the issue of education, especially connected with distance learning. Solutions to real-life problems always require extensive knowledge of different areas, which is why we will emphasize the role and importance of cyber didactics. Results show progress in comparison to classic teaching. Nevertheless, they are still behind the suggested 0.84 -1.05 sigma and are oscillating now around 0.65 sigma. But this is only the first attempt at developing intelligent learning environments of future.

Keywords

Learning process, cybernetic pedagogy, cognitive science, connectionism, hybrid systems, programmed learning, learning algorithm, e-learning material.

INTRODUCTION

Modern research in education processes shows that the highest educational goals cannot be achieved without active participation by the student. In order to follow the appropriate development of the student's potential it is therefore of utmost importance that we continuously follow and evaluate the educational process and implement the necessary corrections when needed. This way of working is to a great extent enabled by modern electronic learning material in smart or intelligent learning environment, but only if it is correctly designed (from the viewpoint of pedagogy and didactics) and technologically implemented. Such material must also, among other aspects, evaluate the user and upon poor results change the path to achieve the planned goals. We believe that smart/intelligent learning environment designed on the basis of the revised cybernetic pedagogy and appropriate algorithm can lead to the fulfilment of all of these requirements while they not only symbolise the learning process, but also the social environment in which it takes place.

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Based on the didactical guidelines of programmed instruction, cybernetic didactic and different cognitive approach for the greatest possible individualisation is presented in the Figure 1. On the bases of metadata, analysis and evaluation of students' educational achievements and the evaluation and optimisation of the individualized e-learning material can be prepared (Aberšek, 2013, 2018).

The theory of algorithms deals with guiding of the "automatized" learning. Programmed lessons were developed on the basis of algorithms. Because there is no generally accepted formal definition of what an algorithm is, we can use the information definition which states that an algorithm is a series of rules, which specifically define the type of operations and every final specific sequence of directions or instructions, which solve an endless amount of problems of the same category.

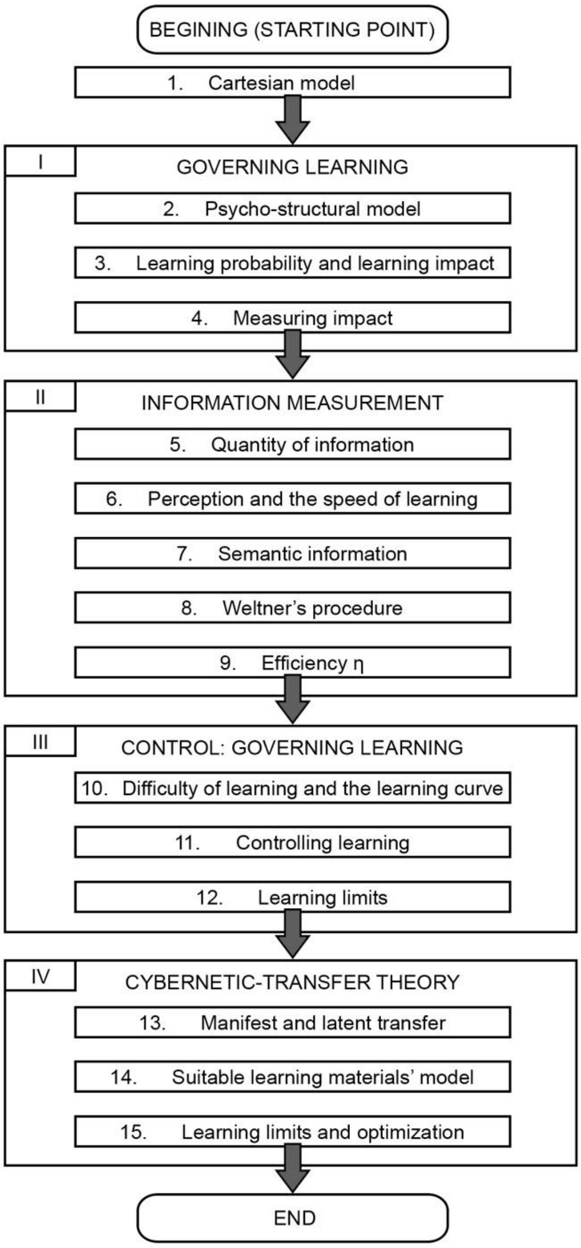

Figure 1: Algorithm of cybernetics teaching/learning system (Aberšek, 2018)

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The important value of algorithms is in the demand for "algorithmic description", for a precise description of the sequence of instructions, which is a precondition for algorithmic learning. If we wish to change a certain didactic situation, we need to precisely describe it first, discover its structure, regularity, causational and other relations, but not only in this situation but also the processes of learning in the minds of students. Only on such foundations is it possible to build operative procedures ("algorithmic instructions"), which guide the processes that change this situation ("algorithmic process"). Algorithm for the base system of cybernetic didactic is schematically presented in the Figure 1.

METHODS

The background of new-age cybernetics

In developing a new version of cybernetics according to different authors, such as Zangeneh, Haydon, and Roberto (2004) and Mancilla (2013), (Table 1), an attempt was made to address some, if not all, of the shortcomings of previous versions. What is presented by this author is by no means final and complete – rather, it is a promising first step for a theory in progress. The main purposes of developing a new version of cybernetics were: (a) to introduce a paradigm shift; (b) to address an explicit discussion of the human system, including problem solving; and (c) to develop a model to demonstrate how structure and context influence such systems. Central to this effort is the application of a unique, critical theory inspired by the works of Giddens (1971, 1990) and Lyotard (1979) to the cybernetic theoretical framework. The epistemological orientation of the theory proposed from these authors is that of multiple realities shaped by social, cultural, economic, ethnic, gender and disability values, which centralize on the asymmetric power relations in society.

Table 1: Summary of the different cybernetic models

Orientation and Approach		**Focus**	**Feedback**	**Important Contributions**
First-order cybernetics	Engineering, technological	Homeostasis	Negative feedback; Circular causality	1. Definition of boundaries 2. Subsystems and supra-systems
Second-order cybernetics	Functionalist-constructivist	Morphogenesis	Positive and negative feedback	1. Observer as an important part of system 2. No "ultimate" perspective 3. Self-reference; self-production
Third-order cybernetics	Social-constructivist	Top-down and bottom-up circular causality; Morphogenesis	Positive and negative feedback	Emphasis on the meanings of interactions
Fourth-order cybernetics	Multiple realities; Post-modern	Agent-structure interactions	Positive and negative feedback	1. Asymmetric power relations 2. More focus on positive feedback

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First-order cybernetics, which originated from an engineering approach, stressed the importance of clearly defining the boundaries of the system under study. The main focus of this model was on control systems and homeostasis; therefore, it only considered negative feedback loops. All observers were considered to be equal and were thus able to provide an "objective" truth of the system being studied. Teaching/learning process in cybernetic pedagogy

Let us now try to transfer the mentioned general principles of first order cybernetics to the field of education. Cube (1982) set the cybernetic foundations for learning and teaching. Frank and Mader (1971) developed the so-called "cybernetic pedagogy" that was based on natural sciences. Cybernetic pedagogy is the science of how a learning process can be influenced.

Planning, implementation and evaluation should in greater part take place in the frame of technical systems, i.e. learning environment. Cybernetic pedagogy perceives lessons as a unified whole of communication processes between at least one learning programme (teaching system) and at least one student (learning system). These processes need to comply with the navigation and guidance of cybernetic models as seen in Figure 2.

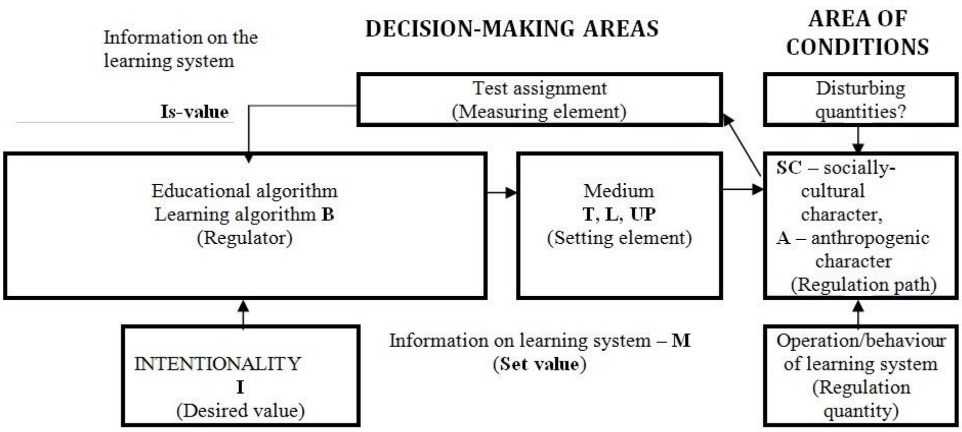

Figure 2: Elements and functions in a teaching-learning process applied in cybernetic pedagogy

According to Frank and Mader (1971) it is possible to formalise or objectivise the learning process as an educational algorithm and express it as a mathematical logical function with the following five conditional variables: L – learning material, M – media, P – psychological structure, S – social structure, Z – setting learning goals and B – teaching or learning algorithm, i.e. a system connecting all the aforementioned elements in an indivisible whole. Accordingly, the teaching-learning process must be subject to supervised and guided cybernetic models, as shown in the figure below.

A learning process can also be (technically) realised as a learning programme (intelligent tutor) (Frank, Mader, 1971, Frank, 1999); if so, it has to include a learning algorithm B formally written in symbol form with a mathematical logical function with the presented five conditional variables:

$$B = \mathrm{f}\,(Z, L, M, P, S) \qquad (1)$$

Thus, from the viewpoint of cybernetics, the teacher and students, learning process and the organisation of lessons are only a subsystem of the entire education system. A teacher

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is a subsystem functioning as a transferor and a guide who holds, plans and provides information. A student is a subsystem functioning as the guided one, one who receives, processes and stores information, and responds to it or is guided by it. Teaching within this meaning is a deliberate interaction in which students and the teacher change their characteristics and their actions in a quantified and qualified manner and can therefore be considered as an adaptive system; in other words, learning is a process that leads to adaptive changes in the system. Changes that are a consequence of learning make it possible for the same population to solve the same tasks faster and more successfully than before the learning process (Aberšek, 2018).

Second-order 4.0 cybernetic pedagogy approach

Let us try to reject the reasons of first-order cybernetic pedagogy, and thereby bring second-order 4.0 cybernetic pedagogy as a teaching/learning strategy back to life. The didactics of learning theory has at its centre a relatively simple structured network made up of the six phenomena which categorises those phenomena and places them in the whole via a system of symbols that enable a comprehensive inclusion of all the essential circumstances and decisive tasks of the lesson. After almost forty years since this model of a structured lesson was presented, it is clear that the statement, which was regarded as stemming from it, is the first problem and the source of all the problems: lessons are an example of a formally constant structure or a structure whose validity is unlimited (Heimann, 1976). This thesis is false since there are no structures whose validity is unlimited; they are always created by humans through their practical operation in a certain time-specific social system. For example, emphasising certain teaching aids in a model can thus only be explained on the basis of current social-political circumstances and school policy.

Another problem is represented by the fact that two entirely different areas are included in the model of a structured lesson from the viewpoint of symbolisation. It is relatively simple to formalize decision-making areas or to write them in symbol form with a limited number of modifications of individual factors since the number of methods for achieving the set goals is limited, as is the number of teaching aids and topics. Problems with formalisation occur in the area of conditions when we no longer talk about a certain specific process with clearly defined goals and limited quantities of content, method and teaching aids related to them. Here we are faced with a completely open system of anthropogenic and socially-cultural characteristics that are usually entirely individualized. It is clear that this part of model should be, at least partially, dynamical, which means it should include socially-cultural as well as anthropogenic characteristics and development levels. The goal of each model must be to maximize the quality of the student's knowledge. The learning process is indeed an indivisible union between the teacher and the student or between teaching and learning; however, the latter is more important.

If we wish to overcome the criticism of ignoring the differences between the distinctive psychological and pedagogical features of mental operation on one side and the characteristics of technical systems on the other, and take into account in modelling higher cognitive processes also the distinctive features of the educational field, where the student is not only the object of teaching but also the subject of its own control and change, structuralism with symbol models must be replaced with modern cognitive science with dynamical systems as the fundamental premise.

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On this basis we could re-define the learning process algorithm (Aberšek, Borstner, Bregant, 2014):

$$B = f_1(I, T, L\ f_2(I), UP, ME)\ f_2(SK, A, Y) \quad (2)$$

Two types of functional dependency are included in the equation, f1 for symbol system (mostly decision-making areas) and f2 for net system for intentionality and area of conditions.)

Under this equation the learning process algorithm is expressed as a mathematical-logical function of seven conditional variables:

- I – intentionality: its definition is complex since the goals are essentially connected with the topic; despite this it makes no sense to develop a neutral catalogue of goals. (Searle, 1983) The teachers should themselves determine which orientation patterns and structures are behind a particular goal since it makes a significant difference whether it refers to only knowledge transmission or to creating something new. A reference point for regulating intentionality can also be found in anthropology: Since human behaviour does not exist on its own, but is always a consequence of thinking and emotions, Heimann (1976) defines thinking, wanting and feeling (head, heart and hands) or, according to Bloom (1956), cognition, affection and psychomotor skills as the three fundamental dimensions of human behaviour. What is of particular importance is their combined operation, which has to be in tune.
- T – topic;
- L – learning environment, which should be seen in a slightly wider sense than in standard cybernetic didactics and is mainly dependent on the topic and closely related to learning aids and used information communication technologies (ICT);
- UP – learning aids;
- M – didactics or methodology of lessons in the strict sense. Different topics can be presented in different ways; however, selecting them depends mainly on the desired goals and results of the lessons. This conditional variable is the basic factor in optimising the learning process.
- SK – socially-cultural character;
- A – anthropogenic character;
- Y – psychosocial characteristic.

It follows that we cannot use the same tools and the same work methods for the symbolisation of both areas (except for intentionality). Symbol systems can be used for modelling decision-making areas, as was done in the past, while the area of conditions must be modelled using network systems or some other tools of artificial intelligence (genetic algorithm, fuzzy logic) that enable complex individualisation and differentiation of the learning process. Second-order cybernetic pedagogy 4.0 should be treated and presented as a hybrid system since it nowadays combines two different methods of formalisation supplied by the cognitive platform, symbol and connectionist ones, and not as a symbol system as it was treated and presented in the past.

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RESULTS

LE_LMS_AI

Figure 3 schematically shows the intelligent learning environment (a learning management system or LMS) based on second-order cybernetic pedagogy 4.0 and AI solutions. We named it the LE_LMS_AI.

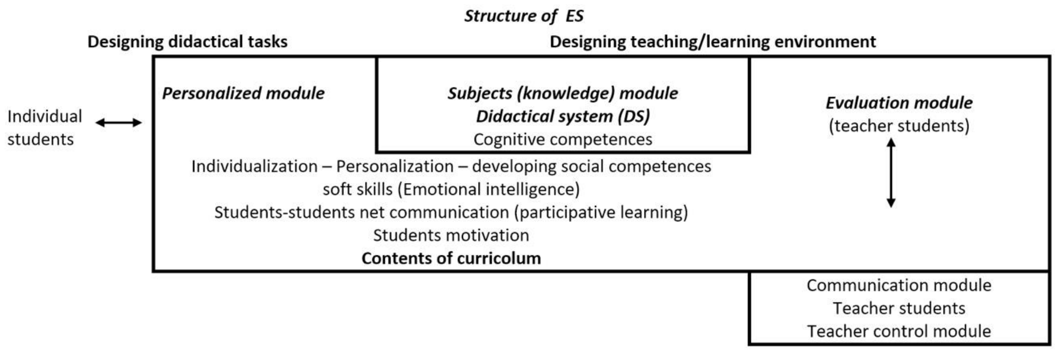

Figure 3: Structure of the education smart/intelligent learning environment LE_LMS_AI

General description of the LE_LMS_AI

Based on the concept shown in Figure 4, we developed the LE_LMS_AI, consisting of three permanent system modules (the personalized module, the evaluation module, and the communication module) and one module relating to the subject matter at hand (the subject module), which can be independently adapted and/or altered by the teacher. The basic functions of the individual modules are as follows:

The personalized module (PM) is a connecting system between the individual learner and the learning system LMS_AI. It is a link between the teacher and the learner, as well as a link between the learners themselves during their engagement in participatory classes. The PM is closely linked to the evaluation module (EM). Its primary task is to adapt the learning path to an individual learner (individualization and personalization), to determine their initial state (the level of knowledge about a particular topic (learning content) and the learner's attitude regarding this topic), to monitor their progress and adapt the learning path to their needs (e.g., their learning style) and abilities (differentiation). Since both system modules are AI-based, this module is used to store the personal data of an individual, for whom the learning system has been adjusted already at the beginning by modifying the subject module (SM), in order to fit his/her needs and abilities, as defined during previous lessons (i.e. previous SM). If at the beginning of the school year the LE_LMC_AI is the same for all students, at the end of the school year we will have as many different LE_LMC_AI as there were students in the class. They will have all achieved the same learning goals and met the same learning standards, however, they will have reached these goals through entirely different paths.

The evaluation module (EM) is a module based primarily on AI methods. Its basic purpose is to:

1. analyse the existing condition of
    - the students' knowledge (the cognitive component) and

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   - the decisions, the awareness (the social component, emotional intelligence) of an individual student.
2. and forward the results of these analyses to
   - the teacher, who can thereby monitor the progress in individual students (formative assessment),
   - the student, for the purpose of self-evaluation and motivation, and
   - the system, i.e. to the personalized module (PM), with the intent of individualizing and personalizing the learning path for the individual student.

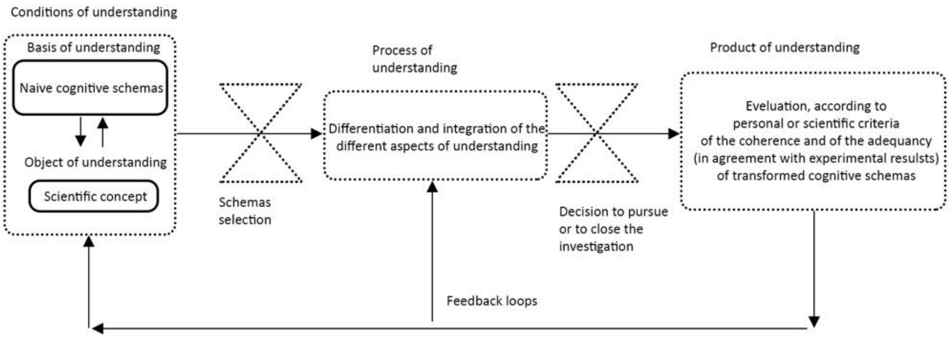

Figure 4: The structure of the SM block

The subject module (SM) is a module related to a specific subject, i.e., to the concrete teaching/learning content. This module consists of several elements (blocks) and is founded on the idea of brain-based teaching/learning. The individual learning contents (activities) are divided into learning units with the duration of approximately 45 to 90 minutes, consisting further of blocks in the duration of 10 to 20 minutes. Such modules can be organized for individual subjects as a whole (intelligent i-textbooks), or they can be organized for individual problems or projects, which are stored in a database and are accessible to teachers as a teaching aid. The modules are set up on the basis of concrete examples/learning situations to facilitate individual problem- or research-based work in students engaged in formal (here, the modules serve as a teaching aid to the teacher) or non-formal types of learning (self-learning, reinforcing knowledge, homework assignments, etc.). These modules represent the flexible part of the LE_LMS_AI, which can be adapted or complemented to meet the existing needs and/or requirements (e.g. a change in the curriculum).

The basic structure of individual blocks is shown in Figure 4.

Each SM is built hierarchically, which enables a differentiation of the knowledge acquisition path, and is automatically adapted to the individual learner. In theory, three levels are anticipated (high, medium and low), while the possibility of employing AI methods would eventually result in a "complete" personalization of the learning paths. The SM are divided into three groups, depending on the difficulty level of the learning content, and on the ways and methods of acquiring this content, namely:

- for lower cognitive levels, which are related to the elementary acquisition of basic knowledge (memorizing), and where traditional (frontal instruction, transmission approach) forms of teaching are used as the teaching method, the LMS_AI is intended mainly for teachers in the preparation of classes;

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- for medium cognitive levels, learners use it mainly to reinforce their knowledge. This module includes various learning strategies, especially game-based techniques, used to increase the motivation and interest of students. By means of this, the teacher can formatively monitor the individual students' progress and adjust subsequent lessons accordingly.
- for higher cognitive levels, the LE_LMS_AI can be used predominantly as a self-learning tool for the student, supported by the teacher's research-, problem-, or project-based working methods. In this kind of situation, the teacher only appears as a tutor, as the one who provides guidelines and encouragement to the students involved in the learning process. In this kind of process, students are active, curious, and motivated.

The communication module (CM) is the link between users (students) and the learning system. It is a module that enables data input, and communication, both between teachers and students, as well as between students and the ITS.

DISCUSSION

It is obvious that the students' experience and the quality of their knowledge are most important. From this point of view, in recent years we have talked a lot about efficiency of teaching and the learning process. Bloom (1984) in his research, the average students who had one to one tutoring was about two standard deviations (2 sigma) above the average with the convectional teaching in the class. The difference is indicatively equivalent to raising students' average achievement from 50% to 98% (Figure 5). This research has become the cornerstone of all further research in the field of e-learning. All the researchers started to seek the ways to accomplishing this result. These are also our limits. Another research that provided a reference point for all researchers involved in the evaluation of distance learning efficiency and e-learning systems is the Fletcher (2003) study, where it summed up some research findings for technology-based instruction. Based on the meta-analysis of research in this field, he calculated the effect size, based on the distribution theory of Glass's estimator of effect size (Hedges, 1981) (insted of Cohens's) delivered the following starting points for the evaluation of e-learning efficiency: computer based instruction 0.39 sigma (233 studies), interactive multimedia instruction 0.50 sigma (47 studies), intelligent tutoring system 0.84 sigma (11 studies), recent intelligent tutoring system 1.05 sigma (5 studies). The results of the latest ITS research are still moving around 1.05 sigma (Craig et al., 2013; Jaques et al., 2013; Wijekumar, Meyer, & Lei, 2013). The results of Fletcher's research and the further development of ITS suggest a gradual improvement in the efficiency of e-learning.

It should be noted, however, that the presented learning environment is only at an early stage of development and is subject to continuous pilot testing. We have set ourselves the goal of getting as close as possible to the individual way of education (0.84-0.98). From the evaluation under Figure 5, a small shift in the right direction can be determined. We have prepared only one 20-minute block of the subject module for medium cognitive levels on the sustainable use of various energy sources in correlation with environmental issues and/or environmental footprint. The prevailing learning method was game-based learning. With this SM we conducted a short test with a group of 10 students. It is clear from the

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picture 5 that we have made, although very small (0.65), but a significant shift towards the desired results.

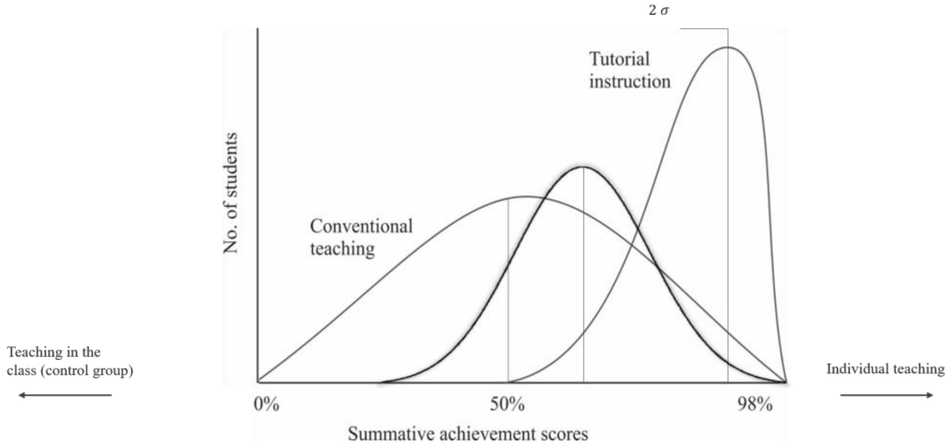

Figure 6: Efficiency of pilot model of individualized ITS

CONCLUSION

One of the problems of contemporary society is that the educational system must be able to train youths for life, equipping them with not only knowledge and different skills, but in particular teaching them how to confront everyday challenges and problems, and in turn, how to resolve them. Young people have to develop their cognitive competences, but also cooperativeness and social competences, since these are one of the basic conditions for life-long learning and improved employability. In order to achieve this, flexible forms of learning have to be implemented (Aberšek, 2018). The educational process must be more closely related to the individual's needs, their personal development and the cultural environment in which they live. The complexity of all the things affecting the youth of today (the environment, technology, a large amount of immediately accessible information, the possibility of direct communication with the entire world, newest insights from the fields of cognitive and neuroscience, AI, etc.) requires a well thought out and quicker response on behalf of the creators of school policies than it did in the past, mainly because the social environment in which we live (society, technology, etc.) is changing very rapidly, and because the school of today must prepare students for occupations and social environments, which at this moment don't even exist yet. All these changes in the social environment in turn require different, innovative ways of learning and teaching, to which the entire school system must be able to adapt on a paradigmatic level. In this contribution, we have shown one of the potential complex development opportunities, which will require a huge amount of investment to be fully operational.

Results show progress in comparison to classic teaching. Nevertheless, they are still behind the suggested 0.84 -1.05 sigma and are oscillating now around 0.65 sigma.

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Primary School Students' Functional Literacy in Digital Learning Environments - How to Teach

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Abstract

This study describes a research focused on primary teachers' evaluation of I(nternett) R(eciprocal) T(eaching) as a suitable reading/studying strategy for reading on World Wide Web in the frame of functional literacy competence in digital learning environments - one of basic competences in the structure of natural science literacy of research and comprehension competence. With the term, primary teachers, we mean teachers of first and second three grades (trianium) of compulsory school. A phenomenological research method, an interpretative research paradigm, was used, to get the insight into the teachers' personal perspective and interpretation of their experiences while implementing IRT in students age 6 - 8 and 9 – 11. The results showed that IRT is a suitable didactic approach for developing students' functional literacy in digital learning environments for students of second triennium (age 9 – 11) and that, when using it for students of the first triennium of primary school, it needs some adaptations.

Keywords

Primary students - generation Alpha, functional literacy, digital learning environment, scaffolding strategy.

INTRODUCTION

Previous research on students' competence for reading in the process of learning in digital environments points in two directions: Early studies assumed that "digital natives" already enter school digital competent (Prensky, 2001). Later studies (Cornu, 2011; Sadler, 2011; DeStefano&LeFevre, 2007; Kordigel Aberšek et. al., 2015), which measured the relationship between learning in digital environments and learning outcomes, noticed a remarkable difference between students with relatively high level of digital pre-knowledge and those with weak digital pre-knowledge. Meanwhile the generation changed. The primary grades students do not belong to the millennium generation, or, as they were called: Generation Y, anymore. They belong to Generation Alpha – they are children of Millennials and younger siblings of Generation Z. Generation Alpha is a generation born in (or after) 2010, the year the iPad was launched, and Instagram was created. Not only were their parents constant users of smart devices themselves (unlike the parents of Millennials, who struggled with new technologies), they used smart devices as pacifiers, entertainers, and educators, as screens were put in front of their children at the youngest possible age (McCrindle & Fell, 2020a). The consequence of a different digital environment in early

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childhood could lead to significantly higher level of (at least basic) digital competence at the age when children – Generation Alpha – enter school, which would enable them to successfully participate in digital learning environments (McCrindle & Fell, 2020b).

This optimistic speculation usually overlooks the latest data, derived from research, which focused on learning outcomes, when students learned in digital environments - from screen in comparison with learning outcomes, when they learned from printed text. A meta-study with the title: **Don't throw your printed books: A meta-analysis on the effects of on reading comprehension** summarizes the above mentioned data. The authors P. Delgado, C. Vargas, R. Ackerman, L. Salmerón (2018) examined research published between years 2000 and 2017, focused on comparing the reading of comparable texts on paper and on digital devices. Their analysis covered studies with (altogether) 171,055 participants, and reveals three significant moderators: text genre, time frame and the year in which the research was performed (and the results published).

Results concerning reading comprehension with respect to the text genre show that the reading outcomes of students who read from digital-based devices were lower than the reading outcomes of students who read from paper materials. Results concerning reading comprehension in relation to the time frame show, that all studies examined in the meta-analysis demonstrated an advantage of paper-based reading over digital text reading, but the impact of media on comprehension was significantly lower when students read the text without a time limit. When reading under time pressure conditions, the impact of media was significantly higher. Digital reading seem to be a less favourable learning environment when reading/learning in a time-limited situation. Results concerning the publication year in which the research was performed, contrary to what was expected, showed that the negative effect of digital learning does not show a decreasing curve in time. Quite the opposite: the ability to search, navigate, and read critically in digital environments obviously does not develop only through the use of smart phones for playing and digital socializing. "If simply being exposed to digital technologies were enough to gain this skill, then we would expect an increasing advantage of digital reading, or at least decreasing screen inferiority over the years." (Delgado et al., 2018, p. 27) However, contrary to this assumption, the results of the meta-study indicate that the screen inferiority effect has increased over the past 18 years, and that there were no differences in media effects with respect to age groups.

At this point we could ask, what to do. Shall we extend Delgado's taught **"don't throw your printed books away"** and simply say instead of that: **let us throw computers away**? Or at least: remove computers, tablets and smartphones from the educational process?

Well this will not do. Of course not. Computers and other digital devices are more and more present in our lives and with this presence, they are important carriers of information and knowledge. They are simple not to be taught away also from the educational process from the early ages of educational system. This is consistent with the ***COST E-READ Stavanger Declaration Concerning the Future of Reading***, which is the result of researching the impact of digitization on reading practices of a group of almost 200 scholars and scientists of reading, publishing, and literacy from across Europe. The Stavanger declaration summarizes the following key findings:

- Digital text offers excellent opportunities to tailor text presentation to an individual's preferences and needs. Benefits for comprehension and motivation

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have been demonstrated where the digital reading environment was carefully designed with the reader in mind;

- Contrary to expectations about the behaviour of 'digital natives', such screen inferiority effects compared to paper have increased rather than decreased over time, regardless of age group and of prior experience with digital environments;

On the base of that the Stavanger Declaration has put forward the following recommendations:

- **Students should be taught** strategies they can use to master deep reading and higher-level reading processes on digital devices. In addition, it remains important that schools and school libraries continue to motivate students to read paper books, and to set time apart for it in the curriculum.
- **Teachers and other educators must be made aware** that rapid and indiscriminate swaps of print, paper, and pencils for digital technologies in primary education are not neutral. Unless accompanied by carefully developed digital learning tools and strategies, they may cause a setback in the development of children's reading comprehension and emerging critical thinking skills;

To put it differently, a new reading curriculum in the 21st century school should develop, among other things, both sets of reading competences: competences for reading classic, linear printed texts and those for reading digital texts from screens. Or in other words: functional literacy in digital environments must be taught in schools. It does not develops by itself.

The solution seems very simple: **let us teach students, how to successfully read from screen**, let us teach them, how to read from World Wide Web to find reliable knowledge/information. The solution of this is not as simple as it seems. On contrary. If we have on one side a wide range of reading/scaffolding/ study strategies, which empowers students how to approach the printed text successfully, on the other side there is a limited offer of reading/learning/scaffolding strategies for searching information or acquiring knowledge from World Wide Web. And consistent with that, the didactic knowledge, how to teach students to read successfully on the World Wide Web didn't' reach, or hardy reached the teachers training institutions.

The aim of the study

The aim of the presented case study was

- to select a potential suitable method for developing functional literacy in digital learning environment for students on primary level of compulsory school.
- To teach teachers, how to implement the selected IRT method.
- To implement IRT in primary students' case studies and to collect and analyse their teachers' experiences.

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All this with the purpose to detect if IRT is a suitable reading/studying strategy for reading on World Wide Web in the frame of functional literacy in digital learning environments, one of basic competences in the structure of natural science literacy of research and comprehension competence for students on primary level of compulsory school.

RESEARCH METHODOLOGY

The research background for establishing digital literacy of Generation Alpha (compared to the previous generation - Generation Z) was the study conducted in Slovenia in spring 2021 (Legvart, Kordigel Aberšek, Kerneža, 2021). This study examined primary school teachers' assessment of their students' new natural science literacies of online research and comprehension competence and in the frame of that: functional literacy in digital learning environments. A study revealed that generation Alphas' prerequisites for digital literacy skills only slightly differ from those of generation Z. A consequence of this fact is an urgent need of didactic intervention in form of implementing functional literacy in digital learning environments into compulsory school curriculum.

Sample selection

A sample were ongoing teachers, students of the Faculty of education, University of Maribor, Slovenia, who participated a course Didactics of Slovene language and literature 2 in the 4th year of study programme Elementary education. One of the central aims of course curriculum is to empower students to teach literacy – in traditional and digital learning environments. 67 participants of the course were instructed, what is IRT, how to teach IRT, how to evaluate the study outcome and than to implement the method in an own case study. This part of the study was obligatory for all course participants. Next step was for students optional: they were invited to participate in a qualitative study with the aim to evaluate the implementation of IRT for primary students. 42 students decided to participate.

Ethical procedures

Participants' approval was obtained in research in line with the voluntary principle. All participants were informed about the purpose of the research. At all stages, the identities of the participants were kept, and the codes, given to the participants were used when quoting raw data texts.

Instrument and procedures

In a sequence of 6 hours course, students were gradually and systematically trained and educated to use I(nternet) R(eciprocal) T(eaching) in the classroom. To learn the strategy of thinking aloud, the general method of reciprocal learning was introduced. To teach the students to use the method of reciprocal learning, we used the same method – the method of reciprocal learning. The text in question was chosen from the field of natural sciences.

When the students were well acquainted with the method of reciprocal learning and knew how to use it sovereignly, we introduced them to the method of IRT. We developed

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segments that addressed prior knowledge needed, i.e., basic computer skills, web search skills, and navigation skills. Above all students needed additional explanations and representations of more complex search strategies (quotation marks, paraphrases, synonyms, Boolean operators) and the meaning of URLs (.si, .com, .net, etc.). It also turned out that they had some problems with the ability to formulate important questions, find, evaluate, and summarize information online.

When we were convinced that the students had all the basic knowledge, the steps of the method of IRT were presented to them frontally (demonstration, think aloud strategy), which we first put into practice and then explained theoretically. In this way, they put themselves in in the role of a child who is to be trained to search for information online. After each step, we also went through the corresponding checklist of the TICA scale. The students worked in small groups the whole time, using thinking aloud method. In the first step of the strategy (teacher's instructions), the topic of the search was partially open. Students worked in groups for the answer to the questions which arose while reading the text from the beginning of training (method of reciprocal learning). In the second step (frontal modelling of online reading strategy), we determined the objective of the 4th or 5th grade curriculum. This required them to ask the right questions, locate information, critically evaluate it, and summarize what they learned; they discussed the solutions. When problems arose, they showed each other the steps and strategies that led them to the correct information. The final step of the reciprocal online learning strategy (research) focused on independently searching for information on the internet, where students tested themselves in finding new, original solutions for successfully using the internet for learning at all levels of method of internet reciprocal teaching.

After the evaluation of their theoretical knowledge about IRT, students were instructed to implement IRT for developing functional literacy in WWW learning environment with the child of their choice (recommended age between 6 and 11). This way they created 67 case studies for implementation of IRT.

Next step of our research was to collect the experiences and to make conclusions, so we invited students to write an essay about the sequence of events while implementing IRT, their opinions, their taught, insights, interpretations of events and about results, they had reached. 42 students (from 67, who participated the course and performed the case study) decided to participate in the evaluation process, so they declared the preparedness to write a short essay according to the prepared guidelines with the aim to get answers to following questions:

- Is IRT a suitable didactic approach for empowering primary students with computer basics?
- Is IRT a suitable method for empowering primary students for locating information by using a search engine and for searching for a proper website?
- Is IRT a suitable didactic approach for empowering primary students for critical evaluation of the site they had found and the information on that site?
- Is IRT a suitable didactic approach for empowering primary students for navigation on a website?

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Page Setup

For data analysis, a phenomenological method of qualitative research was selected. Phenomenology is a form of qualitative research that focuses on the study of what an individual has lived experiences within the world (Neubauer, Witkop, & Varpio, 2019). As a research methodology, phenomenology is uniquely positioned to help us learn from the experiences of others. Phenomenological research involves the detailed study of a subject to discover information or to achieve a new understanding of the subject. Such detailed study often requires understanding the experiences of others so that we can glean new insights about a particular phenomenon. To be precise: for the evaluation of essays we chose the interpretive phenomenological analysis (IPA), a blended approach that aims to provide detailed examination of the lived experience of a phenomenon through participant's personal experiences and personal perception of objects and events.

In the first step of data evaluation process, we entered the responses into the data collection template. Responses were entered based on the data question identifier. In order to analyse the data, we have collected, and to guaranty the anonymity of respondents, we coded responses based on themes. In the second step, we formed subcategories. In the third step of data analysis, we summarized the results of analysis by identifying the patterns and supported them by adding quotes from respondents.

RESULTS

The results of analysis of essays aloud us to identify following insights in suitability of IRT for teaching functional literacy in digital learning environment for primary students:

1. *IRT is a suitable didactic approach for empowering primary students with computer basics, which are a prerequisite for functional literacy in digital learning environment.*

The items for defining computer basics were adopted form TICA Checklist, developed in Teaching Internet Comprehension Skills to Adolescents project, which was focused on studying skills, essential to online reading comprehension (Leu et al., 2008). The adaptation, used for our research, reduced the number of items. After the consideration, what can we expect from primary students and which are the essential prerequisites for searching, navigating and evaluating the www contents, we decided for following items: turn a computer on/off, use the mouse/track pad, open programs and files using icons and/or the Start Menu, create/open a new folder/file. We added also launching a word processor, opening a word processing file, typing a short entry in a word processing file, copying/cutting/pasting text, naming a word processing file and saving it, opening a new window and opening a new tab. In their essays teachers expressed the opinion that the obstacles for the implementing od IRT in the first triennium of compulsory school is the absence of basic literacy. In Slovene school literacy acquisition starts in the first grade but students have – according to curriculum guidelines – an individual literacy acquisition plan and have 3 years to reach a functional literacy level – a level where they can use reading and writing for learning. Nevertheless teachers expressed the opinion, this is not an argument to push computer basics in the process of functional literacy in digital learning environment in curricula for later years (2nd triennium). With some adaptations IRT can be implemented before/or parallel to basic literacy process.

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The second conclusion, we can derive from students' essays regarding computer basics, is the circumstance, we have to divide students in at least two groups. Those, who come from stimulative digital environments, and those, who come from non-sitmulative digital environments. A stimulative digital environment encourages computer/tablets/smart phone use for different aims: for work, for searching information, also for one, you need in everyday life, for communication, for reading for pleasure. In such environment (parents or older siblings) a child sees the possibilities and develops the curiosity, which buttons to press to reach the same goal. On the other hand essays show, only playing games and/or viewing cartoons does no contribute much to computer basics.

My 1st grade student couldn't read yet. Nevertheless, we (he and me together!) decided to implement IRT strategy – we searched for pictures with animals (related to his science curriculum). Before our first session, the boy had almost no basic computer literacy skills: he could only turn on the computer and find cartoons on You tube. In our meetings we managed to learn some of the of TICA computer basic skills: to create/open a new folder/file, to type a short entry in a word processing file (I did it, but he told me, what to write!), to copy a picture, to past, to name a word processing file and to save it. My judgement: the acquisition of functional literacy in digital environments is a long process – and to be successful, children (as my child) need guidance. IRT is a suitable path for this process. (23/1/35)

My experience with IRT was extremely positive. A boy was excited about, what he can do with the computer and what interesting information he can get there. The only difficulty, I faced by implementing IRT curriculum, was his attention span. Here and then, we had to implement some minutes with computer games, and afterwards we could continue with acquiring basic computer skills. (37/1/42)

My boy (2nd grade) was able to perform all the competences included in TICA basic computer skills, with exception of copying and pasting the text. He told me, his dad taught him all that. He enjoyed learning to surf in the www and to find information of his interest. He most enjoyed, when "we caught the guy, who was lying to us". (43/1/51)

2. *IRT is a suitable method for empowering primary students for locating information by using a search engine and for searching for a proper website.*

In adapting IRT for primary students, we reduced the number of structural elements in the frame of the competence: locating information by using a search engine and finding the proper/useful web site according to a searching aim.

Primary students'skills cheque list for monitoring his competence to locate information by using a search engine and for searching for a proper website, expected from students to be

- able to locate at least one search engine and to
- use several of the following general search engine strategies during key word entry: topic and focus, single and multiple key words entry, phrases for key word entry.

In cases IRT was implemented in students age between 9 and 11, teachers reported positive experience in introducing this phase of IRT. In cases, students were children between 6 and 8 (first triennium), he majority of essays reported some difficulties in the process of implementing this second phase of IRT. Teachers were rather disappointed, they suggested, the second phase training should wait for a year or two. But also other opinions were expressed. Teachers reported that with some adaptations also the search engine use

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could be introduced to the students, who lack some computer basic skills and basic literacy. Question could be discussed, suggestion of key words could be collected and tried, results could be monitored (seen or read) together.

My 2nd grade student (7 years) obviously came from digital simulative environment. She had all the skills from TICA basic literacy checklist, she could use the majority of icons. But when we started to search for a www page, she soon lost the attention. Every new message, which arrived, disturbed her concentration and she wanted immediately to cheque, what was new. (12/2/23)

My girl (5th grade) had already acquired the basic computer skills. So we could begin the process of searching a proper web site, asking a proper question, entering promising key words, predicting, what we are going to find there, skimming the text to decide, if we are on the right place and, if not, to repeat the procedure. (/23/2/27)

My 1st grade student possessed only some computer basic skills (turn on/off the engine, to navigate the mouse and to find some known sites). And of course he couldn't read and write. Nevertheless I decided to work with him to provide him with the experinace of sucssesful surching and finding a desired information. We didcussed, what question we can ask, which key words we should enter and than we together looked at the pictures and finally decided if "we" could together read this site. After my reading aloud, we discussed, if we are content with the result. So my experience is: IRT method can be, with some methodical adjustments, applied also in the first trianium of primary education. (39/2/45)

3. *IRT is a suitable didactic approach for empowering primary students for critical evaluation of the site, they had found, and the information on that site.*

Teachers were instructed to evaluate students' competence for reading search engine results effectively to determine the most useful resource for their task. The information on the site should be monitored from two points of view: according to content in the narrow meaning of the word and according to agenda.

Focusing on the first perspective student should immediately after entering the site skim the main results before reading site more narrowly. He should read summaries carefully and evaluate the content according to the usefulness for his searching aim.

Focusing on the second perspective it is important that students/readers are competent to identify, evaluate, and recognize that many websites have an agenda. It is important to use strategies such as: observing which search results page are sponsored, which sites are containing commercially placed links, and which are not. It is also important to identify specific markers, that may affect reliability, such as: the author is an authoritative source (e.g., professor, scientist, institute, etc.) in contrast: the site does not give the information about the author. Finally it is important to consider, if the information make sense? Do the images or videos appear to be altered? Does the author include links to other reliable websites? Does the website contain numerous linguistic mistakes?

All the essays report students had difficulties in using strategies for evaluating the content and agenda of the site. But also the majority of them (with the exception of those teachers, who expressed the opinion, it would be better to wait some years to implement the his phase of IRT and wait for "development" of computer basic skills) expressed the opinion that evaluating of content, found on www, is extremely important – also in very early age. Consequently the acquisition of competence to recognize www trash, fake news,

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sites with agenda … can not begin soon enough. Teachers' recognized the strategies, IRT is equipping students with, are easy to use and are a useful tool for evaluate www content.

My 4th grade student had great problems at recognizing the fact that he should not be satisfied with the first www page, related to the topic. Although we "agreed" that the first page might not be the right one, he did not want to skim it and decide to try on the next one. He could not resist reading the whole page in the hope, he might find the information, he was looking for. (17/3/28))

The child's (9 years) didn't reach the level of basic reading fluency. He used a great amount of reading energy for decoding the meaning of words, he was reading. Consequently, he didn't have enough cognitive energy for making the decision, if the information is reliable, if the author and the web page are worth trusting. (29/3/40)

My student (9 years) evaluated himself as competent according TICA basic computer skills. So we could immediately begin with developing the competence for reliable web page and information, he needed according to biology curriculum aim. After the third session, he learned to use the criteria for dividing commercial site from informative one. (33/3/49)

I have a positive experience with IRT. I was working with the boy in 5th grade. He was, as he said, already "digitally literate". He frequently played computer games and searched for interesting video contents. With the help of TICA checklist nr. 2. and 3., we quickly found out, he has problems with evaluating if the information is worth trusting. We had learned what mean the extensions .org; .si, .com. We learned, how to pay attention on the language and linguistic mistakes, how to identify, if the site is a commercial one. Where to look to decide, if the author an authoritative source (e.g., professor, scientist, librarian, etc.). To think, if the information makes sense, to cheque if the author includes links to other reliable websites and if the images or videos appear to be altered? (36/3/51)

4. *IRT is a suitable didactic approach for empowering primary students for navigation on a website*

Managing the navigation on the website is a specific skill, which has to be learned. This can happen spontaneously, by accidently clicking here and there and recognizing the click had no efficient result, or it can happen through a guided (didactic) activity. The second path is shorter and more efficient. IRT is using the 'thinking aloud' method combined with demonstration method to make "visible" the self regulated recursive thinking circle (Coiro, Dobler, 2007), which should follow/accompany every click with the mouse, every move of the finger on screen. In this self regulated recursive thinking circle a computer/tablet/ smart phone user predicts information behind a link to make efficient choices about where information is located. A self regulated recursive thinking circle consists of four metacognitive strategies*: plan, prediction, observation and evaluation.* Acording to Coiro, Dobler (2007), who first noticed and described the self regulated recursive thinking circle, in the phase *plan*, a reader initiates the thinking process with the questions: *What do I want to find out?, Where should I start?, What should I do first?* In the second phase, called *predicting*, the reader forms an action plan, accompanied with questions *I think this connection will bring me … If I click this, I hope, I will arrive … I hope, I will find...* In the phase *observation* the reader is monitoring the result: *Is this, what I wanted?, Did I want to get here? Shall I read the page or shall I look further?* The last station of the self regulated recursive thinking circle is the *evaluation: »Had this choice brought me closer to my goal or should I start new? Is this I right place, where I will find, what I am looking for? Shell I move*

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on? Shell I open this embedded link or this will move me even more away from what I am looking for? Shall I start the whole process by inserting new/different key words?

The self-regulated recursive thinking process is an essential metacognitive part of functional literacy in digital learning environment. The skilled readers are performing it spontaneously by using the structural knowledge of a web page to help locate information, including the use of directories. Opposite to that unskilled readers are accidently clicking from node to node, from chunk to chink, from site to site, which makes their learning process in digital learning environment extremely inefficient. That is, why the fact, that the majority of essays reported about positive experience with 'thinking aloud' method in the process of website navigation skill is so important.

I think the most important thing in implementing IRT is to use the thinking aloud method. This way the child can follow his steps in the process of searching for a site and above all - to navigate on the site. Thinking aloud is equally important, when a child is "moving the mouse". This way a teacher can monitor his taughts and his strategies and correct them immediately – before the student gets lost in the www universe. (12/4/16)

In my experience the IRT method can not be implemented without being accompanied with method of demonstration and the thinking aloud method. This is important in all three phases; when the teacher demonstrates, what to do, when students, gathered in groups with different level of functional literacy in digital learning environment work together and demonstrate each other their searching and evaluation strategies and also, when students are using the IRT for their own research. In this last phase, a teacher or a peer can intervene, when something seem to go wring and show a right path. (31/4/42)

DISCUSSION AND CONCLUSION

As a final conclusion we could summarize the experiences with implementing IRT in to the primary students curriculum: IRT is a suitable didactic approach for empowering primary students with functional literacy competence for reading/learning in digital learning environment. For the age group 6 – 8 it needs some didactical adaptations.

I think it is good that IRT equips the teacher with cheque lists, so he can, before beginning the intervention judge the level of students' basic computer literacy and his ability to navigate in www. This cheque lists are a better predictor of students digital competence than the information, how many years is a child using the computer/tablet/smart phone. Only playing games or/and monitoring videos does not contribute much even to the basic computer literacy, not to mention more advances computer skills. The same cheque lists are a good tool for formative assessment of students' progress. (17/4/26)

IRT is a good approach to develop students' competence for learning from www. A child learns, how to ask proper questions, critical evaluate of information, he gets from computer after entering the key words, derived from the question. He also learns communicating about new (content) knowledge. And – above all – he can communicate about his new knowledge, connected with his functional literacy in digital learning environment. (19/3/28)

There is no need to wait with the implementation of the competences: searching for the proper web site, evaluating the content on the site and navigation on the web site after the student would acquire all the structural elements from the Computer basic list. The

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majority of teachers expressed the opinion that this process cannot begin soon enough. With cheque lists, IRT is equipping the teacher, there is relatively easy to set the goals, the teacher can monitor students' progress, and with some adaptation, they can be a useful tool for child's assessment of his own progress in acquiring functional literacy in digital learning environment.

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Virtual Robotics in Education at Elementary School

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Abstract

Our study focuses on the use of educational robotics in teaching in elementary schools. The use of educational robotics in the educational areas of STEM has great potential and enables greater interconnection of individual educational subjects. At present, various sets of educational robotics are used in schools, from robotic models to structural robotic kits. In our study, we present alternatives to educational robotics that can be used in distance online learning that took place during the global Covid-19 pandemic. The study presents robot simulators that can be controlled and programmed in an online environment. We focus on robot simulators, which are free, available online and allow you to program several different robotic platforms and real robotic models. In the research part, we focus on teaching robot programming in online simulators and how it is perceived by elementary school students. Our study will enable greater use of educational robotics in other subjects, especially in the field of STEM.

Keywords

Robot, Virtual Robot, Simulator, Programming, Elementary School.

INTRODUCTION

Interest in the use of educational robots in teaching in schools is still growing. In the Czech Republic, after the approval of the new concept of teaching informatics at elementary schools (MŠMT, 2021), the interest in educational robots has increased even more. Many schools and teachers incorporate robotic building blocks into their teaching and often address what teaching methods and forms to use. In this study, we also focus on the educational area of STEM (Coufal et al., 2021). Individual science subjects are often challenging and sometimes rejected by students (Garcia-Piqueras et al., 2021). In the case of connecting subjects of natural sciences and technology in the field of STEM with the use of educational robots, teaching is very interesting and attractive for students (Garcia-Piqueras et al., 2021),(Hubálovský 2016),(Voborník, 2019),(Khoshaim, 2020).

Perspectives on STEM education (science, technology, engineering, and mathematics) are different, but they agree that STEM education is considered a curriculum and pedagogy (Núv, 2021), (Margot et al., 2019). STEM is effective in learning students (Margot et al., 2019). and it is not just about knowledge of individual topics, but it develops the key competencies of students' skills (Margot et al., 2019), (Wahono et al., 2020), (Sorby et al., 2018), (Saw, 2019), (Siregar et al., 2019). The educational field of STEM and sometimes STEAM (science, technology, engineering, arts, and mathematics) is gradually expanding

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into educational curricula in national education systems (Garcia-Piqueras et al., 2021), (Margot et al., 2019), (Bybee, 2010), (Yata et al., 2020), (Hubálovská, Hubálovský, 2016), (Li et al., 2020).

Educational robotics is a powerful and flexible educational tool with a high motivating factor (Coufal et al., 2021). Educational robotics can be divided according to the type of construction, according to the use in teaching, or according to other criteria (Coufal et al., 2021), (Voborník, Němec, 2019), in our study, we focus on structural robotic kits (Němec, Voborník 2017). The use of structural robotic kits is ideal for teaching in the field of STEM and for integration into project teaching. Structural robotic kits can be divided according to the used material of structural parts, their use, or according to the programming language (Hubálovský, 2013), (Voborník, 2020).

At the time of the worldwide Covid-19 pandemic, there was a problem with full-time teaching using educational robotics (Jahodová-Berková, Němec, 2020), (Němec et al., 2020). About long-term distance learning in the online environment, it was necessary to look for some teaching alternatives using educational robotics. There are more possibilities for how to implement teaching with educational robotics, and we present them in an overview:

- **Students work with a borrowed set of robotic construction kits**. Each student works at home with a borrowed school set, which they use in online programming teaching. The advantage of this form of teaching is students' practical work with the kit the development of their motor, construction, and technical skills. The disadvantage is the cost of many structural robotic kits for lending to all students. This form of teaching is suitable for students and is popular.
- **Students work with a robot model in a remote laboratory.** Students have the opportunity to work remotely with a real robot model, to which they connect via an online interface. Students can control, program, and manage the robot and watch everything live via a camera. This solution is ideal for the individual work of the student. The advantage is access and working with a real robot model at any time. Disadvantages include limiting the number of active users and maintaining the robotic lab, such as charging the robot's batteries.
- **Students work in a simulator with a virtual robot model.** The simulator allows you to replace a real robot model with its 2D or 3D form. This virtual robot model can be controlled, controlled, and programmed mostly just like a real robot. In most tools it is possible to use built robot models, some tools allow you to build a robot model or modify its configuration. In addition to the assembled design of the robot model, the location and connection of sensors and motors are important. The advantage of using these simulators is their ease of use and involvement in teaching even in an online environment. In addition, students can share their created controls with classmates. The use of simulators eliminates the time-consuming maintenance of educational robots by the teacher. Some teachers use simulators in regular classes instead of real robots. We perceive that it is important for students to work with real robots and therefore it is appropriate to use simulators in regular teaching as a supplement. Breakdown by program version:
    - **The desktop version of programs.** To work in a robotic simulator, students use a desktop version of the program, which they have installed on their device. The great advantage of these programs is their

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cooperation with the programming environment in which students program real robots in regular teaching. It is also a quality simulator with a 3D graphical environment for simulating robot movements. Disadvantages include the cost of licensing these programs. Representatives include Virtual Robotic Toolkit, RobotC, and Miranda.

- **Online versions of programs.** Students work with online tools that are available and executable in a web browser. No programs or add-ons are required to use these programs. These are usually freely available programs that are free to users. Another advantage is working in the program without registering. In some tools, it is useful to have your user account because all programs and projects are stored in it. The advantage is the ability to program real robots in the same environment or run the created programs in the simulator. Representatives include Open Robert Lab, MakeCode, and VEXcode VR.

METHODOLOGY

At the time of closing the schools for full-time teaching, we were looking for a quick solution for the involvement of educational robotics in online teaching. After assessing all the pros and cons, we chose a solution using the online versions of Open Robert Lab, Microsoft MakeCode, and VEXcode VR. In teaching robotic building blocks programming and other subjects, we focused on solving the tasks that each environment enables and offers. To a large extent, the tasks are similar to the tasks we solve with students in regular full-time teaching. In the following part, we present the used online tools for the control and programming of educational robots in various simulators.

Open Roberta Lab

It is an online tool for programming educational robots for various platforms and various manufacturers. The programming is based on the block programming language NEPO, which allows programming through visual blocks and text code. In the Open Robert Lab environment, it is possible to program robots from the Lego WeDo kit, Lego Mindstorms NXT, and EV3, robots NEO, BOB3, mBot, Edison, as well as Arduino and Micro: bit microcomputers, and many others. For the selected type of robot or robotic kit, it is advisable to configure the robot, setting the ports for connecting sensors and motors, and setting the wheel size and their distances. After the initial configuration, the robot can be programmed using color-coded blocks. Programming is similar to programming in the Scratch environment, which is most familiar to students and they have experience with it. To load the created control program into a real robot, it is necessary to connect the robot with the program. If we want to use only the simulator in teaching, just release it in the left part of the window under the SIM button. In the simulator environment, we see a scene that can contain different colored shapes or objects, in Figure 1 we see, for example, black lines. In the simulator, we can change scenes by selecting from the scene menu, or we can create our scenes for teaching purposes, such as a maze of black lines. In addition to scene editing, we can see the display of data from robot sensors in the simulator, which we will use when creating programs for autonomous robot behavior. Figure 1 shows an open window of a simulator with a robot, in the left part is created a block program for the robot.

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The Robert Lab's Open environment is an ideal tool for creating students' learning tasks. Of the existing scenes, scenes for driving the robot along the black line, detecting and avoiding objects, and recognizing colors are suitable for teaching. In the environment of this tool, there is a quality help and a gallery of projects of other users, which can serve as inspiration for students or teachers. In the Robert Lab Open environment, it is easy to change the environment language or the selected robotic platform.

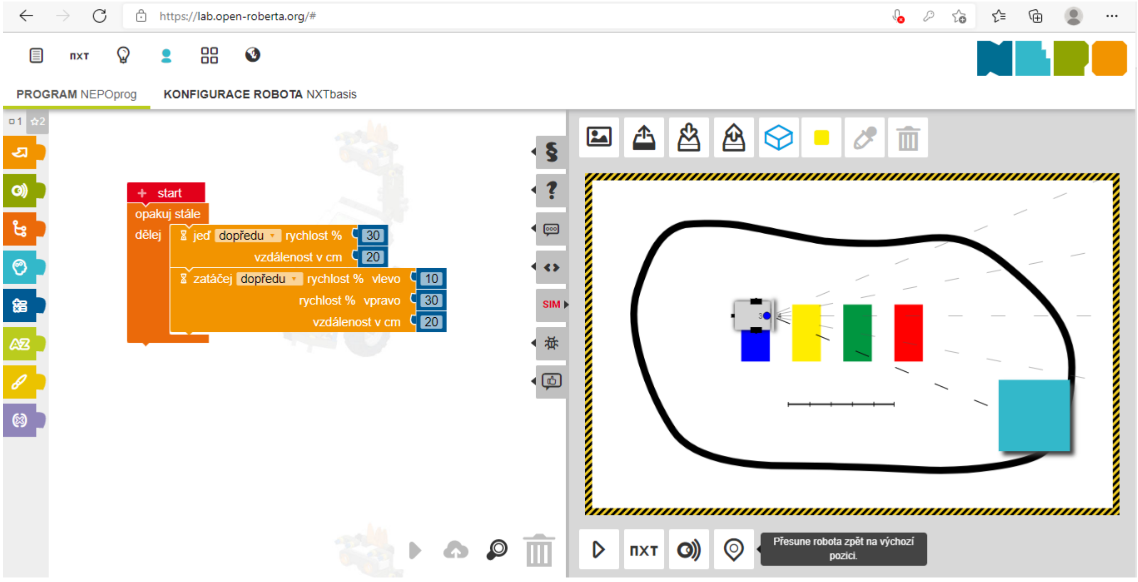

Figure 20: Open Roberta Lab: Environment for programming real robots with an open simulator window.

Microsoft MakeCode

Microsoft MakeCode's online environment allows you to program multiple platforms. For our study, we use the possibility of programming a construction robotic kit Lego Mindstorms EV3 or a microcomputer Micro: bit. It is also possible to program popular Minecraft or Arcade games in the MakeCode environment. In the MakeCode tool, we can program real robots or test programs in a simple simulator of robot I / O elements. The simulator has limited functions and is for guidance only. It is not a full-fledged motion simulator of a robotic model. The tool allows block programming and text programming in JavaScript or popular Python. Using the switch, which is used to switch between block and text programming, it is easy to navigate and learn new code. The MakeCode environment offers a large number of tutorials and educational videos that can be used in teaching or self-study. It is possible to insert other program blocks into the environment, which are intended for control and programming of the extension of the selected platform. If you purchase components, motors, and sensors for building robot models for the Micro: bit microcomputer, all you have to do is add the selected extension and the individual blocks will be added to the programming environment. This is very easy and allows you to control and program a wide range of extensions in one environment. The advantage of the environment is the choice of language, storage, and sharing of created programs, and environment settings. Figure 2 shows the MakeCode environment, in the left part there is a Micro: bit microcomputer simulator, in the middle there is a column of individual sections of programming blocks, on the right, there is a space for creating control programs. At the top center is a visible switch between blocks and Python.

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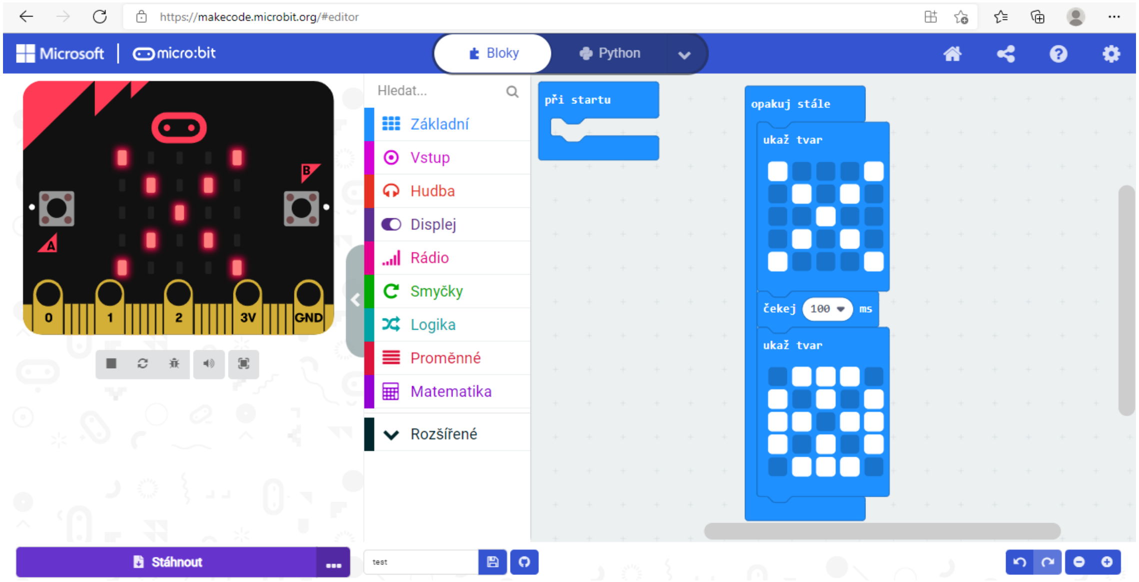

Figure 21: Microsoft MakeCode: Micro: bit microcomputer programming example

VEXcode VR

The VEXcode VR online environment is designed for programming virtual robots through block programming, the same as Scratch. The individual command blocks are color-coded. The VEXcode VR environment can be used in many different languages, which makes it a universal environment. In addition to block programming, we can also program a virtual robot in text in Python. In the environment we can find educational instructions and videos, this is evident in Figure 3. For teaching in this environment, teaching instructions are created, as well as teaching lessons that are suitable for teaching pupils and students. An important part is a simulator, which is very sophisticated and in addition to the 2D model of the robot also contains a 3D model of the robot. In the simulator, we see information displayed from the robot's sensors, which can be used to debug the program. We can adjust the camera view of the virtual robot. Various tasks are prepared in the simulator, for which a methodology and teaching materials are created. Some scenes are created dynamically, so they come in several forms, such as a dynamic maze with walls. For example, the task "Cleaning the coral reef" has an environmental overlap, and students will also receive a generated certificate with their results in the cleaned waste. The offer of individual tasks is relatively wide, but you cannot insert your own tasks, which is limiting. Working in an environment it is easy for pupils and students to control and program a virtual robot.

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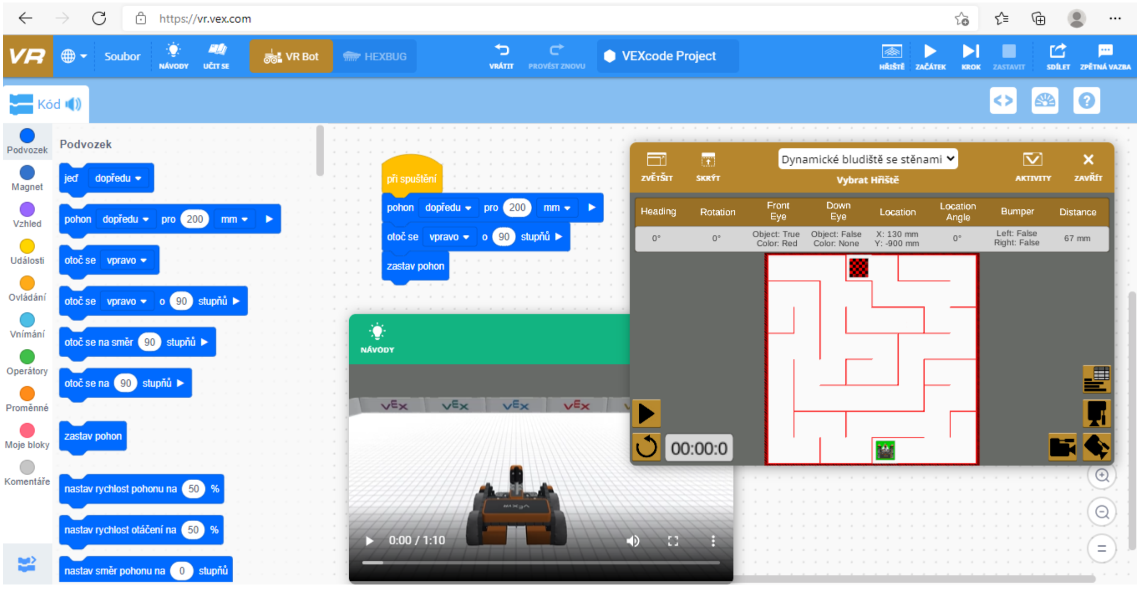

Figure 22: VEXcode VR: demonstration of programming a virtual robot for driving in a maze

RESEARCH

The research was focused on the field of virtual educational robotics, and how it is perceived by secondary school students. The research was carried out in the form of a questionnaire, which was presented to students in printed or electronic versions in the online form. The compiled questionnaire contained questions of various types. Some questions of the questionnaire were open-ended, and some questions used the Likert scale to select an answer.

Research objectives

The main goal of our research survey carried out in the form of a questionnaire survey is to obtain students' views of virtual educational robotics. A partial research goal is to compare real and virtual educational robots and their programming in teaching from the perspective of elementary school students. Another partial goal of the research is to compare the above-mentioned environments for programming robots in an online environment with an implemented simulator.

Research sample and implementation of research

The research survey included a sample of students in the second stage of elementary schools, where the teaching of educational robot programming took place even during distance learning. The group of students consisted of boys and girls from different classes in the second grade of elementary school. It was a group of students from several elementary schools in the Czech Republic. The total number of participants in the questionnaire survey was 26 students, of which 17 were boys and 9 were girls. The questionnaire survey was conducted after the end of teaching programming with the use of educational robots in the online environment. The teaching of programming in schools took place with the same tools that can be used in a common browser and on different devices. When solving the data collection in the questionnaire survey, a larger target group of students was addressed, but

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the return on completely completed questionnaires was low. Therefore, evaluate the obtained data, which we present in the next chapter, with this information.

RESULTS

The first part of the questionnaire consisted of questions using the Likert scale to select ratings. The questions focused on students' perception of working with real robots and virtual robots and their use in teaching. From Figure 4 we see that most students like to work with real robots, this is almost 90% of the answers. In Figure 5, which focuses on virtual robots, there is a positive attitude towards robots in only over 70% of the answers, at the same time we find dissenting answers.

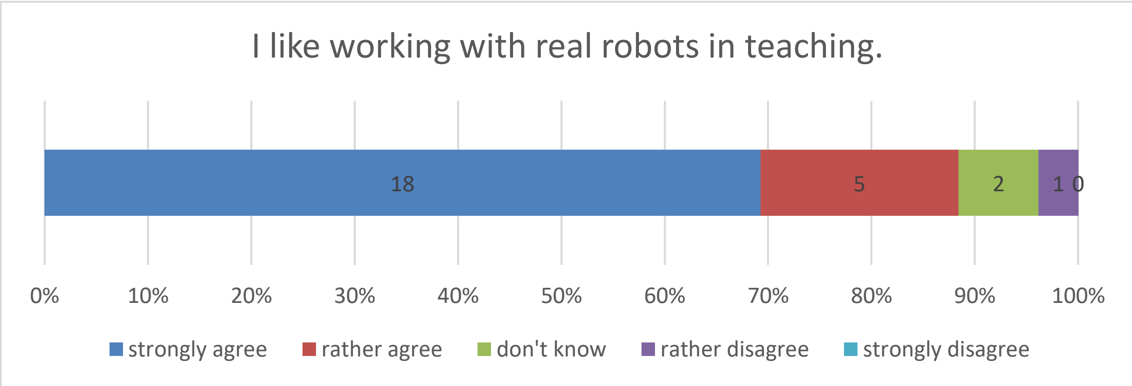

Figure 23: Student's perception of working with real robots

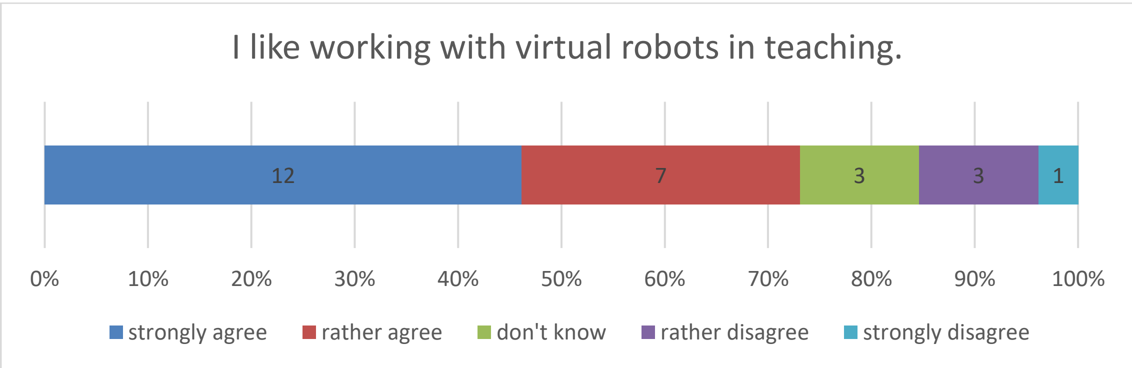

Figure 24: Student's perception of working with virtual robots

Most students prefer to work with real robots rather than virtual robots. We must perceive the context of full-time and distance learning on this issue. Because students prefer to work in groups in full-time lessons than at home through online connections. We must also perceive the social context and the length of distance learning. To a lesser extent, we find students who prefer virtual robots as opposed to real educational robots, as can be seen from the graph in Figure 6.

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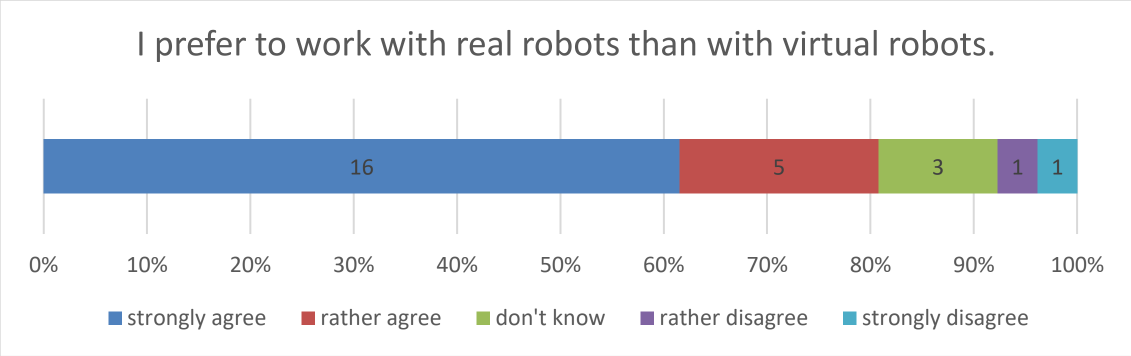

Figure 25: Student perception of real and virtual robots in teaching

The middle part of the questionnaire was focused on programming robots in the online environment and on ways to solve traditional tasks with robots. Some of the questions in the questionnaire used closed-ended answers, evaluations using the Likert scale, and open-ended questions. The majority of students agreed with the positive evaluation of the statement "Virtual robot is programmed better than a real robot", about 90% of the answers. A slightly lower percentage rating was for a positive evaluation of the statement "I can program virtual robots anywhere.". Some questions focused on the complexity and complexity of creating a robot control program. Furthermore, there were questions focused on the perception of the environment for creating programs and their execution in the simulator. For most students, programming virtual robots were easy due to their experience with another programming, in most cases, it is programming in the Scratch environment. The students wanted to continue using virtual robots and simulators in regular classes. After our own experience in the implementation of this study and the integration of virtual robotics into full-time teaching, we agree with the students. Using these environments is beneficial for both teachers and students. It has many aspects, from the greater motivation of students to programming, through the ability to program anywhere to individual teaching of each student in the class.

In the final part of the questionnaires, students evaluated the individual environments in which they programmed robots. In the questionnaire, the question was listed separately for each of the three environments. It was an open-ended question, where students wrote their subjective opinions according to their experience of teaching programming. First question: Write down what you liked and did not like in the Robert Lab Open environment. After summarizing the answers, we present the most common answers in a clear Table 1.

Table 1: Summarized answers of students for the evaluation of the Open Robert Lab environment.

Write down what you liked and did not like in the Open Robert Lab environment.	
+	various robots, line driving, program storage, custom images and scenes, easy programming
-	small robot, old graphics, confusing

For comparison, in Table 2 we present the results for other used environments, namely MakeCode.

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Table 2: Summarized answers of students for the evaluation of the MakeCode environment.

Write down what you liked and did not like in the MakeCode environment.	
+	block programming, switching to text code, tutorials, and videos, extensions for robots
-	there is no robot, no robot that is not running, little space for programming

For comparison, in Table 3 we present the results for other used environments, namely VEXcode VR.

Table 3: Summarized answers of students for the evaluation of the VEXcode VR environment.

Write down what you liked and did not like in the VEXcode VR environment.	
+	nice robot, 3D model of a robot, nice tasks, programming as in Scratch, instructions
-	can't upload to a real robot, complicated tasks

The evaluation of individual environments for programming educational robots reflects the experience of students in programming and solving basic tasks with virtual robots. With more comprehensive and long-term use of the problem-solving environment, student assessment may be different.

Student assessments show that their most popular tool for programming virtual robots is the VEXcode VR environment. Mainly because of the well-known block programming from the Scratch environment and also because of the nice tasks for working with robots.

CONCLUSION

Our study represents a relatively new area of educational robotics programming using various robot simulators. Teaching programming with the use of robot simulators allows you to work with robots outside the classic full-time teaching, which we commonly encounter in schools. Through online robot programming tools, we can program with students remotely and implement teaching online. This solution is optimal at the time of school closure. However, this is not a full replacement for real educational robotics or structural robotic kits, in which the structural part of the robot model is important. Students need to work with a real construction kit for the development of their technical competencies. We can use virtual robots in full-time teaching as a supplement to classical teaching.

In the presented article we describe various possibilities of remote work with educational robots in teaching programming and their strengths and weaknesses. In the research part of the work, we present the findings in a questionnaire survey conducted among secondary school students.

The main goal of the research part of this study was to get students' views of virtual educational robotics. The results of the research show that students perceive virtual robotics positively, they like to use it in full-time teaching, especially for easier programming of robotic models.

A partial goal was to compare the online environment for programming virtual robots. Students perceive the strengths and weaknesses of each environment, which we present in

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the tables. The most attractive environment for the students was the virtual educational robot VEXcode VR, one of the reasons was the sophisticated 3D model of the robot and the shooting of the view camera. We managed to meet the proposed research goals.

In the next period, we want to focus on expanding our study by a larger number of respondents from students and students from secondary schools. The second direction of our study is teachers and their perception of the use of virtual robots in teaching programming. Today, we focus on the development of student competencies through the teaching of educational robot programming. We perceive that the field of educational robotics and its use in teaching is increasingly in demand.

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Learning Styles in Distance Education

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Abstract

The development of distance education is excellent now. Dynamic changes in employees' knowledge, skills, and competencies are placing ever greater demands on education and the tertiary sector. Distance learning makes it possible to study even under conditions where face-to-face teaching is impossible, for example, during the Covid-19 pandemic, often in educational institutions where face-to-face teaching has prevailed. However, many studies show that learning outcomes in distance education are worse than in face-to-face education. It is, therefore, necessary to look for new approaches to improve distance learning. The preparation and development of appropriate study materials can motivate and help students in their studies. Different methods and learning styles suit the students. This paper describes a survey in which learning styles preferences are identified using the VARK questionnaire. The aim was to determine whether preferences for learning styles differ by field of study and which styles students prefer more. Following these results, the distance learning methodology was then adapted. The second part of the research focuses on comparing students' success rates in full-time, synchronous, and asynchronous distance learning. The aim was to determine whether these forms significantly impact learning and success rates. Another objective was to compare how much the synchronous and asynchronous modes of communication in teaching affect learning. From the results, it is clear that asynchronous instruction is the most difficult for students and their learning outcomes are worse than face-to-face and synchronous distance learning.

Keywords

Asynchronous, distance learning, full-time learning, learning style, VARK, questionnaire, synchronous.

INTRODUCTION

Distance education has become an integral part of the educational process. Distance education opportunities are constantly improving thanks to information and communication technologies. The need to provide teaching even in the Covid-19 pandemic has extended distance education to spheres where it has been used only to a small extent, such as primary and secondary schools. The use of distance education in universities and tertiary education has also increased.

Distance online education can be applied in a synchronous or asynchronous method. There is a rather fundamental problem between these forms. In the synchronous form, the learner can directly respond to other participants. The work is usually more efficient and

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often more enjoyable for students and teachers. On the other hand, it requires adapting to a specific teaching time. This tends to be a problem for students who cannot study full-time due to time constraints. For example, they are already working. These students choose distance education so that they can study at any time they decide that does not interfere with their work activities (Okaz, 2015).

Existing evidence shows that students' learning outcomes in distance education are worse than those of face-to-face students. To increase the success rate of distance learners, different teaching methods are tried, and learning materials in other formats are used. In addition to the regular text, practical solved examples, animations, pictures, and videos are used. Despite the variety of teaching materials, the success rate of distance learners does not improve significantly (Fojtik, 2018). In terms of the theory of teaching style preference, it might help to focus on the targeted delivery of different learning materials and working methods (Massa & Mayer, 2006) (Pashler, 2008) (Willingham, 2015). Therefore, the aim was to find out the preferred learning styles among students. The following research questions were set: is there a significant difference in learning style preferences among students? Does the field of study influence the importance of learning styles?

The first hypothesis was set for the research:

H1: Preferred learning styles are the same among the group of computer science students and economics students.

The next part of the research focused on whether the form of distance learning impacts students' success. The aim was to compare face-to-face teaching and distance learning in synchronous and asynchronous forms. The following research questions were formulated: can students' success rate be affected by whether they study in synchronous or asynchronous distance form? What difference will student success rates between full-time and distance synchronous forms of study?

Two hypotheses were established:

H2: The results of study success are the same for distance learners in the synchronous form and distance learners in the asynchronous form.

H3: The results of the success rate of learning outcomes are the same for full-time students and distance learners in synchronous form.

METHODS

To test the validity of the first hypothesis, a questionnaire method was used, which contains 13 standardized closed questions. The questionnaire is designed primarily for the self-detection of preferred learning styles. And it is based on the VARK learning styles theory developed by Neil D. Fleming in 1987. The model was based on the preference of sensory modalities in learning and information processing. VARK is an acronym for the words Visual, Aural, Read/Write, and Kinesthetic. Each item contains 3 to 4 suggested responses. Respondents select the responses that best describe their reactions to the situation. The survey used an online questionnaire at http://www.vark-learn.com (Fleming, 1995). The survey was administered to two groups of respondents. The first group consisted of students of the bachelor’s degree program in Applied Informatics at the Faculty of Science, University of Ostrava. The second group consisted of students of the Faculty of Business

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Administration of Silesian University studying bachelor's degree programs focused on economic sciences.

The second part of the research focused on comparing students' success rates in full-time and distance learning. The results were compared separately for the synchronous and asynchronous forms for the distance form. The synchronous form was conducted according to a predetermined timetable. The synchronous online communication and study were guided through the MS Teams tool. Study materials in text and video form were available through LMS Moodle. The same study materials were available to the students of all groups. Independent assignments worked by students were also submitted to LMS Moodle. Distance learning in the asynchronous form took place in the form of self-study. Students used learning materials that could be obtained on LMS Moodle. They also submitted independent work there. These students participated in online tutorials and group consultations during the semester. Each course had 2 to 3 tutorials which were conducted via MS Teams. In each subject monitored, students could score O to 100 points. Students had to score a minimum of 51 points to pass. The results - the number of points were compared in each group. All the results obtained were statistically processed. F-test was used to compare the variance. T-test was then conducted to test the null hypothesis.

RESULTS

A survey of learning style preferences was conducted with two groups of students. The first group consisted of 82 distance and full-time students in the bachelor's degree program in Applied Computer Science. The second group consisted of 51 distance and full-time students in the bachelor's degree programme in economic sciences.

The results of comparing the learning style preferences of the two groups of students show that the null hypothesis cannot be rejected. Both groups of students have the same learning style preferences, which do not depend on the field of study. Despite the respondents' different fields of study, the results were consistent with the alpha level of 0.05. The first hypothesis is valid. In both groups studied, most students preferred multi learning styles. Only a tiny proportion had a clear preference for a particular learning style.

The graph in Figure 1 shows the preferred learning styles of a group of computer science students. The vast majority of students prefer a multimodal style.

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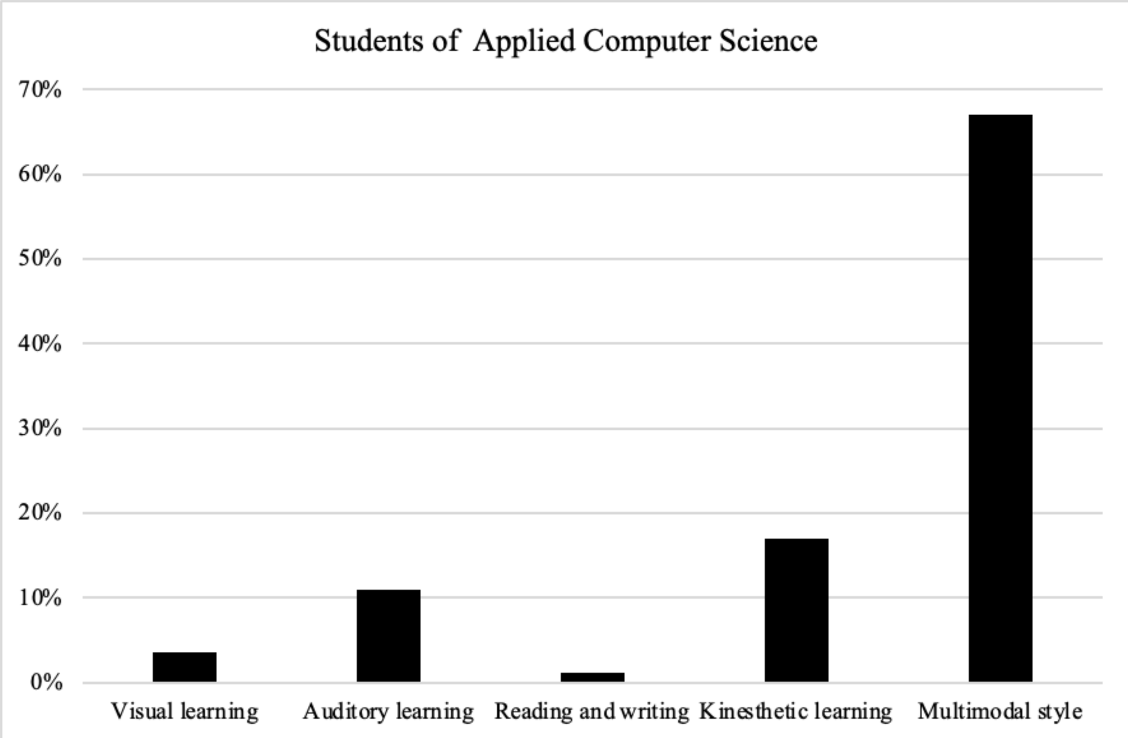

Figure 1: Learning Style Preferences - Computer Science Students.

Economic science students had a similar distribution of learning style preferences. The result is shown in the graph in Figure 2.

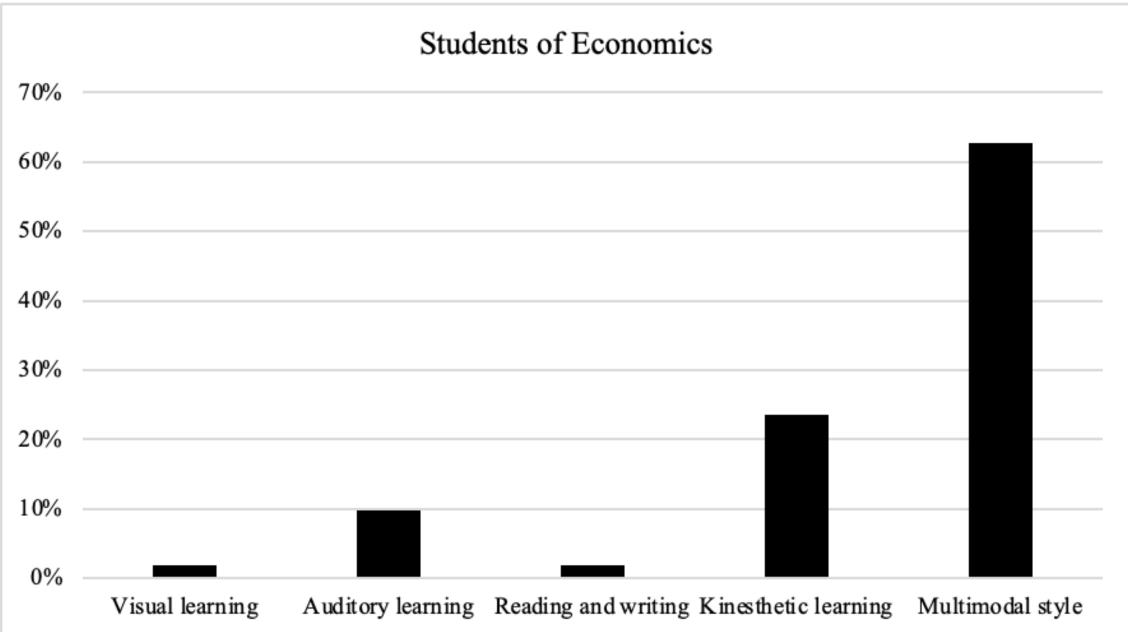

Figure 2: Learning Style Preferences - Economic Science Students.

The results of all students from both groups show that most respondents prefer the multimodal style (65%). In terms of individual styles, kinesthetic learning is the most preferred. This style is preferred by 20% of the respondents. This is followed by auditory style 11%, visual learning 3% and reading/writing style 2%. Kinesthetic learning is the most

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preferred style among the specific styles. This style is usually preferred by people who learn best if they can do something with the information and learning materials, touch and manipulate the learning tools, move while learning, and learn with activities. Therefore, it is advisable to include as many practical examples as possible in which students can practice what they have learned. They like to learn by experience, often by trial and error, and prefer this to listen, read, and write. If we observe the frequency of selection of each learning style, we get the following results: Visual learning 9%, Auditory learning 23%, Reading and writing 8%, Kinesthetic learning 59%.

The second part of the research dealt with the impact of different forms and methods in teaching and their effect on student achievement. Specifically, it involved a comparison of face-to-face, synchronous, and asynchronous distance learning forms of instruction. The success rate of students in selected courses of the bachelor's degree program in Applied Informatics was monitored. Specifically, the courses were Computer architecture and operating system fundamentals (first semester), Basics of programming (first semester), Algorithms and data structures (second semester), Operating systems (second semester), Principles and algorithms of computer graphics (third semester), Object-oriented programming (third semester), Computer networks (fourth semester), Software Engineering (fourth semester). The following graphs show the percentages of successful students in 2019 or 2020. Each student who successfully completed the course had to score a minimum of 51 out of 100 points.

Figure 3 shows the percentage success rate of full-time and asynchronous distance learning students in selected subjects in 2019. The results show that distance learning students have a significantly lower success rate than full-time students, especially at the beginning of their studies.

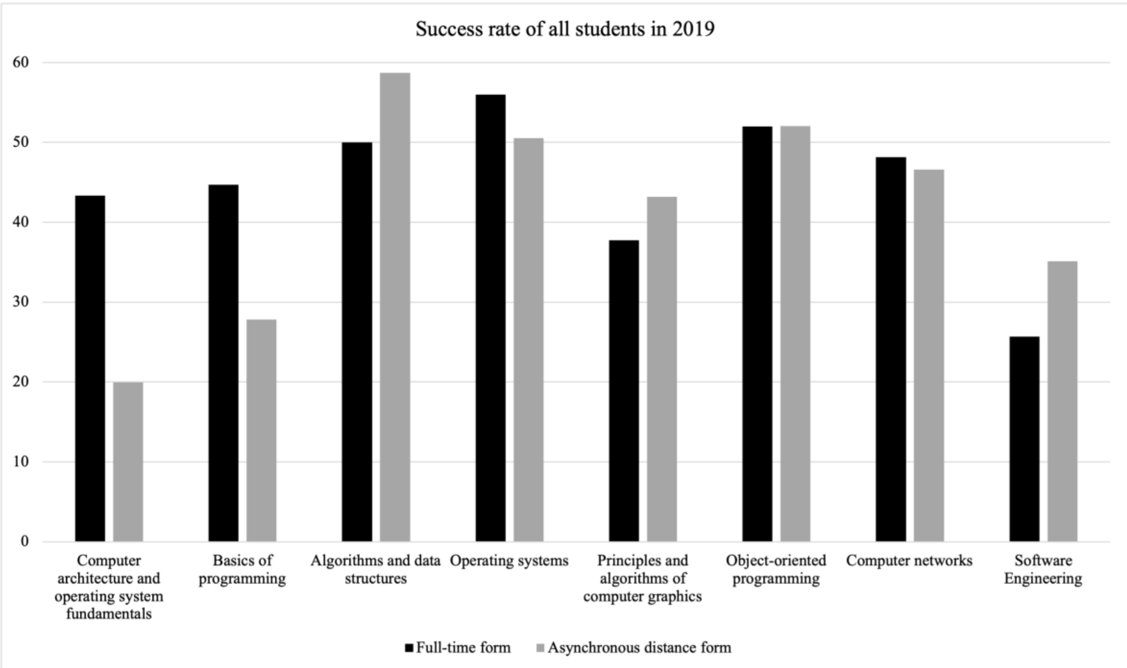

Figure 3: Success rate of students in 2019 year.

F-test and T-test were performed for each observed course. Table 1 shows the results of the comparison of students in the full-time and asynchronous distance learning formats,

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namely in the course Computer architecture and operating system fundamentals in the year 2019. The average score for the exam was compared. It can be seen from the table that the null hypothesis can be rejected, and the groups studied do not have the same results. Similarly, other courses were compared.

Table 1: Comparison of the results of full-time and asynchronous distance learning, 2019.

t-Test: Two-Sample Assuming Equal Variances	*Full time form*	*Asynchronous distance form*
Mean	43,36	21,19
Variance	1192,67	1251,66
Observations	107	57
P(T<=t) one-tail		0,000076
t Critical one-tail		1,654314
P(T<=t) two-tail		0,000151
t Critical two-tail		1,974716

The results are very similar in 2020, in which full-time students had to study synchronously at a distance. The comparison is shown in Figure 4.

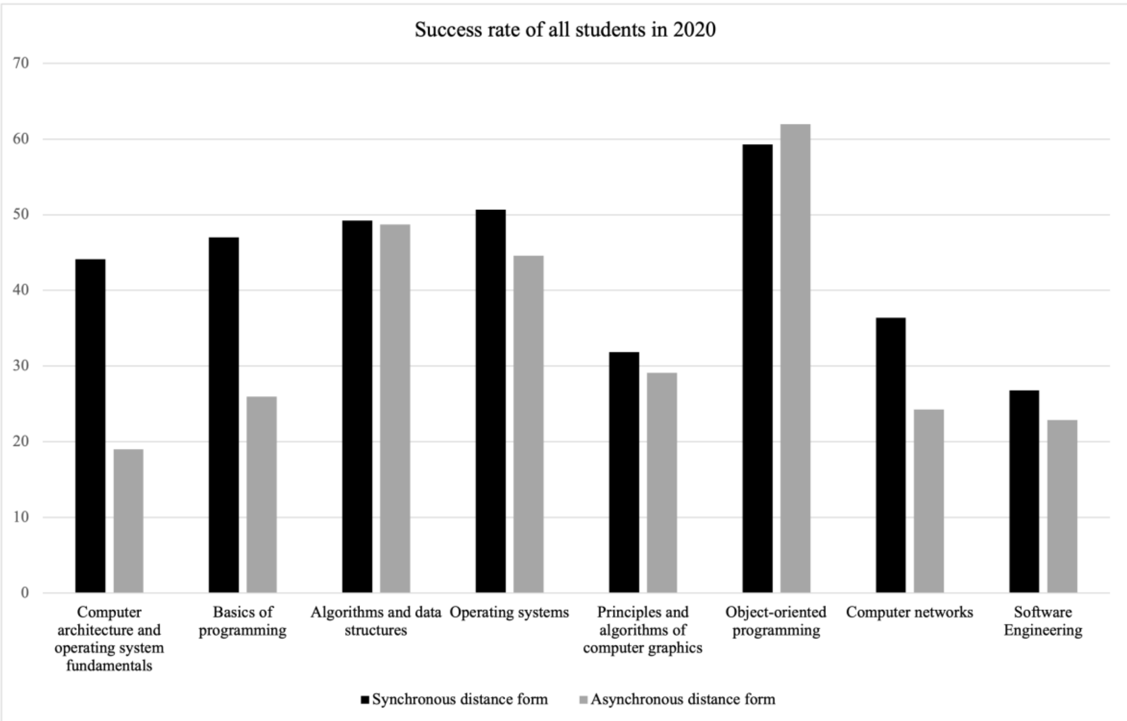

Figure 4: Success rate of all students in 2020 year.

Table 2 compares students in the synchronous and asynchronous distance learning courses in Computer architecture and operating system fundamentals course in 2020. As in 2019, the null hypothesis can be rejected, and the two groups achieved clearly different results. Again, students in the asynchronous distance form achieved worse learning outcomes.

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Table 2: Comparison of the results of synchronous and asynchronous distance learning, 2020.

t-Test: Two-Sample Assuming Equal Variances	*Synchronous distance form*	*Asynchronous distance form*
Mean	44,13	19,03
Variance	1145,87	1072,09
Observations	89	64
P(T<=t) one-tail	0,0000047	
t Critical one-tail	1,6550074	
P(T<=t) two-tail	0,0000094	
t Critical two-tail	1,9757989	

Comparisons of full-time students' performance in face-to-face and synchronous distance learning in the Computer architecture and operating system fundamentals course in 2019 and 2020 are shown in Table 3. The result shows that both groups achieved the same average success rate. Therefore, it can be assumed that synchronous face-to-face and distance learning can be approximately equally effective. In contrast, the results in the asynchronous distance form are significantly worse for mainly novice students.

Table 3: Comparison of the results of face-to-face and synchronous distance learning.

t-Test: Two-Sample Assuming Equal Variances	*2020*	*2019*
Mean	43,53409	42,84906
Variance	1126,55055	1176,35795
Observations	88	106
t Stat		0,13984
P(T<=t) one-tail		0,44447
t Critical one-tail		1,65283
P(T<=t) two-tail		0,88893
t Critical two-tail		1,97240

In the long term, it has been shown that students have a big problem with the organization of self-study in asynchronous distance learning. Many do not work continuously, and at the end of the semester, many tasks and responsibilities accumulate that they cannot manage. Therefore, they often do not even show up for the exam and do not finish the course early. Distance learners, on the other hand, who are highly motivated and can organise their self-study properly, often have better results than full-time students. Figures 5 and 6 show the percentage results of only students who appeared for the exam. It can be seen that distance learners, on the other hand, have a higher success rate, as their motivation to complete their studies successfully is often higher than that of full-time students.

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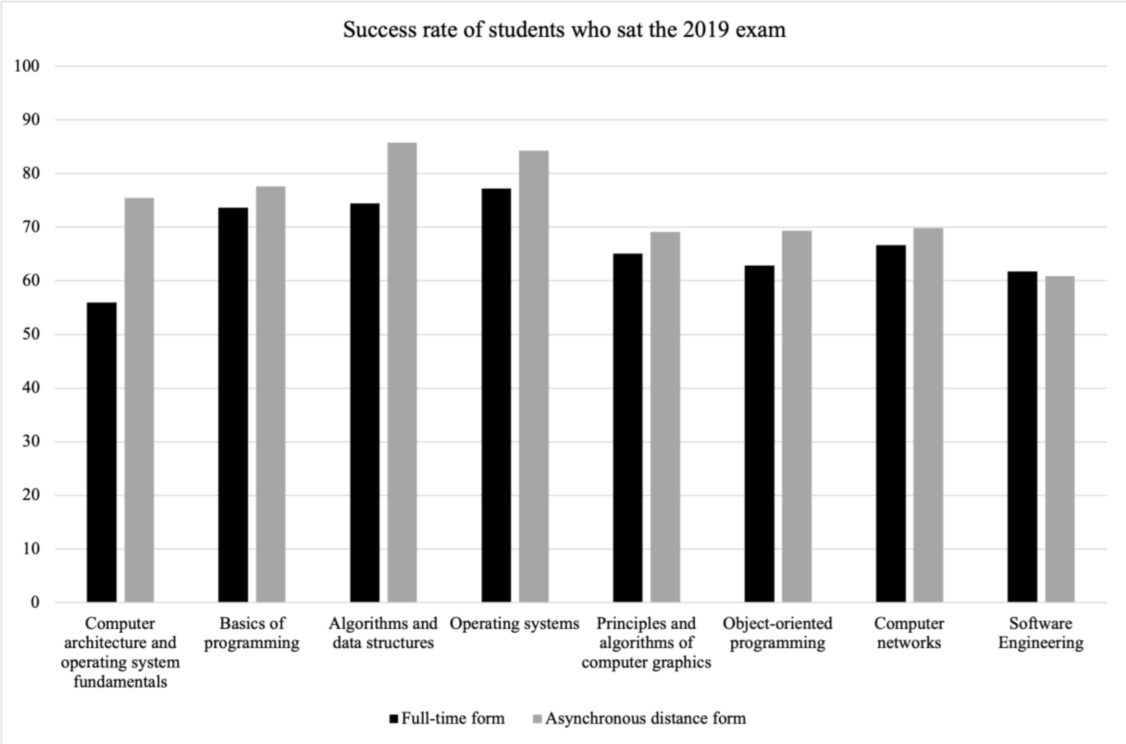

Figure 5: Success rate of students taking the 2019 exam.

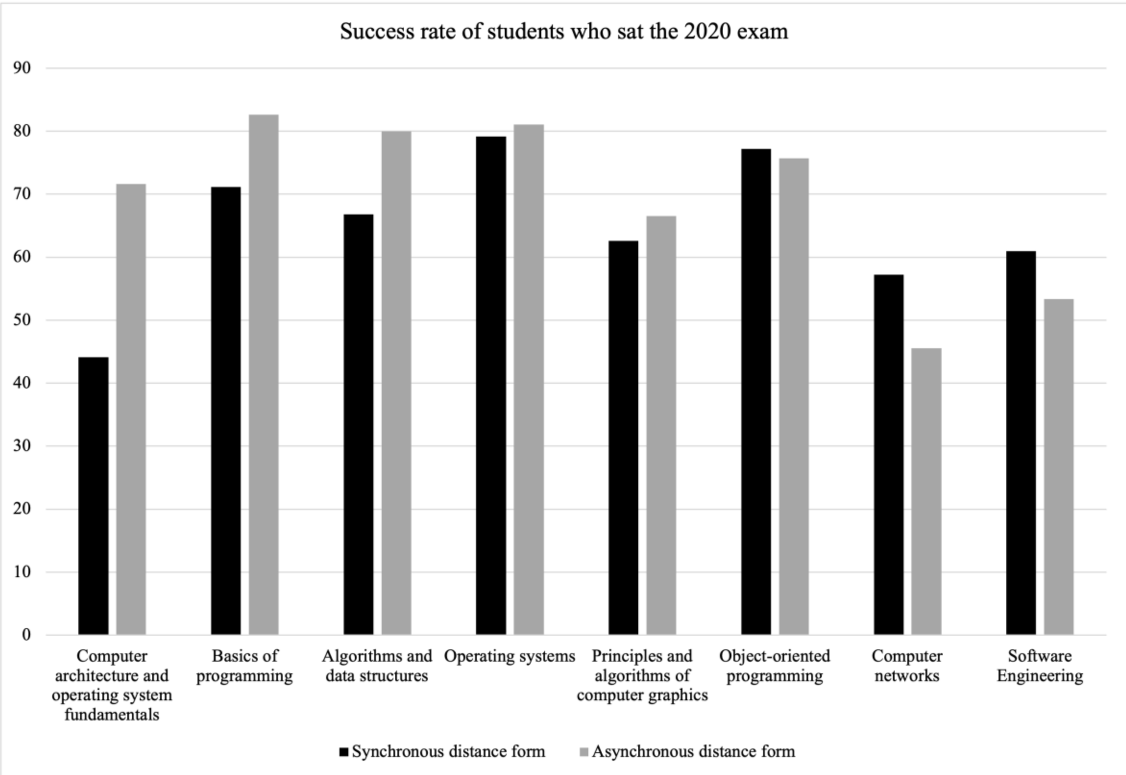

Figure 6: Success rate of students taking the 2020 exam.

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DISCUSSION

Students have different preferences for learning styles. However, most students do not have one distinct learning style and prefer multimodal learning. This means that teaching methods need to target all learning styles. No significant differences were found when comparing computer science and economics students. Therefore, learning styles are not related to different fields of study.

Some research in this area suggests that learning styles may be overestimated. Their influence depends not only on learner preferences but also on the fields of study, specific topics, or situations in which the learning process occurs (Kirschner, 2017) (Riener & Willingham, 2010). Thus, it cannot be conclusively judged that by more thoroughly targeting the support of different learning styles, significant improvements in student learning outcomes can be expected in asynchronous distance education. This is confirmed by long-term experience using different formats of learning materials and diverse teaching methods, which do not bring significant improvements (Fojtík, 2015). It turns out that the form of teaching, specifically whether it is synchronous or asynchronous, has a much more substantial impact. Asynchronous teaching places significantly greater demands on students' intrinsic motivation and their ability to independently manage the learning process. This is confirmed by more than twenty years of experience and the results of a comparison of face-to-face, synchronous, and asynchronous distance learning. The students who do not complete the course are the largest in the asynchronous distance form (Fojtík, 2018).

On the other hand, distance learners with high intrinsic motivation often perform better than students in the full-time form. This may be related to their older age and the need to complete their studies for reasons related to work requirements successfully. Conversely, correctly managed synchronous online learning can be just as successful as face-to-face learning. For example, the learning process is improved by direct interaction between participants, a precisely planned teaching schedule, and the possibility to react immediately to problems (Boström, 2021) (Fojtík, 2015) (Paechter, 2014).

CONCLUSION

The survey results indicate that a greater focus on multimodal learning styles and assignments and teaching methods in which distance learners learn through hands-on activities are probably needed to improve student achievement. On the other hand, some research suggests that learning styles may be overrated. A comparison of students' results in full-time and distance learning shows that the mode of instruction has a significant impact on student success. In distance education, whether it is delivered in a synchronous or asynchronous way is very important. The asynchronous distance form is more challenging for students because it requires more motivation, the ability to schedule study time, and study without direct interaction with other students and instructors.

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Factors Influencing Effectiveness of Pandemic Distance Learning – Preliminary Findings From a Complex Survey

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Abstract

This study is focused on identification of factors affecting the effectiveness of pandemic distance learning both on the side of students and teachers. The attention is devoted also to prevalence and perceived usefulness of the individual distance learning approaches and activities. We recruited 35 teachers of Czech language, German language, geography, mathematics, physics (seven per each subject). Questionnaires for teachers and students were developed on the basis of focus groups held with the teachers and an extensive literature search. 70 classes (two per each teacher) and more than 1400 students participated in the research. We found that preference to the online communication and attitudes towards distance learning among students are predictors of the effectiveness of distance learning. Sufficiently developed executive functions were also important for its managing. The perceived usefulness of individual activities by teachers and students strongly correlated with the prevalence of these activities during distance learning and the conventional approaches such as explanation of the learning content by teacher with shared screen were assessed as more useful than activities requiring higher level of activization of students (e.g. long-term project, group presentation). The findings presented here are a starting point for more in-depth going data analysis leading at the end to an online-available screening tool which should help teachers to identify students who are in danger of lowered effectiveness during the distance learning.

Keywords

Effectiveness, distance learning, covid-19 pandemic.

INTRODUCTION

The forced switch to distance learning caused by the pandemic of covid-19 put this topic into focus of not only educational specialists but also broad public. At the beginning of pandemic in early 2020, schools were temporarily closed for more than 1.6 billion students in almost 200 countries worldwide (Stringer & Keys, 2021) and distance learning became the only option how to proceed with the education process. Teachers and students had to

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adapt to new conditions in short time and very often without previous in-depth going experience with distance learning (Wang, 2021). However, pandemic can be seen also as a great opportunity both for the development of distance learning itself and the related educational research (Adedoyin & Soykan, 2020). The latter is based on that distance learning became a necessity for all educators and not only matter of choice for teachers interested in this approach. This selection bias has been important issue affecting the research focused on distance learning in the pre-pandemic time (Nguyen, 2015).

The educational researchers caught this opportunity and significant attention has been devoted to topics such as effectivity of distance learning, impact of pandemic on attitudes of students and teachers toward it, their socio-emotional status etc. (Reimers & Schleicher, 2020). Especially the effectivity of distance learning has been extensively studied and several complex review articles on this topic are available. It was found that the distance learning resulted in significant learning loss compared with standard “brick and mortar” classes especially in mathematics (Newton, 2021). Extensive description and analysis of current findings in this field can be found in our previous paper (Kohout et al., 2021).

Despite the focus on effectivity of distance learning, there are some understudied areas related to this topic. Firstly, distance learning is typically taken in these studies as a whole and no (or very little) attention has been devoted to the issue which particular activities were carried out and how the outcomes of distance learning are affected by the selection of these activities. Although it was reported that students attending synchronous classes including active-learning techniques reported higher level of engagement motivation, enjoyment, and satisfaction with instruction (Nguyen et al., 2021), no data showing higher effectivity of these approaches in reaching relevant outcomes has been presented. Secondly, despite the fact that effect of some sociodemographic variables such as education of parents or socio-economic status on effectivity of distance learning has been clearly determined, very little is known about how the outcomes are affected by other potentially relevant factors related to personality characteristics of students and teachers (Yu, 2021), their beliefs about and attitudes towards distance learning, ICT inclination, preference to online communication etc. This is mainly because of research focus on use of the complex and standardized diagnostic tests during which there is no space for collection of in-depth going data about students and teachers besides basic characteristics. The surveys using standardized tests are undoubtedly valuable for complex view on this topic and prediction of economic losses caused by this switch to distance learning. However, they are quite worthless for a teacher thinking about how to set distance learning in his/her class considering his/her abilities and experiences as well specifics of the students.

Based on the discussion above, we aim in this study (i) to identify factors affecting effectiveness of pandemic distance learning both on the side of students and teachers, (ii) to analyse which activities of distance learning were used and (iii) to evaluate perceived usefulness of these activities both from the point of view of teachers and students.

METHODS

Development of the questionnaires

The development of the tools for this research started in December 2020 by focus groups with teachers of the subjects involved. Seven teachers of lower and upper secondary

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schools were recruited for each subject with the aim to involve individuals representing different approach towards distance learning (based on our previous experience from cooperation with them). The focus groups were held separately for each subject and resulted in identification of the main factors potentially affecting the effectivity of distance learning from the teachers' point of view. Based on findings from focus groups and extensive literature search, we developed pool of more than 250 potentially relevant items (in total for teachers' and students' questionnaires) covering all relevant aspects of this topic. Each item was then marked by each team member based on its relevance and an omitting of items judged as less relevant resulted in pre-final version of the questionnaires. These versions were piloted with ten students and two teachers and findings from this step were used for finalization of the research tool in April 2021.

In the final version, the students' questionnaire is besides basic socio-demographics questions divided into four parts:

Part A – 68 statements for which students indicate their (dis)agreement on 5-point Likert scale (1 = fully disagree, 5 = fully agree). The items were related to students' experience with and attitudes towards distance learning, perceived support from family, class and teacher, equipment for distance learning available etc.

Part B – 6 statements reflecting perceived outcomes of distance learning. Specifically, demands of teacher, how much the pupils learned, time cost of learning and overall attitude towards subject were assessed. 5-point Likert scale was used for each of the items and all of them were taken relatively to standard learning (for instance: 1 = demands of teachers were much lower than in the standard in-house learning, 5 = demands of teachers were much higher than in the standard in-house learning or 1 = I had to learn for the given subject much more than during in-house learning, 5 = I had to learn much less than during in-house learning). From these 6 statements, composite score of effectiveness of distance learning by students was computed simply by summing the points from the individual items.

Part C – evaluation of how commonly 20 selected groups of distance learning activities were used in the distance learning. The list of activities was developed of the basis of so-called iPadagogyWheel (Carrington, 2016). 5-point Likert scale was used (1 = activity was not carried out at all, 5 = activity was carried out very often) here.

Part D – evaluation of the same 20 groups of distance learning activities as in part C in terms of their perceived usefulness. 5-point Likert scale was used (1 = not useful at all, 5 = very useful).

The teachers' questionnaires included besides some introductory questions (gender, length of practice etc.):

Part A – 10 items related to how the given class or school stands in comparison with other classes/schools in parameters such as cognitive abilities of students, their socio-economic background, methodological support at the school level etc. 5-point Likert scale (1 = significantly below average, 5 = significantly above average) was used.

Parts B and C – 7 items each covering how the teachers feel confident in different aspects related to distance learning (ICT competence, prior knowledge about distance learning and attitudes towards it, time management etc.) at the beginning of pandemic (part B) and one year later (part C).

Part D – two items related to ratio of synchronous/asynchronous distance learning at the beginning of pandemic and one year later and one item about demands of teacher on students relatively to standard in-house learning (5-point Likert scale: 1 = much lower demands, 5 = much higher demands)

Parts E and F – the same as parts C and D in the students' questionnaire but from the point of view of teachers.

Part G – assessment of all in research participated students taught by the teacher in terms of their outcomes and activity during distance learning (relatively to standard in-house learning) on 5-point Likert scale (1 = much worse, 5 = much better)

The score of effectiveness of distance learning by teachers was computed from two items from Part G (outcomes, activity during lessons) and one item from Part D (demands on students).

Data collection and characteristics of respondents

After the finalization of the questionnaires described in the previous section, the main phase of the research has been carried out in May and June 2021. All of the teachers recruited for the research selected two of the classes taught by them in the given subject and were provided by material needed for conducting of the data collection. All principals of the schools and parents and guardians of the children involved obtained via the teachers an informed consent in which the aims and methods of the content were described in accord with the general requirements put on the ethical aspects of research. Contact details of the main investigator were given in the consent and all participants were instructed to not hesitate to contact him with eventual questions and comments. All principals and overwhelming majority of parents and guardians agreed with the participation in the research. After it, the data collection was carried out. In more than 90 % of cases, the questionnaires were distributed online using Google forms. The rest of participants answered questionnaires by pencil-paper method. In most classes, the teachers gave the students unique codes and stated these codes in part G of their questionnaire in order to make the mutual coupling of teachers' and students' responses possible. Thus, the identification of the students was not available to the researchers at all. Remaining data obtained were fully anonymized and prepared for further processing.

In total, 1421 students from 70 classes (after the data cleaning leading to rejection of approximately 30 clearly biased or multiple responses) and 35 teachers participated in the research. 993 (70 %) of students attend lower secondary school (314 were in 7th year of study and 331 in 8th year), remaining 428 (30 %) were in upper secondary schools (181 in 10th year of study and 208 in 11th year). 489 (34 %) students have no siblings living in the same household and having also distance learning, 763 (54 %) of students have one such sibling and 171 (13 %) have two or more. 489 (34 %) of mothers and 410 (29 %) of fathers finished secondary education with matura, 291 (20 %) of mothers and 251 (18 %) of fathers completed tertiary education. From 35 teachers involved in the research, 12 (34 %) were men and 23 (66 %) were women. They had on average 11.1 years of pedagogical experience (SD = 7.8 years). 19 (54 %) of them cared for one or more children in (pre)school age. Regardless of the subject taught, they had on average 6.8 (SD = 3.0) different classes during the distance learning.

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This study is primarily focused on preliminary analysis resulting in identification of the variables affecting significantly the effectiveness of the distance learning and serving as a starting point for more complex evaluation and modelling. From this reason, we used only basic techniques such as descriptive statistics and correlation analysis based on Pearson's correlation coefficient here. This analysis has been carried out in standard MS Excel software using built-in formulas.

RESULTS

The data relevant to student-related variables (i.e. socio-demographics characteristics and statements from the part A of the student´s questionnaire) affecting effectiveness of distance learning are presented in Table 1. Note that only statements having correlation with score of effectiveness by students or teachers higher than 0.15 are presented. This threshold was set in order to demonstrate the most relevant effects and only 12 out of 68 items met it. All the reported correlations are in intuitively expected direction (for example, lower confidence of family corresponds to lower effectiveness etc.). It may be seen that the highest observed correlations with the score of effectiveness by students occurred for the items related to attitudes of students towards distance learning and also for their preference towards online communication (feeling of privacy, hesitancy to require further explanation etc.). On the other hand, from the teachers' point of view, the highest correlation was observed for the items related to responsibility of the students and their ability to organize appropriately and effectively their school work (missing at the online lessons, problems with the home works etc.).

Table 1 – Effect of student-related variables of the effectiveness of distance learning during pandemic

Variable/statement of the students' questionnaire (in italics)	Pearson's correlation with the composite score of distance learning effectiveness by students	Pearson's correlation with the composite score of distance learning effectiveness by teachers
Year of study	-0.01	**0.17**
Education of mother	0.03	0.09
Education of father	0.02	0.08
Number of siblings living in the same household and having also distance learning during the pandemic	0.00	0.01
My family does not believe me to manage distance learning	**0.12**	**0.28**
I often forget to complete a homework	0.06	**0.22**
I often miss the online lesson without a relevant reason	0.00	**0.16**
I am happy to have distance learning during pandemic	**0.31**	0.09
Distance learning is for me better than regular in-house learning	**0.38**	0.04
I would like to have distance learning also in the future.	**0.36**	0.03
I remember only very little from the content explained by teacher during distance learning	**0.26**	0.06

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I go through distance learning without problems	**0.26**	**0.22**
I feel better in the online communication than face-to-face	**0.27**	0.03
The feeling of privacy makes me happy during distance learning	**0.21**	0.07
It is for me difficult to force myself to work on the given tasks/homework	0.12	**0.17**
During the distance learning, it is for me much challenging to request further explanation than during regular learning	**0.22**	0.00

Regarding the variables related to the family environment, only the confidence of the family that the child can manage distance learning was found to be relevant in terms of correlation with the score of effectiveness. Surprisingly, only low correlations were found for the variables such as level of education of parents, their support of children during distance education and overall effect of pandemic on the given family. Similarly, no significant effect of equipment available for the distance learning was found. The same was true for the conditions at home during distance learning and perceived support from teacher and classmates. Attitudes towards the particular subject also did not play significant role for the effectiveness of the distance learning based on the correlation analysis presented here.

Now we focus on how the variables relevant to and reported by teachers affect the effectiveness of distance learning based both on students' and teachers' evaluation. The relevant correlations between the statements of the teachers' questionnaire and the scores of effectiveness are presented in Table 2. As in the case of Table 1, only the correlations higher than the threshold of 0.15 are presented here. It may be seen that the only 7 out of 26 potentially relevant variables met the threshold. In all cases, the sufficiently high correlation was observed for the score of effectiveness based on teachers' evaluation, all correlations with students-based score were lower than 0.1.

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Table 2 – Effect of teacher-reported variables of the effectiveness of distance learning during pandemic

Variable	Pearson's correlation with the composite score of distance learning effectiveness by students	Pearson's correlation with the composite score of distance learning effectiveness by teachers
Cognitive abilities of the students in the class	0.06	**0.17**
Social-economic background of the students	0.01	**0.16**
Methodological support of the distance learning at the level of school	0.06	**0.15**
Self-confidence of teacher to manage the distance learning in terms of time management at the beginning of pandemic	0.03	**0.16**
Self-confidence of teacher to manage of distance learning in terms of time management after one year of pandemic	0.02	0.18
Ratio of synchronous to asynchronous distance learning at the beginning of pandemic	0.04	0.15
Ratio of synchronous to asynchronous distance learning after one year of pandemic	0.03	0.16

Higher teacher-based effectiveness score was observed for the higher reported ratio of synchronous to asynchronous learning, higher self-confidence of teachers in the field of time management as well as better cognitive skills and socio-economic background of students in the class and methodological support focused on distance learning. On the other hand, no relevant effect of parameters such as technical equipment of the school and students for distance learning, self-confidence of teachers in the fields of ICT, their prior knowledge about and attitudes towards distance learning or reported class environment was found using the correlation analysis.

In the last part of Results, we focus on how often selected groups of distance learning activities were used during the distance learning from the point of view of students and teachers and which was their perceived effectiveness. It may be seen from Table 3 that the most often activity used was explanation of learning content by teachers with shared screen. This approach was also perceived by both students and teachers as the most useful. Note the relatively high level of agreement between teachers and students was observed in terms of prevalence of the particular activities during distance learning but very little correlations (close to zero, sometimes even slightly negative) were observed for their perceived usefulness. Lower reported usefulness was observed for the activities requiring higher involvement of students and their cooperation such as long-term project, work group on presentation or animation etc. These activities were also carried out significantly less often during the distance learning. In this context, we should note that the correlations between the prevalence of the activity and its perceived usefulness both from the point of

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view of students and teachers were surprisingly high at approximately 0.7 despite the fact that respondents should evaluate perceived usefulness only in the case that the activity has been carried out (otherwise the option Not relevant was available).

Table 3 – Prevalence and perceived usefulness of activities of distance learning by students and teachers

Distance learning activity	Percentage of students / teachers reporting that the activity was used at least occasionally	Perceived usefulness of activity by students (mean+- SD of the scale 1-5 points, 1 = not useful at all, 5 = very useful)	Perceived usefulness of activity by teachers (mean+- SD of the scale 1-5 points, 1 = not useful at all, 5 = very useful)	Correlation between students' and teachers' evaluation – for use of activity / for perceived usefulness
Independent work of students with texts available online	57.4 / 44.4	3.25±1.09	3.00±0.89	0.14 / -0.03
Independent work of students with literature (books, journals etc.)	43.9 / 37.7	3.06±1.19	3.18±0.83	0.20 / 0.16
Independent work of students with textbook	61.0 / 62.6	3.31±1.16	3.23±0.98	0.31 / 0.13
Work group on presentation, animation or movie	32.4 / 25.8	2.93±1.28	3.28±1.11	0.16 / 0.07
Long-term project	25.4 / 20.2	2.87±1.28	3.15±1.22	0.05 / 0.03
Explanation of learning content by teacher with camera on	67.1 / 69.2	3.76±1.29	4.01±0.93	0.25 / 0.06
Explanation of learning content by teacher with shared screen	86.7 / 95.8	4.20±1.06	4.30±0.78	0.36 / -0.01
Presentations of groups of students	26.9 / 17.7	2.77±1.30	3.29±1.32	0.20 / 0.06
Quizzes and interesting online activities during the lesson	69.0 / 83.6	3.73±1.16	3.94±0.90	0.43 / 0.13
Work of teams of students in separate online rooms	40.8 / 28.6	2.98±1.33	3.12±1.34	0.41 / 0.09

DISCUSSION AND CONCLUSIONS

Regarding the first objective of this study focusing on determination of student-related variables we have found different predictors of effectivity by teachers and by students. In the case of students, the most important factors seem to be the preference to online communication and attitudes towards distance learning. Openness to new experience was found to be an important predictor of distance learning effectivity in the study of Yu (2021). From the point of teachers, executive skills of students such as their ability to finish the task properly and on-time are relevant. Importance of executive functions for distance learning was highlighted besides others by Meijs et al. (2021). Surprisingly, no significant effect of

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family background variables such as education of parents or their perceived support by children was found in contrary to another research of effectivity (Newton, 2021). It may be caused by different methodology used in this study taking into account in the evaluation of effectivity not only outcomes, but also time cost, attitudes, activity and so one. We may expect that parents with higher education are more outcome-oriented and push their children to better results but sometimes at the cost of more time spent by learning and potentially more negative attitudes towards the subject.

From the point of view of teacher-reported variables, we observed an effect of cognitive abilities of students and their socio-economic status on effectivity based on teachers' evaluation (but not for effectivity by students). Methodological support from the school was also relevant in this context for teachers in opposite to technical equipment. It is in line with the finding that insufficient development of theoretical backgrounds and methodology of distance learning is a challenge which may be more serious than technical issues (Shtaleva et al., 2021). Higher proportion of synchronous activities correlated with higher effectivity which is in agreement with finding of Nguyen et al. (2021) that students having synchronous lessons are more engaged and motivated.

Finally, we found that most often carried out activities during the distance learning were also perceived as most useful by both teachers and students. The highest perceived usefulness was observed for explaining of learning content with shared screen, i.e., classic approach that does not require significant activization of students. On the other hand, more challenging activities requiring cooperation among students such as long-term project or presentation in groups were assessed as not as useful by both teachers and students. It is questionable whether this finding is mainly caused due to low experience with distance learning and the related hesitancy toward more progressive activities or if the similar results would be obtained also in the standard in-house setting due to general scepticism to effectivity of constructivist approaches. Anyway, preliminary results of our study do not fully support the idea that distance learning provides a unique context in which to infuse constructivist principles as stated by Tam (2000).

This study has couple of limitations. Firstly, the findings are presented here for simplicity globally across all five school subjects studied (Czech language, German language, geography, mathematics, physics) despite the fact that specifics of individual subjects may play significant role. Secondly, only basic statistical techniques were used for data analysis which make impossible to cover this topic in its full complexity. However, it is necessary to note that it is only a preliminary study and the detailed results for the individual subjects as well as a complex statistical model will be developed and presented afterwards. Thirdly, the composite scores for distance learning effectiveness are based on the subjective evaluation by teachers and by students and not on objective test results. It would be very valuable to have for comparison also results from standardized tests for the students involved in our research. However, such tests are not available for the broad spectrum of subjects and years of study in our study. Finally, the validity of some data from the students' questionnaire could be affected by prevailing online data collection method. Despite very careful data cleaning it is possible that some of the responses of students were not taken seriously.

Despite the limitations stated, this preliminary study brings many original insights into the topic of effectivity of distance learning during pandemic from the different points of view. It could be useful not only as our starting point for advanced statistical model enabling

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to teachers to predict effectiveness of distance learning on basis of characteristics of their participants and activities choose but also as an inspiration for other researchers dealing with this topic.

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The Importance of Eye-Tracking for Evaluating the Reading Comprehension of Multimedia Text in Computer Education

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Abstract

The current pandemic has shown growing necessity to review existing practices and to experimentally verify the applicability of these approaches to e-learning. Greater emphasis needs to be placed not only on the content of e-courses, but also on their communication options so that education can be implemented remotely, or so that the conditions for their consummation can be reliably repeated by students at home using facilities that are freely available. Continuing in our research of students' reading comprehension of computer science study materials, which was carried out in the pre-pandemic period using high-end eye-tracking technologies, we were forced to improve accessibility to education and to develop new research methods in order to continue research in this area. Due to the transition from full-time to distance learning, we have developed a new methodology that allows us to perform a larger number of research experiments in the field of eye-tracking using traditional desktop PCs, but also mobile computing devices, such as laptops, tablets and smartphones - technologies that are not only widely available for students, but also attractive and easy to use.

Keywords

E-Learnig, Learning Management System - Moodle, The Effectiveness Of Education, Reading comprehension, Eye-Tracking

INTRODUCTION

The main aim of our research efforts is to describe and validate a way to create and provide students with educational materials, focusing on increasing the comprehension of the provided text and its connection to the studied lectures. Given the current form of mandatory distance learning using ICT, it is important to realize how the arrangement of text and multimedia elements can invoke the highest possible level of understanding of studied matter. Distance learning often requires students to work more independently than they may be used to, so teachers must accept and work around this. They must also choose the methods that are appropriate for this type of teaching. Instead of concentrating on simple text, it is advisable to use the advanced capabilities offered by the online environment and to a greater extent also utilize illustrations, graphs, tables, maps,

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diagrams, videos, etc. It is important to point students towards resources such as dictionaries, technical literature, magazines, encyclopedias, datasheets.

The creators of the e-courses provided to our students have the experience, education and knowledge necessary to craft comprehensible texts of high information density, both in printed and electronic form. Nevertheless, students often consume this content very superficially and do not process and store this knowledge. This understanding has been further decreased, due to the lack of oversight and motivation in their home environment when compared to the in-person learning. It is important not only how we distribute and present information to the user, but also that he actually understands the text and its content correctly. This is defined as reading comprehension. (Adler & Van Doren, 2014), in How to Read a Book, identified four levels of reading:

- *Elementary reading*– The reader can recognize letters, read them and understand the basic meaning of words.
- *Inspectional reading* – The reader reads actively and can answer the basic questions about the text: What is it about, what is being said in detail, is it true and how to act on the information in the text. Taking notes and underlining important parts are essential tools in Inspectional reading.
- *Analytical reading* **-** This type of reading assumes the reader knows what he is reading and why. It builds on inspectional reading in that the reader inspects the book, the title, subtitle table of contents, etc. Reader can summarize in a few sentences, analyze the organization of the text or a book, confront the author's intentions and identify key sentences.
- *Syntopical reading* **–** Builds on reader's analytical reading skills. Reader actively reads and analyses multiple books, creates their own terminology and propositions in order to find knowledge in an area common to the bibliography created by the reader.

The end benefit of the higher-level reading is the information that the text contains. The ability to understand the text is influenced by the skills of the readers and their ability to process information. If a student has difficulty recognizing words, they use too much of their cognitive ability, which prevents them from properly understanding the text being read. We have summarized these considerations in our paper, and we are trying to solve the problem areas just mentioned in research using the technology used.

MATERIALS AND METHODS

It is important for students to use multimedia learning materials that stimulate cognitive selection, organization and integration processes, without overloading the visual and verbal channels in memory (Mayer, 2017).

Previous research suggests that students who read educational text with illustrations perform better than students who study reading simple text. If the lecture contains both verbal and visual information, the learning outcome may improve. However, students are sometimes forced to divide their attention between text and illustrations in multimedia learning materials. When the student's attention is divided by searching the related element

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in the illustration, it is important to ensure that recently obtained textual information is kept in the working memory at the same time. Students may have difficulty integrating multiple sources of information, such as text and illustrations, at the same time. One of the proposed solutions to this problem is the spatial integration of related text and images (Sweller & Chandler, 1992). This design principle has been validated by the findings that learning is improved when the related text and images are placed in close proximity to the integrated study material, instead of being separated in space. The text itself will help to create a mental model of the content that needs to be learned. These pairing processes may be apparent from the monitoring of data resulting from said activity (Hyönä, 2010). In multimedia-supported education, research into the textual parts of teaching materials already examines the effects of social text designs. Another group of studies examined the influence of interesting but irrelevant information (Garner et al., 1989; Park et al., 2015) with respect to learning outcomes and situational interest. Although these variations of multimedia teaching can evoke students' emotional states, they are not primarily intended for this purpose.

Researchers in the field of new approaches to education have been looking for different research methods in the hope of presenting the learning process from different perspectives. One such method is based on using the eye-tracking technology on students' reading a presented text. The eye tracking method is known for its ability to record online cognitive processes and reveal the basic mechanisms of information decoding and integration. Based on the eye-mind assumption that eye fixation sites reflect attention distribution (Just & Carpenter, 1980), the eye tracking method can reveal a temporal change in visual attention, which can further inform how learners approach information processing during learning. Such use of eye tracking technology as a tool to detect the learning process is not new but it is still rapidly evolving research approach in education. Related works in the field of multimedia education is beginning to grow in size and detail. Some studies used eye tracking as a method to examine students' attention distribution in relation to various components of teaching materials, such as text, graphics, illustrations, and so on, have been conducted to reveal how students spend their cognitive resources on multimedia information (Hyönä, 2010). An interesting finding from these studies is that the text clearly attracts more attention from students. Eye tracking allows researchers to understand not only how the educational material has proved itself, but also to gain knowledge of the level of understanding provided to students by the text. Based on the results of this analysis, it is possible to examine in detail the interactions between processing behavior, lecture design and learning outcomes.

Influence of cognitive process on the eye movement

Based on the eye-mind hypothesis, which states that there is a strong correlation between where one looks and what one thinks (Just & Carpenter, 1980), it is possible to point out the relationship between eye fixation behavior (place, duration and sequence) and a cognitive processing model for both graphic and textual visual materials. Eye movements can reveal much about the underlying cognitive processes (Rayner, 1995, 1998). Further research has suggested that the longer the fixation time recorded is associated with better transmission performance (Ozcelik et al., 2009). To better describe gaze behavior, Rayner (1998) proposed eye movement parameters, such as the number of fixations, the

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average duration of fixation, and the total inspection time, which are particularly important for learning. Several studies have specifically addressed the characteristics of eye movements when it is necessary to process and integrate both text and images into comprehension. (Underwood et al., 2004) reported that in both cases, the duration of fixation was longer in the images than in sentences in which the sentence with the images appeared simultaneously or when the sentences preceded the image. Conversely, reading the text after first inspecting the image causes fewer fixations on image and processing text appears easier than when it is read first.

From this use of the eye-tracking method, we can conclude that we are on the right track in our endeavors. Direct adaptation, or an automated interaction with the student based on eye-tracking cannot be practically realized in the conditions of daily use. This process would require that students access e-courses using only computers equipped with eye tracking devices and in proper conditions. However, based on the above, we can use the eye-tracking method in a similar way to evaluate the quality of study texts, their readability and as a source of information needed to improve them.

Research methodology using eye-tracking technology

An integral part of our reading comprehension in the context of computer science education research is the use of modern methods of data mining and eye-tracking. In the pre-pandemic period, we conducted our gaze tracking experiments using s specialized eye-tracking apparatus, a headset created by Pupil Labs company. However, given the current long-running global pandemic of SARS-CoV-2 (COVID-19), it was not possible to continue in-person teaching at our university. The usage of Pupil Headset device wasn't feasible in this situation anymore, due to pandemic mobility restrictions, as it was not possible to travel to the students in order to continue our research with the said technological device. Therefore, it was necessary to develop an alternative method of obtaining gaze data. After considering several options, we decided to use existing web technologies, the JavaScript web camera-based eye-tracking library webgazer and heatmap.js to create a web application that would allow us to conduct research more quickly with more students regardless of time or location restrictions. The main disadvantage of this method of gaze tracking is lower accuracy, significantly affected by the parameters of the student's equipment and a lower degree of control over the environment in which the experiment is performed. However, a great advantage of our solution is the almost unlimited scalability of parallel experiments, the minimum price and also time and personnel savings.

The purpose of this paper is to describe the ways of finding problem areas in current e-learning courses and their subsequent content and formal adjustment. E-learning has become part of today's education also thanks to its diverse use, from the presentation of digital content to LMS systems (Kostolányová, 2012).

However, an important question to answer is, what is the level of reading comprehension concerning the educational texts, which are provided to students using the LMS MOODLE environment in the form of a Computer Architecture e-course.

The implementation of the correct LMS methodology for its users, according to Balogh and Koprda (2014), means that there is a detailed model that covers all aspects of the system.

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To better confirm our assumptions about factors increasing the reading comprehension of specific text, we have put forth these research questions that should contribute to a clearer methodology in further research.

Q1- Which methods of text presentation as described in related works will achieve an increase of information retention for our students?

Q2- Will putting an emphasis on the keywords in presented text affect a change in the reading speed, or cause other measurable changes in reader behavior?

The research we have decided to carry out in this area addresses the key issue of improving the structure and content of current e-learning courses. In e-courses, we can clearly illustrate the phenomena and subjects and bring them closer to the reader with the help of multimedia, and the e-courses themselves have the possibility of dynamic adaptation in proportion to the biological and psychological abilities of students. (Petlák, 2005) advises in the creation of teaching materials to ensure that the essentials are highlighted, students are continuously tested and teachers should apply different methods of differentiated teaching.

Using the knowledge gained from the pilot experiment carried out in 2020, we designed and conducted a follow-up experiment in the summer semester of 2021, in which we modified part of the Computer Architecture e-course as described in Kohútek and Turčáni (2020). By random selection from the students of the Department of Informatics, we created two groups – an experimental and a control group. While the experimental group completed the course using e-materials continuously modified to meet the principles of creating effective e-learning courses, the control group had access to the unchanged e-course content carried over from the previous year. Our process consists of two related applications - a web application, based on the JavaScript library webgazer.js (Papoutsaki et al., 2016), which was used to record the eye movements of students reading selected subchapters and an Electron application using our own code and an open-source heatmap.js library to provide numerical representations and graphical visualizations of the recorded measurements. We have originally intended to evaluate the measured data in real time, or immediately after reading, but here we encountered problems with insufficient performance of equipment owned by some students. For this reason, we divided the experiment process into two discrete parts - the measurement and recording, which took place in the students' web browser during the distance study and the processing of the measured data sent by the students themselves. However, with regard to the current situation described above, the experiment could not be performed in a laboratory environment. For this reason, while evaluating the results we had to consider the large variability of both equipment and environment present in the recording phase. The most important factors were screen size, lighting conditions and quality of webcam. To establish a base level of measurement quality, we have limited the experiment to only students, that could meet our minimum requiremets for equipment, environment and their own physiological state. These requirements were:

- Perfect vision, or vision corrected by contact lenses (glare reflections caused by glasses make it impossible to use our eye-tracking software).

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- Ability to read texts in the Slovak language at native speaker level.
- Modern webcam with 720p resolution at a recording frequency of at least 30hz.
- Use of open-source Chromium web browser, or one of its derived browsers (Google Chrome, Microsoft Edge, Opera) to ensure compatibility and sufficient speed of all JavaScript libraries.

Figure 1 shows the graphical interface of our application, specifically the initial settings scree. Here the researcher can select the data file and the associated screenshot.

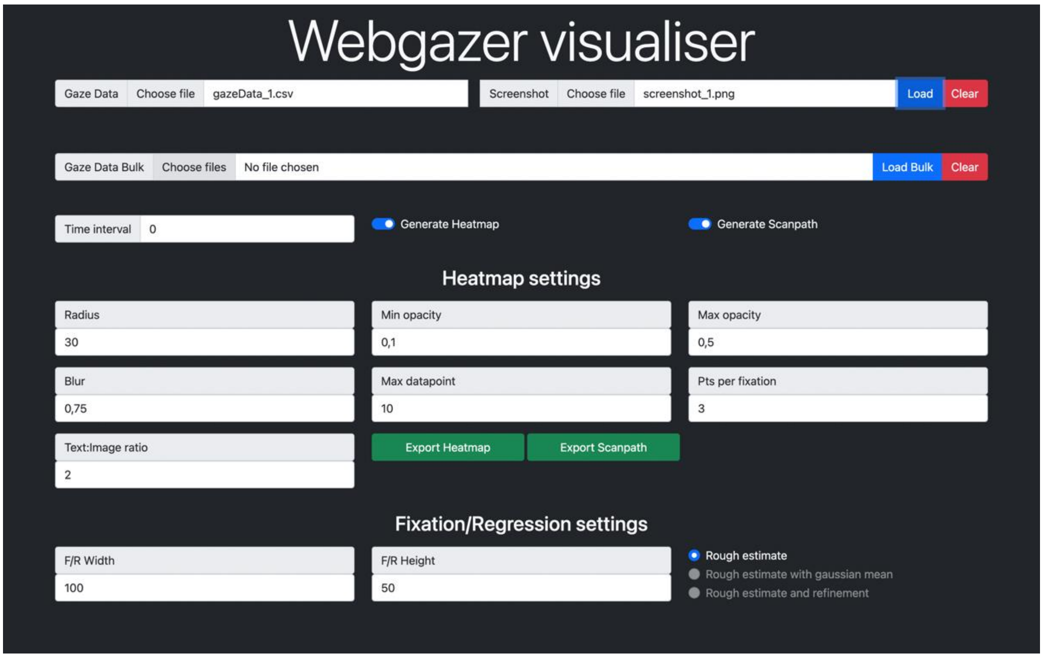

Figure 1: Webgazer Visualiser settings

The second, mutually exclusive option is to load any number of data files (.csv) from which a composite heatmap can be generated. The application compensates for differences in student screen resolutions, normalizes all heatmaps to a uniform resolution and generates them over time. We can also enter the time interval we want to visualize, or leave "0", to generate visualizations from the total reading time. The output is numerical data obtained from the data file and also the heatmap together with the visalization of transitions between fixations in the form of a scanpath (Figure 2). Once the visualizations have been generated, the user can export them to .png images (to maintain the transparency needed for further processing). Such a visualization can be useful for revealing the overall trend and changes between first and repeated readings. Heatmaps are especially useful for a clear display of fixation intensity. Scanpaths, on the other hand, are better for displaying saccades, transitions between individual fixations.

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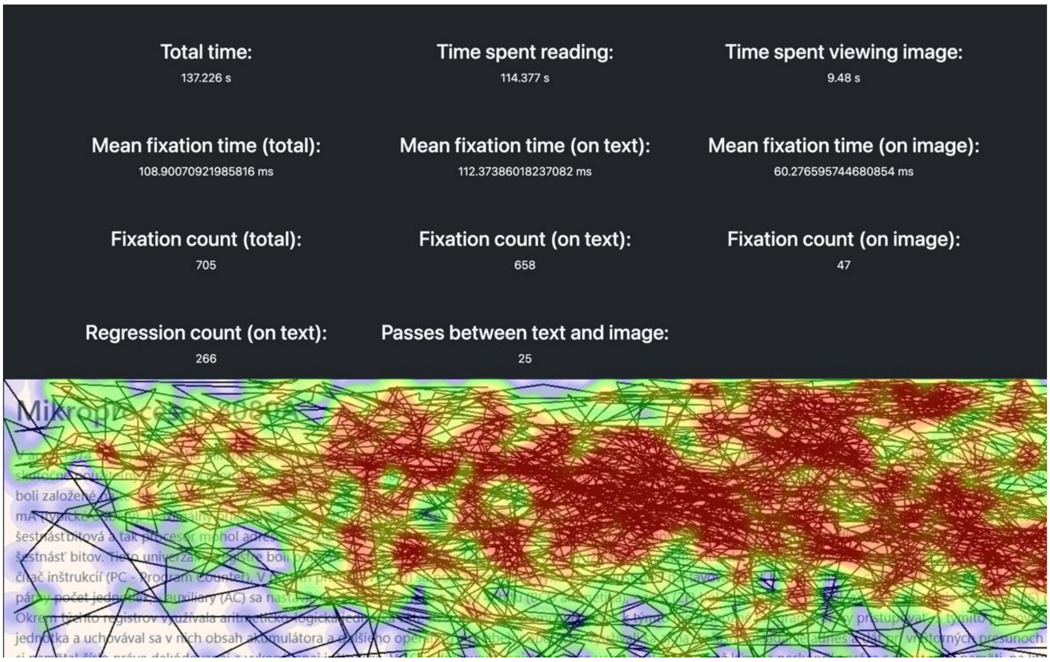

Figure 2: Webgazer Visualiser output

RESULTS

Due to the pandemic, we have conducted this research at the most inopportune time, since at the time of the experiment, our lectures was transformed from in-person into a distance form of teaching using only e-courses and real-time video lectures. Despite this change in the way we were in contact with our students, we did not change our research questions and tried to adapt to the current situation. To create a research sample, we addressed 110 first-year students at the beginning of the semester with a request for assistance and an offer to participate in our experiment. Out of the total number of respondents addressed, 75 students agreed to participate in the experiments. However, there were 45 students in this group, which we had to exclude due to failure to meet the aforementioned requirements. Our research consisted of two readings of texts with the same content. The first reading contained text without marked keywords along with a relevant image. The second reading contained text with highlighted marked keywords related to the attached image. Due to multiple reasons (departure of students during the semester, reluctance to continue the experiment, equipment failure, etc.), only 13 students from the total number of addressed students participated in both rounds of the experiment.

Tab 1. Descriptive Statistics – Time spent on various AOIs

	Total time (s)		Time reading (s)		Time on picture (s)		Time w/o capture (s)	
	raw text	text w/ keywords	raw text	text w/ keywords	raw text	text w/ keywords	raw text	text w/ keywords
Median	113.396	117.524	60.760	75.266	37.513	21.927	1.067	5.147
Mean	107.476	112.666	72.122	74.036	32.622	29.816	2.733	8.813
Std. Deviation	40.430	46.162	28.403	35.589	20.906	27.967	4.079	11.518

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Tab 1. Descriptive Statistics – Time spent on various AOIs

	Total time (s)		**Time reading (s)**		**Time on picture (s)**		**Time w/o capture (s)**	
	raw text	**text w/ keywords**	**raw text**	**text w/ keywords**	**raw text**	**text w/ keywords**	**raw text**	**text w/ keywords**
Minimum	32.925	32.946	30.395	20.843	2.466	6.871	0.000	0.216
Maximum	181.722	217.080	122.572	153.786	65.073	110.466	13.369	42.053

In Table 1 we see the average times in seconds that students spent studying the experimental text. Out of this total time, we can look separately at the time students spent reading, viewing the picture, and the time they looked off-screen. We observe that although the total time spent in the lesson does not differ much between reading with unmarked text and text with marked important terms, we see the difference in the ratio between time spent reading and looking at a picture. It is possible that the text with marked important terms is more visually attractive and therefore attracts some of the attention usually focused on the related image. However, the time spent looking away from the screen also unexpectedly increased, with the increase on average is not only due to a single extreme case, as we see a similar change when looking at the median.

Tab 2. Descriptive Statistics – Mean fixation durations

	Mean Fixation Duration – Total (s)		**Mean Fixation Duration – Text (s)**		**Mean Fixation Duration – Image (s)**	
	raw text	**text w/ keywords**	**raw text**	**text w/ keywords**	**raw text**	**text w/ keywords**
Median	0.410	0.182	0.406	0.183	0.422	0.179
Mean	0.463	0.241	0.490	0.252	0.413	0.209
Std. Deviation	0.258	0.163	0.259	0.176	0.301	0.114
Minimum	0.090	0.062	0.092	0.060	0.062	0.061
Maximum	0.899	0.560	0.857	0.586	1.010	0.416

However, we have noticed an even more significant effect when looking closely at the lengths of individual fixations, which we can observe in Table 2. Here we see a significant decrease in the lengths of individual fixations on both text and image. It's possible that highlighting keywords increased students' reading speed, shortening individual word fixations, but we can't explain the effect this change has on image-focused fixations.

Tab 3. Descriptive Statistics – Fixation counts

	Fixation Count - Total		**Fixation Count – Text**		**Fixation Count – Image**	
	raw text	**text w/ keywords**	**raw text**	**text w/ keywords**	**raw text**	**text w/ keywords**
Median	150.000	339.000	113.000	210.000	53.000	56.000
Mean	285.231	384.231	198.308	275.769	86.769	108.462
Std. Deviation	274.377	286.481	207.062	230.199	90.239	94.772
Minimum	82.000	114.000	50.000	92.000	9.000	12.000

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Tab 3. Descriptive Statistics – Fixation counts

	Fixation Count - Total		Fixation Count – Text		Fixation Count – Image	
	raw text	text w/ keywords	raw text	text w/ keywords	raw text	text w/ keywords
Maximum	1017.000	1124.000	689.000	871.000	328.000	292.000

So far, the biggest change we can see between the two readings is in the number of individual fixations, which is of course related to the change in the average length of fixations. However, in Table 3 we show that the change in the marking of the text is understandably reflected mainly in the text AOI, with the median and the average number of fixations on text increased very significantly as opposed to the illustration AOI, where while the difference mean fixation count increased significantly, the median of the number of fixations on image increased only slightly. This is caused by the mean being influenced by a single extreme case in measurements.

Tab 4. Descriptive Statistics – Regressions and Passes

	Regression Count – Text		Passes Count	
	raw text	text w/ keywords	raw text	text w/ keywords
Median	33.000	46.000	29.000	49.000
Mean	69.385	82.692	40.231	64.538
Std. Deviation	77.737	115.942	31.140	49.956
Minimum	3.000	18.000	9.000	16.000
Maximum	260.000	447.000	127.000	175.000

This trend continues both in the number of regressions (transition from the end of the sentence to its beginning) and in the number of transitions between text and image. Both metrics increased significantly in the case of reading a text with important terms marked, as can be seen from Table 4.

Due to the extraordinary circumstances during which we conducted our experiment, we were unable to obtain the necessary feedback from students to perform quantitative analysis using standard statistical methods. Our results and observations show that although the average reading time does not differ in the larger groups, it has a visible effect on the overall reading time of the individual students, but also on the ratio between reading the text and looking at the picture. As part of our research questions, we also considered the possible effect of marked texts attracting students' attention. This effect is not very significant in terms of time, if we consider only the complete loss of attention (time out of measurement), but within the measurement it can be visualized using composite heatmaps.

DISCUSSION AND CONCLUSION

The growing need for high-quality multimedia materials in a variety of learning environments underscores the importance of eye-tracking research, which can assist in

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improving the teaching methods and educational materials provided to the students. The results of the research show an increase in support for the use of eye tracking technology in educational research areas, which will allow not only a more detailed examination of learning processes, but also an increase in the outcome of learning in general.

Due to the low statistical significance of our quantitative results, we focused more on qualitative analysis using heatmap and scanpath visualizations. These revealed some changes in students' behavior after adding highlighted keywords to the read text. When studying the raw, unmarked text, students made little use of the synergy of the text and the related image. To a large extent, their initial fixation was directed at the image, but they immediately switched to reading the text with minimal transitions between text and images. The text was inspected and students often spent the rest of the time looking at the picture. The achieved results, despite the small sample of students participating in the experiment, confirmed students' shortcomings in understanding the content of the provided materials. The level of analytical reading was not reached and consequently the level of knowledge demonstrated in the final evaluation of their studies is related to it. During the second reading, in the text with marked keywords related to the attached illustration, students worked significantly more with the text and the image, which we also observe in a significant increase in the transitions between the text and the image. This confirms the answer to the second question, which is related to the highlighting of important terms in the educational text. We assume that this adjustment enabled the gradual transition of students from inspectional reading to analytical. In order to verify these questions more precisely, in our next experiment we plan to involve all students attending the full-time form of study in a standardized environment and with standardized resources available in our classrooms.

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Digital Transformation of Higher Education in Hungary in Relation to the OECD Report

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Abstract

This paper focused on the position of higher education in Hungary in relation to factors of digital transformation, and the findings showed that progress is needed in several areas. The OECD report on Supporting the Digital Transformation of Higher Education in Hungary, published in November 2021, also points out that the improvement in online education is based on the wider use and more effective use of digital technologies. The application of teaching methodologies based on the use of digital technologies is essential for both students and teachers, supporting students' independent learning and preparation, as well as activity-based teaching methods. In connection with the OECD report this article focuses on the situation of Hungary in the field of digitization and the factors influencing its digital transformation in higher education in Hungary. This paper reviews the situation of the current state of Hungary and higher education in Hungary in relation to the steps taken towards digital transformation, as well as the key factors of further developments.

Keywords

Digital transformation in education, Hungary, Digital technologies, OECD.

INTRODUCTION

Due to the development of digital tools in the information society, all arenas of society are constantly changing, including the process and methods of teaching and learning. The digital and online world is changing the daily lives of our citizens as well, they are affecting the lives of all of us, we look at almost any area of life. Education has a key role to play in introducing citizens to the targeted use of digital tools in the digital society, which requires adequate digital literacy. Digital literacy seeks to integrate knowledge and skill elements, basic knowledge, and specialized digital competencies (Molnár and Szűts, 2014). The popularity of online education has grown significantly even before the 2020 pandemic. In addition to forms of blended education, fully online institutional training has emerged (Námesztovszki and Kovács, 2021). The Hungarian government's key measures include the

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digitization of higher education, which is reflected in the Digital Education Strategy of Hungary (HG, 2016a) and the Shifting of Gears in Higher Education Mid-Term Policy Strategy 2016 (HG, 2016b). The transition to online education as a result of the pandemic has been, in part, a sharp test for digital education for both digital education systems, educators and students in higher education institutions. The digitization of education has become a key development goal for each institution, which has led to the launch of online education renewal projects at a number of universities (Molnár, 2013) (Rajcsányi-Molnár and Czifra, 2021).

Today, digital technology is significantly appearing in the everyday life of both students and educators familiar with the use of digital devices, not only in connection with teaching and learning activities, but also outside the classroom, in the fields of entertainment, information acquisition and communication (Molnár, 2012). International surveys also show that education policy decisions, which aim to make digital literacy an important part of teacher education and training, are becoming increasingly important (Hill and Fülöp, 2020). The OECD Skills Outlook 2019 study points out that catching up with a world based on a changing digital society can be achieved primarily by supporting government programs, supporting the development of individuals through a lifelong education and training system (OECD, 2019).

This paper reviews the situation of the current state of Hungary and higher education in Hungary in relation to the steps taken towards digital transformation, as well as the key factors of further developments.

THE SITUATION OF DIGITIZATION IN HUNGARY

The EU Digital Economy and Society Index (DESI) tracks the digital development of EU Member States along 4 key dimensions (EU, 2021a):

- Human capital (basic digital skills, ICT specialists, Female ICT specialists);
- Connectivity (Fixed very high capacity network and 5G coverage);
- Integration of digital technology (SMEs with a basic level of digital intensity, AI, Cloud, Big data);
- Digital public services (Digital public services for citizens and business).

According to the latest edition of DESI published in 2021, Hungary finished in 23rd place among the 28 EU Member States with 41.2 points, which is significantly lower than the EU average (Figure 1).

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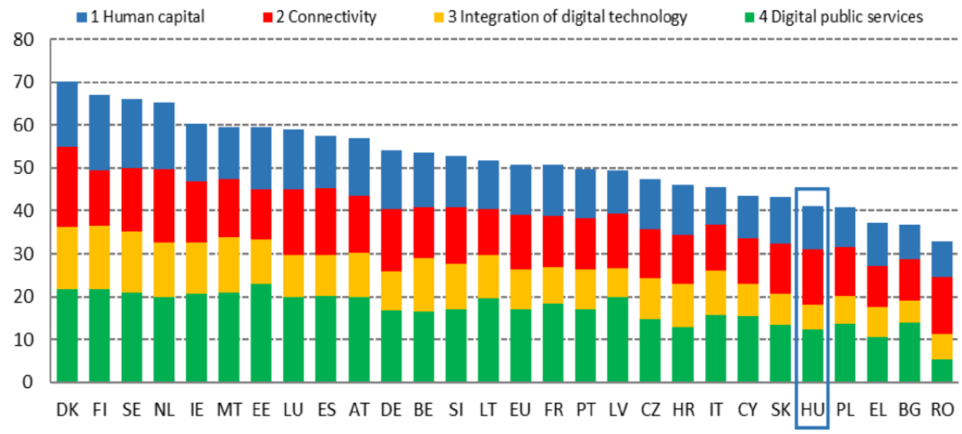

Figure 1: DESI 2021 ranking (EU, 2021b)

Internet access is the only dimension in which Hungary has exceeded the EU average (Figure 2).

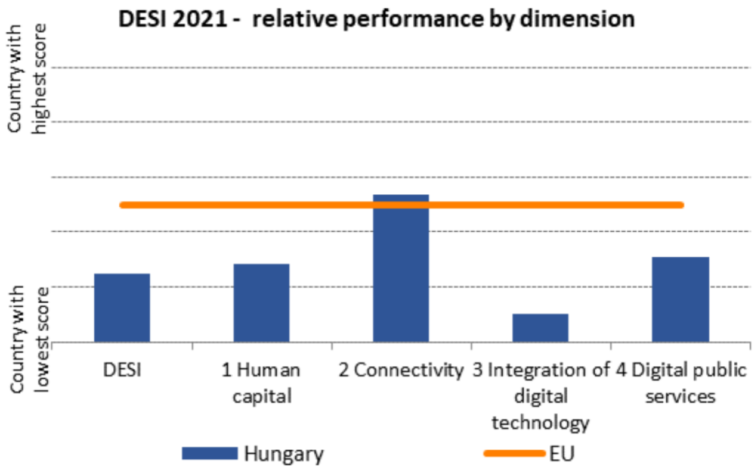

Figure 2: DESI 2021 ranking for Hungary (EU, 2021b)

In terms of Human capital, the share of ICT graduates (compared to all graduates) in Hungary is 4.9% higher than the EU average, which is 3.9%, but the share of ICT professionals (employed aged 15-74) is only 3.8%. compared to an EU average of 4.3%. However, in 2021, basic digital skills remained below the EU average and only 25% of 16- to 74-year-olds had digital skills above basic levels, compared to the EU average of 31%. The proportion of female ICT professionals is 12%, well below the EU average of 19%. ICT training companies account for 16%, compared to the EU average of 20%. The integration of digital technologies is the biggest gap for businesses, at 23.3 points compared to the EU average, which is 37.6 points. The 49.2 points achieved in the field of digital public services is already a smaller lag compared to the EU average of 68.1 points, but this is only enough for the 25th place.

Hungary can be confident that the National Digital Strategy for 2021–2030 (MIT and MI, 2020), which sets out ideas for increasing the widespread use of digitalisation, will improve the current situation. It aims to address the digital skills of the population, network coverage, the digitization of government services and the take-up of digitization by companies.

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THE SITUATION OF HIGHER EDUCATION IN HUNGARY

According to funding, higher education institutions in Hungary can be state higher education institutions and institutions maintained by non-governmental organizations. Non-state maintained institutions include public-interest asset management foundations, private (business organizations, foundations or public-interest foundations) or church-run institutions. The number of model changes that have taken place in recent years, ie the number of institutions operated by public trusts, has increased to 21. However, most of the foundations set up in this way still receive a significant part of their resources from the state under a financing agreement, albeit on a performance basis.

The higher education institution can be based on an academic profile, a university, a university of applied sciences or a college. The distinction is mainly determined by educational capacities. Private institutions tend to have fewer faculty and students. According to the current records of the Office of Education, the distribution of higher education institutions is shown in Table 1.

Table 1: Hungarian state-recognized higher education institutions by financier (EO, 2022)
*: The Institute of Higher Education in the Social Sciences of Innovation is already included in the data, but its state recognition is still in progress

Maintainer	University	University of Applied Sciences	College	Total
State	5	0	1	**6**
Public interest foundation	16	5	0	**21**
Private	2	4	6*	**12**
Church	6	1	19	**26**
Total	**29**	**7**	**29**	**65**

In recent years, Hungary has made many advances in the digital transformation of higher education, including e-learning systems, virtual learning environments, and digital learning materials. However, it can be said that the additional possibilities provided by technology have been used only to a limited extent, because the teaching potential of the appropriate technology can only be achieved by supporting appropriate pedagogical methods.

Based on the strategies already presented, the OECD has summarized the strengths and weaknesses of the digital readiness of Hungarian higher education. Table 2 summarizes an extract of this with more important aspects (OECD, 2021).

Table 2: Strengths and challenges of the digital readiness of Hungarian higher education (extract based on the OECD (2021) report).

Strengths	Challenges
Digital infrastructure	
• Internet. • High-speed network. • Most students have a computer.	• Standardization of educational systems, materials. • Integration of personal devices. • Renewal of IT equipments.

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• Institutes open for digital solutions.	• Renewal of software. • Lack of IT support.
Digital education and research	
• Digital content development. • Increasing university and industry cooperation.	• The quality of digital learning materials is heterogeneous • Partial lack of teacher competencies. • Lack of in-service teacher trainins.
Students' experiences and learning	
• Successful STEM programs. • Career guidance, international mobility services.	• Traditional methodologies (lecture, seminar, practice). • Recognition of credits obtained through non-formal learning. • Curriculum does not support effective e-learning.

SITUATION OF DIGITAL TRANSFORMATION IN HIGHER EDUCATION

The OECD report examines the necessary measures and factors along the lines of digital preparedness, the practical application of digital technologies, and digital performance (OECD, 2021). Digital preparedness refers primarily to digital infrastructure and the availability of technologies at the institutional level, which is a necessary precondition for digitization. However, the increasing availability of digital technologies only provides a basis but does not directly imply the use of digital technologies. The practical application of digital technologies should cover the activities of leaders, educators and non-educators, as well as students, as well as educators' educational organization, curriculum development, knowledge transfer methodologies (Szűts, 2014). The complex nature of the above, depending on policy and environmental factors, and the repercussions are summarized in Figure 3.

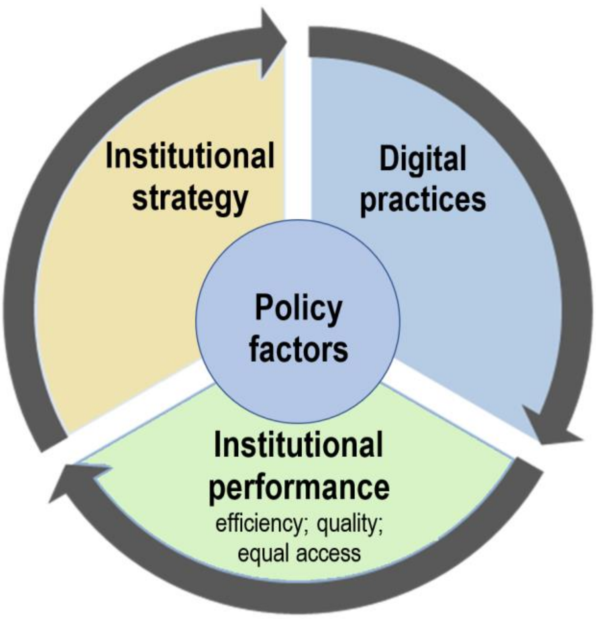

Figure 3: Relationship between factors influencing digital performance.

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The use of digital technologies may differ depending on the nature of each institution, such as the type and level of education in the institution, the composition of full-time, correspondence and distance learning students, the age distribution of students, the number of teachers and students. It also depends on its readiness; therefore, it is advisable to analyse digital performance in the knowledge of this complex environment. The situation analysis summarized the individual influencing factors and their interaction according to connected relationships.

The OECD report also highlighted that from a policy perspective on the digital transformation of higher education institutions, the national strategy and objectives for its digitization are well known, but support and monitoring for the digitization of higher education is currently unresolved at the national level. There are also some opportunities for applications to achieve the stated goals, but there is still work to be done on comprehensive funding opportunities, especially in terms of methodological renewal (Pajtókné, 2011) and the promotion of efficiency (Kovács, 2020), quality and equal access to digital higher education. There are also information gaps in both government support for access to digital tools and government support for digital education. The institutional development plans of the institutions all include plans for the digital transformation of education, but the role or office at the senior management level dealing with digitization is markedly less visible in these. Thus, centralized management in order to introduce digital technologies as widely as possible is not implemented effectively.

On the other hand, institutions in both administration and education management are working to develop digital solutions that are promising for the future. The development of students' digital competencies and the support of their access to digital technologies have been brought to the fore by the online education generally introduced as a result of the viral situation, but no uniform steps have been taken in higher education in this area either. In connection with the support of students, there are issues that arise in connection with the digitization of previously personalized services. On the one hand, it is essential that students are accessible in a digital environment and that their success in their learning outcomes can be supported in the same way as in the case of institutional services that come into contact.

In the context of education, the effective support of extracurricular activities in the digital environment, such as student mentoring, career counselling and health support, is still to be developed.

CONCLUSION

Digital technologies have changed the way people interact, work and learn. The digitization of teaching and learning, research and participation in higher education has been going on for decades, but there are big differences within and within higher education systems. The forced shift to fully online activities due to the coronavirus pandemic was a significant step in higher education. The transition to digital higher education has revealed the ability of higher education institutions to ensure the continuity of their activities, but has also shown that much work remains to be done to ensure that digital technologies are used effectively for quality, efficiency and effectiveness (Rajcsányi-Molnár and Bacsa-Bán, 2021).

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The paper focused on the position of higher education in Hungary in relation to factors of digital transformation, and the findings showed that progress is needed in several areas. The OECD report also points out that the improvement in online education is based on the wider use and more effective use of digital technologies. The application of teaching methodologies based on the use of digital technologies is essential for both students and teachers, supporting students' independent learning and preparation (Capay et al., 2011), as well as activity-based teaching methods (Jámbor, 2019). However, this improvement is difficult to achieve without adequate support, and incentives are needed to increase the motivation of higher education workers, especially teachers, to use technology. On the other hand, all institutions and national levels need to develop a framework and electronic, programmed teaching methods that are suitable for monitoring and developing the progress of digital education (Balogh and Kucharik, 2019; Balogh and Koprda, 2014) and identifying areas in need of support. In addition, human-computer interfaces, e.g. brain-computer interfaces (Katona 2015) and eye-tracking systems (Katona, 2021, 2022), may emerge in the future to help learners and teachers increase their learning efficiency.

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Satisfaction with the Online Education During the Pandemic: A Comparison Between Romanian and Lithuanian Master Students

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Abstract

Satisfaction with studies is an important aspect in assessing the quality of studies. It is understood that the constant changes in society's life are changing the situation, and the assessment of satisfaction is also changing. However, university studies have been conducted remotely in recent years due to the challenges posed by the Covid-19 pandemic. Students' satisfaction with their studies is very important in the current conditions, which requires extensive research. In November-December 2021, a pilot study was conducted that was carried out in Romania and Lithuania. The study involved 64 postgraduate students from 64 Lithuanian universities and 57 Romanian universities. Data were analyzed using key measures of descriptive statistics, and data have also been analyzed with one-way ANOVA. Additionally, a multiple linear regression has been carried out for each sample. The results show that in both countries, master students had a quasi-similar perception of the flexibility of online activities and the lower risks for their health. The results indicate that, at this level of training, the master students proved an important range of developed learning skills, intrinsic motivation, and a high degree of autonomy.

Keywords

Covid19 pandemic, master students, online education, students' satisfaction, regression analysis.

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INTRODUCTION

With the onset of the pandemic, all educational institutions had to switch to remote teaching. It is useful to say that a significant number of universities practiced this method of study even before the pandemic, but it was quite a challenge to completely reorient only to the distance study form. In other words, the whole study process had to be quickly transferred to the virtual space. It can reasonably be argued that the pandemic generated by the Coronavirus COVID-19 challenged universities to go exclusively online thus affecting both the education and personal life of teachers and students (Lamanauskas et al., 2021).

In general, e-learning is becoming particularly important for the greater part of the public in improving their knowledge, skills, acquiring education, professional qualification corresponding to modern technologies, culture, and the level of personal skills, and forming conditions for lifelong learning. Such trends were evident even before the pandemic. Universities have consistently developed e-studies, offering to study individual subjects of the study programs, or even full-time studies online. A survey conducted in Lithuania in 2019 showed that most students need e-studies, and this need will only grow in the future. The students need to combine work, family, and studies, to learn at a convenient time, in a convenient place, in an individually acceptable way, to access the content of distance learning through various IT means, and to use it in various forms (Urbonienė et al., 2019).

It is obvious that distance learning is not a novelty both in Lithuania and in other countries, but, despite the fact, some study institutions face problems in the organization of the teaching/learning process, and in the realization of it. It is obvious that the pandemic situation has caused many of the challenges. It has become clear that the problems of the transition to distance learning are primarily related to technological preparation and provision, which includes all the necessary means for distance learning, as well as insufficient readiness to convey the necessary information during distance learning. However, the development of distance learning has been determined by the pandemic, on the one hand, and the relatively rapid development and modernization of ICT tools. It is obvious that distance learning has both obvious advantages and disadvantages (Kasparavičiūtė & Chadyšas, 2015; Coman et al., 2020; Al Rawashdeh et al., 2021; Lamanauskas & Makarskaitė-Petkevičienė, 2021).

In a scientific sense, it is important how university second-stage students (especially in the context of the pandemic) value distance learning. Such feedback is significant in the development of online studies. In addition, the evaluation of the first and second stage students is likely different in evaluating different contexts, purposes, etc. of bachelor's and master's studies. Research shows that students are competent to evaluate various aspects of distance learning, and their evaluation does not significantly differ from the expert evaluation (Dumčienė & Sipavičienė, 2010). Students' satisfaction with such studies, their compliance with the learners' expectations is one of the essential components of the assessment.

RELATED WORK

The abundance of research conducted in various countries shows that distance learning is a rather important field of university studies. It is clear, such studies vary from country to

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country. This is determined not only by the country's context and requirements but also by the nature of the study programs and so on. Research shows that the range of student requirements for the quality of distance learning is very wide (Penna & Stena, 2008). A research study conducted in Lithuania in 2009 showed that students valued distance learning positively, with a particular emphasis on concentration, convenience, and so on. Most students expressed confidence in distance learning courses, they were satisfied with their participation in the courses (Dumčienė & Valantinė, 2009). In addition, students are recipients of services, thus it is important that the service is of high quality and gives satisfaction. Students' satisfaction with online learning is one of the key indicators of the quality of the studies. Naturally, satisfaction with online learning depends on many different factors, such as students' motivation, the system of study organization, the socio-cultural environment of the educational institution, the quality of teachers' work, the support provided to students, and so on. Learning satisfaction is related to the quality of the studies. If learning satisfaction is low, and students' expectations are high enough, then this may be an indicator that the quality of the studies is unsatisfactory. In this case, according to researchers, universities must immediately carry out various interventions, including additional improvement programs (Valuckienė, 2012). In addition, the competitive environment also has a strong effect (Kanopienė & Tureikytė, 2002). Universities strive to attract students and therefore strive to create more attractive conditions and offer exceptional services. It can be reasonably argued that students' satisfaction with online learning is one of the key outcomes achieved in improving service quality (Duong, 2016; Tsedzah & Obuobisa-Darko, 2015). Finally, student satisfaction with educational institutions can influence their beliefs and future intentions (Thomas & Galambos, 2004).

The study of Ismail and Ismail (2020) analyzed the students' satisfaction with using Microsoft Teams in an online environment during the pandemic. The results drawn from a sample of 154 Malaysian students show that the majority of students were more satisfied with online learning. The main factors increasing satisfaction were the comfort with Microsoft teams, motivation, and time management. As regards the barriers in the online learning environment, students mentioned technical issues, lack of community, and difficulty understanding the instruction's goals. The study of Dutta et al. (2021) reported on the satisfaction level of medical and nursing undergraduate students during the pandemic on a large sample (N=1063). They found that for the majority of respondents the overall satisfaction level was low (37%), with the lowest level among first-year students (23%). The main negative aspects were related to the difficulties of clinical and practical learning in a virtual learning environment. Lengetti et al. (2021) explored learner satisfaction with emergency remote teaching by using a modified students' satisfaction questionnaire and six open-ended questions. They found that students' overall satisfaction was a little bit below the neutral value. As positive aspects of the online activities, they mentioned the flexibility, ease of access, and comfort. Flores et al. (2021) analyzed the personal and contextual factors that are influencing students' adaptation to online teaching and learning during the pandemic on a large sample of Portuguese students. They found that students having prior experience with online teaching felt more comfortable with online teaching and learning and found it more dynamic and effective, while students without prior experience found it more difficult and stressful.

Understandably, students' satisfaction with online learning is a dynamic process and largely depends on the student's expectations and the attitude towards their satisfaction,

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i.e., on the subjective attitude of the student. As already mentioned, satisfaction with online courses is assessed differently by the students of different study levels. On the other hand, due to students' subjective attitude towards satisfaction with online learning, in different situations, satisfaction is determined by different criteria. Though quite a lot is known about students' satisfaction with online learning, the satisfaction with studies in the context of the Covid 19 pandemic is poorly analyzed. Research has shown that distance learning students are more vulnerable, they stop or terminate studies more quickly because at the same time they combine studies with work and with other commitments (Samašonok & Žonych, 2020). Recent research shows that student engagement, course structure, teacher awareness, and facilitation positively influence students' perceived learning satisfaction (Baber, 2020). In addition, student engagement and active interaction are also directly related to learning satisfaction. A research study conducted in China showed that there was a positive relationship between interaction and online learning satisfaction. The results showed that Chinese students who interacted more often during the online education process showed higher levels of learning satisfaction (She et al., 2021). Also, student engagement, effective communication, positive experiences, motivation, and self-motivation, could be the foundation of a successful teaching and learning experience at university (Basuony et al., 2021; Omar et al., 2021). On the other hand, research shows that students' self-efficacy, generalized anxiety, and fear of COVID-19 were significantly related to online learning satisfaction (Al-Nasa'h et al., 2021). Overall, research shows a fairly wide range of satisfaction - from complete dissatisfaction (Tang et al., 2020), to partial (Er Turkuresin, 2020), moderate (Atasoy et al., 2020), and extremely high satisfaction (Kee et al., 2021).

One fact that is worth emphasizing is expressed by Sáiz-Manzanares et al. (2022) and illustrates that students experienced a higher level of satisfaction with online learning - during the pandemic - in their first year of study, rather than in their second year of study.

EMPIRICAL STUDY

Method and Sample

The research was carried out in November-December 2021. Two samples have been collected: one from Lithuania (*N*=64) and another from Romania (*N*=57).

The sample of Lithuanian subjects consisted of: by gender - 61 (95.3%) female, and 3 (4.7%) male postgraduate students; by study year - 36 (56.2%) first study year and 28 (43.8%) second study year. Practically all master students represent the field of social sciences: educology (*n* = 10, 15.6%), educational management (*n* = 16, 25.0%), pedagogy (*n* = 13, 20.3%), social pedagogy (*n* = 13, 20.3%), pedagogical psychology (*n* = 3, 4.7%), and social work (*n* = 9, 14.1%).

The Romanian sample of students is structured as follows: - 55 (96.5%) female, and 2 (3.5%) male postgraduate students; all of them are master students in the second (last) year of study. Most of the students represent the field of educational sciences (*n* = 41, 71.9%), the others covering various fields (engineering, mathematics, science, geography, economics, languages, and journalism - *n* = 16, 28.1%).

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The following research questions guided this study: (1) Are master students satisfied with the online education system? (2) Which online activities should be preserved after the pandemic?

Students have been asked to answer four questions regarding their satisfaction with the online activities and one open-ended question regarding the activities which may be preserved in an online format after the pandemic. A 5-point Likert interval scale was applied.

Differences between the two samples as regards the two samples have been analyzed with one-way ANOVA. Additionally, a multiple linear regression has been carried out for each sample. The differences as regards the online activities that may be preserved have been analyzed with the multifunctional Fisher criterion ϕ (Sidorenko, 2002). The Fisher criterion (is the Fisher`s angular transform) is intended to compare two samples according to the occurrence frequency of the effect under research. The criterion estimates the reliability of the differences between the percentages of the two samples in which the effect is recorded (Ermolaev, 202).

When carrying out the research, specific ethical principles have been respected: (a) voluntary participation (participants were free to choose to withdraw at any time); (b) informed consent (before accepting or refusing to be engaged in research, the surveyed students were informed concerning the purpose, benefits, and risks of participation); (c) anonymity and confidentiality (regulations regarding the participants' sensitive personal data and its processing); (d) potential harm (participants are not affected by the research itself); (e) communication of results (participants were informed concerning the accuracy of the interpretation of the results).

Satisfaction with the Online Education

The mean (*M*) and standard deviation (*SD*) for each sample is given in Table 1. As it could be noticed, the mean values are high in both samples, over 4.00.

Table 1: Descriptives for Romanian sample (*N*=57) and Lithuanian sample (*N*=64).

Item	Statement	RO		LT	
		M	*SD*	*M*	*SD*
S1	I am satisfied with the physical comfort of online activities	4.67	0.61	4.58	0.64
S2	I am satisfied with the flexibility of online activities	4.61	0.67	4.59	0.61
S3	I am satisfied with the lower risks for my health in online activities	4.65	0.74	4.67	0.67
S	Overall, I am satisfied with the online learning system	4.39	0.77	4.45	0.78

In both countries, master students had a quasi-similar perception of the flexibility of online activities and the lower risks for their health. Romanian students were more satisfied than Lithuanian students with the comfort of online activities. As regards the overall satisfaction with online education, the Lithuanian students had a higher perception. Nevertheless, a one-way ANOVA (1, 119, 120) showed that differences are not significant.

The differences between the mean values are illustrated in Figure 1.

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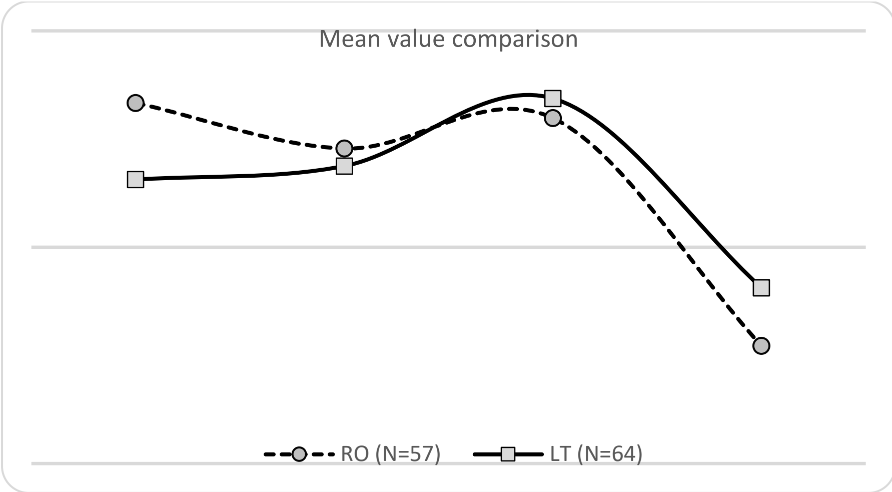

Figure 1: Students' satisfaction with the online education.

Regression Analysis

The overall satisfaction (S) was regressed on the variables S1, S2, and S3. The results for the Romanian sample are presented in Table 2 (standardized regression coefficients β and their significance, R^2, and adjusted R^2). The multiple correlation (R = 0.577) for regression was significantly different from zero (F (3,53) = 8.811, p < .0001). Only one predictor was statistically significant: satisfaction with the lower risks for health (p = .018).

Table 2: Regression analysis – Romanian sample (N = 57).

Variable	Coefficient	Standard err	*t*-value	*p*-value
Intercept	0.841	0.720	1.167	.248
S1	0.241	0.202	1.190	.239
S2	0.170	0.184	0.924	.360
S3	0.352	0.144	2.450	.018
R^2=0.333, Adjusted R^2 = 0.295, F(3,53) = 8.811, p =.0001				

The results for the Lithuanian sample are presented in Table 3. The multiple correlation (R = 0.727) for regression was significantly different from zero (F (3,60) = 22.412, p < .0001). Two predictors are statistically significant: satisfaction with the physical comfort of online activities (p = .0041), and satisfaction with the lower risks for health (p = .0001). The adjusted R^2 value indicates that 50.5% of the variability in overall satisfaction is predicted by the independent variables.

Table 3: Regression analysis – Lithuanian sample (N = 64).

Variable	Coefficient	Standard err	*t*-value	*p*-value
Intercept	-0.278	0.639	-0.435	.665
S1	0.407	0.136	2.986	.004
S2	0.099	0.125	0.797	.429
S3	0.516	0.126	4.107	.000
R^2=0.528, Adjusted R^2=0.505, F(3,53)=22.412, p = .0001				

In both countries, the reduced risks for health had a significant influence on the overall satisfaction with the online education system.

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Students' Position on the Preservation of Online Activities after the Pandemic

The frequencies are presented in Table 4. There are significant differences between the two samples except for two cases: lectures and group projects. In all other cases, there are significant differences between Lithuanian and Romanian students.

Table 4: Comparison between Romanian and Lithuanian students.

Online activities	LT		RO		ϕ_1 - ϕ_2	Fisher criterion	
	N	%	*N*	%		$\phi_{empir.}$	*p*
Lectures	53	82.8	45	78.9	2.286-2.187	0.54	> .05
Seminars	13	20.3	35	61.4	1.801-0.935	4.75	< .001
Individual projects	29	45.3	36	63.1	1.836-1.477	1.97	= .024
Group projects	18	28.1	20	35.1	1.268-1.117	0.83	> .05
Homework assignment	6	9.4	37	64.9	1.873-0.623	6.86	< .001
Debates	8	12.5	18	31.5	1.192-0.723	2.57	= .004
Consultation	41	64.0	22	38.6	1.855-1.341	2.82	= .001

As it could be noticed, in both countries most students liked so much the online lectures and would like to be preserved after the pandemic. In fact, this activity was preferred to be kept in an online format by 78.9% of the Romanian students and 82.8% of the Lithuanian students.

The results indicate that, at this level of training, the master students (from both countries) proved an important range of developed learning skills, intrinsic motivation, and a high degree of autonomy. They effectively manage their resources that facilitate their learning thus the teacher intervention is oriented on guiding the learning process. On the other hand, those results may indicate that teachers were focused on the quality of the lectures and taught materials - they adapted the courses and teaching methods, based on the students' feedback, to become effective. The Romanian students also emphasized (in a consistent proportion - 61.4%) the seminars, as important activities for consolidating their knowledge.

Apart from lectures, more than half of the Lithuanian students mentioned the consultation (64%). The Romanian students mentioned this activity in a less proportion (38.6%), although they can benefit from such activities on request, offered free of charge by teachers, on a pre-set weekly schedule.

Three other online activities were mentioned by more than half of the Romanian students: homework assignments (64.9%), individual projects (63.1%), and seminars (61.4%). Those high percentages indicate the preference of Romanian students for activities that involve individual work (projects), homework, individual study because it gives them the freedom to perform at their own pace, to set priorities related to their personal and professional development, in-home comfort, minimizing the risk of illness.

The differences on all those levels between the Lithuanian and Romanian students can be the expression of the differences between the educational systems, policies in the field (applied to both countries), different visions regarding education and professional training, cultural and national specificities.

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Summarizing the results, we appreciate that Lithuanian students want to keep fewer activities than those carried out online, in the order of their importance: lectures (82%), consultation (64%), and individual projects (45.3%). The Romanian students claim that a series of activities can be maintained post-pandemic: lectures (78.9%), homework assignments (64.9%), individual projects (63.1%), and seminars (61.4%).

In strong agreement with Urbonienė et al. (2019), the master students must fulfill different roles and statuses, combining professional life with family and study - learning at the right time, in the right place, having the freedom to choose their own way of learning, and accessing the content of a course through various technological means and its use in various forms. All those are seen as advantages of online education, opening up multiple opportunities.

DISCUSSION

The study aimed to determine the satisfaction of postgraduate students with distance learning, as well as to find out their position in assessing various educational activities that could remain (be continued online) in the post-pandemic period. In other words, this research analyzed the master students' satisfaction with the online activities during the pandemic on two samples, one from Romania and another from Lithuania. Four indicators have been analyzed: the overall satisfaction, satisfaction with physical, comfort, flexibility, and reduced health risks of online activities. The findings show a high level of students' overall satisfaction with non-significant differences between the two samples.

Even though the study was conducted during a pandemic period, when essentially the entire study process takes place remotely, the results also correlate with previous studies. For example, a study in the United States in 2001 showed that student satisfaction in online courses was influenced by three constructs: instructor variables, course management, and technical issues (Bolliger & Martindale, 2001). Similar results were obtained in another study that showed that students in the online program were satisfied with the courses (Roach & Lemasters, 2006). A study in which students in the social sciences participated showed that satisfaction was determined by two essential factors - the course design and the learning content (Barbera et al., 2013). Of course, it cannot be said that everyone is completely satisfied with online studies. Some studies show that satisfaction with online studies is not high. A study involving Moroccan university graduates showed that the majority of students would like to resort to hybrid education instead of online classes (Jami, 2021), in other words, their satisfaction is not high. Finally, a study conducted in Rwanda revealed that fully online learning in particular subjects such as mathematics and science had more disadvantages than advantages (Nsengimana et al., 2021), resulting in relatively low student satisfaction with studies. Other researchers, meanwhile, argue that online learning has more advantages than disadvantages, and students are very satisfied with this mode of study (Elfirdoussi et al., 220).

It was found that Romanian students scored higher on satisfaction with the physical comfort of online activities, reduced health risks, and flexibility. This is not surprising, since a previous study (Manea et al., 2021) revealed several personal advantages of remote education, such as the comfort of learning from home, time flexibility (no travel), more time for other activities, and money-saving.

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The study also revealed that graduates had different views on online activities that could remain after a pandemic. Although most students agree that lectures could remain the predominant activity, their positions differed on activities such as group work projects, homework, debates, and counseling. According to researchers, there is a need to assess the context of studies and anticipate potential challenges after a pandemic (Fernández-Sánchez & Silva-Quiroz, 2021). This is associated with both external and internal challenges (Manuel et al., 2021) that relate to pedagogical and organizational issues within the learning process in the university.

Thus, the research broadly confirms that postgraduate students (especially in the social sciences study programs) are satisfied with their online studies. Covid-19 pandemic accelerated the adoption of online education by higher education institutions (Cejas Martinez et al., 2021).

Since this is a pilot study, there are inherent limitations. A limitation is the small number of observations in each sample. Another limitation is related to the unbalanced gender distribution of both samples, female students being the large majority. As Flores et al. (2021) found, female students reported higher levels of satisfaction with emergency remote teaching.

CONCLUSIONS AND IMPLICATIONS

This pilot study contributes to the identifying of the level of satisfaction recorded by two samples of master students concerning online education, during the pandemic, and also to the understanding of the factors that can contribute to streamlining the educational process in the academic environment.

Online education has opened windows to various opportunities, unlimited time, space, or means. In this context, the beneficiaries' satisfaction represents a variable key that can differentiate between success and failure, but also a qualitative variable according to which higher education institutions rethink and adapt strategies in the short, medium, or long term. The students' satisfaction contributes to increased motivation for learning, deep involvement, and high performance in the study; it generates proactive behaviors, self-confidence, and an increased interest in knowledge.

The global post-pandemic education will screen and integrate models and good practices from this period, in which innovative solutions and ways to streamline learning have been researched and experimented, capitalizing on the paradigm focused on students' needs.

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Use of Indigenous Knowledge in Education

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Abstract

The aim of this research is to identify the traditional knowledge that indigenous peoples in many parts of the world use for education in combination with the so-called scientific, or Western approaches, typical of developed countries. This area is mapped in the paper and there are examples of specific educational activities based on these approaches, that is, largely on traditional (or indigenous) knowledge. The paper attempts to generalize the view of traditional knowledge, especially by analysing the similarities and dependencies found between the identified knowledge. It describes some possible procedures and methods, which are based on traditional knowledge and which in connection with modern science can or could serve as an additional tool usable at various levels of education. Using several recent interesting approaches to integrating indigenous knowledge into various educational programs, we intend to emphasize their potential importance even in such countries where typical indigenous communities can no longer be fully identified. We believe that enriching study programs with traditional knowledge, typical of a given locality, will lead to a better understanding and deepening of people's relationship with the environment in which they live and operate, which will undoubtedly contribute to better environmental sustainability.

Keywords

Education. Sustainability, Indigenous communities, Indigenous knowledge.

INTRODUCTION

In recent years, traditional or indigenous knowledge has come to the forefront of interest, especially in underdeveloped or developing countries. This concept can often be encountered in developed countries, where the question of their possible integration with relevant areas of contemporary science is often examined.

Indigenous knowledge is an example of the importance that knowledge has had and continues to have for humans. This is a very specific subgroup of knowledge, which is not so often mentioned in connection with knowledge management, and therefore there is still no significance of their importance or the very existence of such awareness.

Indigenous knowledge is based on a very detailed and developed worldview of a particular group of people and relates to a large extent to methods and practices specific to that group. The precondition for the emergence of this type of knowledge can be seen in the continuous interaction with the environment in which the community has existed for

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many consecutive generations. Therefore, indigenous knowledge has a strong link to the respective cultures and represents the specific lifestyles of the populations with which they are inextricably linked (Shaw, Uy and Baumwoll, 2008).

According to UNESCO (2017), this unique knowledge and skills are important aspects of global cultural diversity and form the basis for appropriate and long-term sustainable development in the respective localities. Indigenous knowledge includes a lot of evidence mapping man's long relationship to the environment, soil, water, weather and other natural forces (Bruchac, 2014).

In this paper, we shall try to define the concept of traditional knowledge, emphasize their potential for their use, and last but not least, draw attention to the possibilities of their use in education. The inclusion of indigenous knowledge in education is not only important in the so-called underdeveloped countries, but also in developed communities, where it promotes an awareness of nature and sustainability issues. We shall illustrate the use in education on several relevant examples.

INDIGENOUS KNOWLEDGE

How can we define the concept of traditional (or indigenous) knowledge? What exactly is it, and how does it differ from other types of knowledge? What can they be used for? In this chapter we will try to answer the above questions.

Anwar (2010) describes the characteristics on the basis of which traditional knowledge differs from other knowledge, as follows:

- are local, holistic and rooted in the daily life of a community, which they also unite,
- it is experimental rather than theoretical knowledge, which is obtained on the principle of "trial and error",
- their acquisition takes place by constant repetition, which helps to consolidate and preserve them,
- they are subject to constant change, so they are highly adaptive, they are still being created, but they are also being lost,
- they allow a quick response as they focus on practicality,
- their sharing takes place to a much greater extent than other forms of knowledge, but the amount of knowledge shared and its nature may vary between individuals, depending on age or gender,
- the vast majority of them belong to the group of implicit, but rather tacit knowledge,
- are transmitted orally or through imitation.

Knowledge transfer is thus a very personal process based on the principles of direct communication, whether verbal or nonverbal, between master and disciple, parent and child, from neighbour to neighbour or between the clergy and the whole village (Lodhi and Mikulecký, 2010), (Lodhi and Mikulecký, 2011).

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Bruchac (2014) adds that members of a particular community usually share a range of general knowledge and traditional ways of understanding associated with the day-to-day activities of the community, but there is also specialized knowledge that only selected people have within the community. These people have long been interested in them and have deep experience, they can be clan leaders or healers, but in general they are people who are highly respected in their communities. However, although they have strong predispositions to master this specific knowledge, they usually have to undergo many years of training in the field.

The use of traditional knowledge in practice is really wide, as it arose from a detailed understanding of virtually all aspects of the environment. Today, society is slowly realizing that the biggest mistake is to consider them obsolete, unchanging, and therefore useless.

However, the gradual return to traditional knowledge is mostly driven by efforts to address global challenges, such as the environmental crisis and the dwindling supply of many natural resources. As the way of life of indigenous peoples has not significantly affected their associated ecosystems, traditional knowledge can be seen as the basis on which the further development of not only indigenous peoples but the whole of global society will take place. According to a number of authors (eg. Chikaire et al. 2012), it is a matter of course for indigenous peoples to develop in a sustainable way, as they believe that human society consists of three basic elements - *"of those who were here before us, of those who are here with us now, and also of those who will be here soon."*

MANAGEMENT OF INDIGENOUS KNOWLEDGE

Indigenous knowledge management strives for the systematic management of traditional knowledge, which should prevent its loss. However, the main obstacle is the lack of formal expression options, in many cases due to the tacit nature of traditional knowledge and the inability to formally express it. However, this is absolutely necessary for their management.

The first initiatives of traditional knowledge management were based on classical knowledge management and were based primarily on the use of information technology by the original inhabitants themselves, which, however, later proved to be the wrong approach. Lodhi and Mikulecký (2010) state that modern technologies should be used minimally by the indigenous people, and only in necessary cases when their use will make traditional systems more durable. According to Senanayake (2006), most knowledge disappears precisely because it is disrupted by foreign technologies and concepts that promise solutions, but are unable to sustain in the long run.

The above is confirmed by a number of studies, for example, a group of farmers in Tanzania have been provided with tools to facilitate knowledge work, and although they have been willing to use radio and mobile phones to some extent, they still prefer face-to-face communication. At the same time, none of the farmers thought of using these technologies to preserve knowledge. The use of the Internet and other more advanced technologies for communication has proved to be completely pointless (Lwoga, Ngulube and Stilwell, 2013).

However, it is still not entirely clear whether it is at all possible to express this indigenous knowledge in a comprehensible way, given its characteristics, and to convert it

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from a silent form to an explicit form. There is still no uniform approach to recording indigenous knowledge, but this is usually done through diagrams, maps, taxonomies, decision trees, calendars, but also dances, stories, songs, drawings and other folklore formats. If the tacit nature of the knowledge does not allow such recording, at least information concerning the individuals or groups who have the knowledge must be kept, as well as information on the location of this source (Sarkhel, 2017).

Anwar (2010) argues that the process of recording traditional knowledge will never fully preserve all knowledge in detail, especially due to its quiet nature, and that the recorded knowledge will always be to some extent impoverished. However, it is important that they are not completely lost. The famous quote by Amadou Hampâté Bâ emphasizing the importance of preserving indigenous knowledge, says that "*when an old man dies, it is as if the whole library has burned down.*" (The World Bank Group, 2004, p. 208).

However, indigenous people still use information technology only rarely and the vast majority cannot afford it, so the storage and dissemination of indigenous knowledge should not take place electronically, as it would widen the gap between indigenous peoples, the population and the rest of society. Materials in the form of printed brochures and newsletters are usually distributed to the poorest indigenous people, and practical lectures and seminars have proved useful for people who cannot read and write (Sarkhel, 2017).

Above all, a wider awareness of this issue can help indigenous peoples, in which educational institutions can play a key role. Incorporating indigenous knowledge into academia will also make students respect their own cultures, traditions and identities, and if young indigenous people meet on a personal basis, they can become a major source of knowledge for the development of their communities (Mwantimwa, 2008).

INDIGENOUS KNOWLEDGE AND EDUCATION

We believe that traditional knowledge can play a very important role at least in the distance education of those communities which, due to their large territorial distribution, can hardly be educated in person. Here, the concept of indigenous (traditional, local) knowledge must be constantly respected and increasingly integrated into education. There are many other examples of the use of indigenous knowledge for educational purposes, where enriching mainstream teaching with topics related to traditional, local knowledge makes sense and brings benefits. Below are some examples from around the world of how indigenous knowledge and their role in education at different levels are viewed in different parts of the world.

Let's start with a quote that will allow us to understand the motivation to use indigenous knowledge in education.

Native people may need to understand Western society, but not at the expense of what they already know and the way they have come to know it. Non-Native people, too, need to recognize the coexistence of multiple worldviews and knowledge systems, and find ways to understand and relate to the world in its multiple dimensions and varied perspectives (Barnhardt and Kawagley, 2005)

(Demssie et al, 2020) argue that identifying and promoting sustainability competencies is an important step towards a socially, environmentally and economically sustainable

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world. There are several major international initiatives that identify sustainability goals and that recognize the key role of education in achieving these goals. Education for sustainable development tends to confine itself to traditional Western educational approaches without making meaningful use of indigenous knowledge. Awareness that indigenous knowledge has the potential to facilitate learning for sustainable development is gradually deepening. It is therefore essential to link learning with the cultural and historical identity of students and the local environment in which learning takes place.

As stated by Botha (2010), many efforts to create state-of-the-art curricula have resulted in curricula based on modern scientific knowledge, but indigenous knowledge systems have played a very marginal, even exotic, role here. However, the situation has been improving in recent years. According to (Hewson and Ogunniyi, 2011), new curricula in South Africa, which can be called innovative, require students to learn science in the context of their social and cultural knowledge and 30% of curriculum content to be devoted to local content and context. These reasons led to the design of several domestic knowledge topics that could be relevant to students in the classroom. Examples are ethnobotany (eg healing properties of aloe); recommended practice of drinking water only when the sound of creeping or dripping is heard; and ways to avoid being struck by lightning.

In Australia, indigenous peoples are still seeking equality in education. Research (Woodroffe, 2020) has shown that understanding the importance of indigenous knowledge for indigenous peoples and applying this understanding to teacher education programs would create an environment to promote engagement and participation and improve educational outcomes for indigenous students.

Regarding the situation in Taiwan (Lee et al, 2012), there is evidence that most indigenous families want their children to be well prepared to participate in Taiwan's majority society, but at the same time they want their children to retain their original identity, worldview and tribal beliefs. This means that indigenous students must learn Western science in the same way as non-native Taiwanese students. Therefore, a balance must be struck in science classrooms between indigenous students who respect and acknowledge their original way of understanding nature in the classroom content. Such a balance in science subjects in primary school during one year of teaching may be about 10% indigenous knowledge and 90% Western science knowledge in the curriculum. The wisdom of indigenous knowledge is based on respect for nature, mostly due to the relationships of indigenous peoples and their responsibility to nature. Indigenous learning can help children recognize this intimate connection between humans and nature (Lee et al, 2012).

According to (Dalvit et al, 2008) Informatics promises a lot to future students in Africa. However, because most computer-related knowledge is produced and consumed in the West and conceptualized in European languages, it inevitably reflects Western assumptions and ways of thinking. This makes it a difficult subject for study for many African students who, in addition to having difficulty accessing the necessary infrastructure, also do not know the paradigms that make up the discipline. The integration of African indigenous knowledge into computer science teaching can help bridge this gap, concludes (Dalvit et al, 2008).

The central thesis of the research into the possibilities of using indigenous knowledge in education is the tension that exists between the original indigenous knowledge passed on for generations and the hegemonic dominance of the paradigm of Western science. Both

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approaches contain ways of knowing the world, however, both approaches differ in their view of what is considered *evidence* (Dentzau, 2018).

Proof that it is appropriate to enrich by indigenous knowledge also doctoral studies, is a conceptual framework, based on traditional knowledge, created for the innovation of doctoral education in social work. This conceptual framework was described in an article by Hertel (2017), which herself comes from a community of Native Americans in North Carolina.

From the above, it can be concluded that traditional knowledge can play a fairly important role in education at all levels. They help to build students a stronger relationship with their localities, to gain a connection to environmental sustainability, to use the conditions provided by nature, but at the same time to ensure that natural resources do not devastate and are preserved for as long as possible for future generations.

CONCLUSION

It is generally believed that the importance of traditional knowledge decreases in indirect proportion to the degree of development of a country. Underdeveloped or less developed countries include a number of indigenous communities, often independent of each other, but communities that have been developing and preserving more or less of their traditional knowledge for many generations.

Gradual awareness of the importance of environmental protection not only in places that have inhabited communities for centuries, but also more generally around the world, has led to intensive research into traditional content and the possibility of preserving it as a valuable ancestral heritage for future generations. It is worth noting that the indigenous population has lived in perfect harmony with nature for ages. Over a long period of time, these populations have gained knowledge of the inner workings of their immediate surroundings or environment. This indigenous knowledge provides the basis for indigenous innovations and experiments. Indigenous knowledge transfer takes place mainly orally, mostly not in writing. If we observe two forms of knowledge, the latest science seeks to understand the whole from the pieces, while indigenous knowledge sees things as wholes. Modern science is considered objective, while indigenous knowledge is intentionally subjective and sees human beings as part of the whole. Indigenous knowledge is strongly tied to local culture.

We believe that the introduction of sustainable development issues at all levels of education can undoubtedly contribute to a higher level of awareness of both our local identity and the need to use natural resources in a sustainable way. Further targeted research and related analysis of the practical implementation of this concept in teaching is needed to demonstrate all of the above. The importance of traditional knowledge must no longer be underestimated.

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Developing Logical Thinking of Computer Science Students – Modelling the Curriculum and Teaching Environment

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Abstract

Logical thinking is a cognitive ability that underpins the understanding of many hard sciences, computer science subjects, and the performance in the fields related to these subjects. It is a lack of consensus, however, as to what constitutes logical thinking, and whether the education system nurtures or hinders its development. If we can understand these aspects, maybe we can start improving the process of developing logical thinking in our students. This research is a qualitative study, using 12 semi-structured interviews with 13 questions, in total duration of 616 minutes, to investigate the perceptions of 5 female and 7 male teachers from three Romanian technical universities about the process of developing logical thinking of their students. The benefit of answering this research question is that we can learn how we could address the systemic gaps to increase the students' performance in technical fields. The study takes an approach of analysis based on Uri Bronfenbrenner's bioecological theory, to look into themes from the micro and meso systems of Bronfenbrenner's model. Three major themes were identified to answer the two research questions, which identify systemic gaps on how logical thinking is mainly hindered in the child's early development, leading to insufficiently developed skills in students entering college that make the learning exercise difficult and increase the drop-out rate. At the same time, the study identifies paths to improve the teaching of technical subjects, and the perception of needed abilities and traits in students applying for technical majors.

Keywords

Logical thinking, Teaching technical subjects, Teaching effectiveness, Student performance.

INTRODUCTION

Several important questions in the field of informatics can be raised in relation to the impact of scientific thinking in general, and, in particular, of information technology (IT) on the development of our society. There is no debate on whether IT has a role in the development of our society through the apport of computer technology fuelling economic development through changes in industries, advancements in theoretical and applied scientific fields, and social changes triggered by the skills IT field develops and requires from people to support the changes in the very fields mentioned before. However, there is an ongoing discussion on how to best implement educational programs to reach more

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individuals and develop this new set of skills in children and adults alike, not only at an operational level (e.g. being able to use applications on a device, operate digital devices from a front-end perspective, etc.), but at a conceptual level, by developing their logical and scientific thinking. The importance of this act is recognized by researchers and experts working in industries relying on or developing autonomous machines and deep learning artificial intelligence (AI). Particularly for programming, logical thinking is required in the building of logical strings of code which (Milkova, 2014; Milkova, 2011), in turn, are the building blocks of functional, useful, and, hopefully, efficient, and ethically built applications.

Jan Piaget' cognitive development theory is the most used framework in research, and it proposes that cognitive development is an internal cumulative process. In Piaget's view, children develop their skills and cognitive functions by adding through experience knowledge which becomes the basis of further acquisition of knowledge and skills (Milkova, 2015; Wood, Littleton and Sheehy, 2006; Oates and Grayson, 2006). Developing abstract and logical thinking is mainly a matter of age according to Piaget, and there are given, biological-bound limitations to what types of knowledge and skills can a child comprehend and master at each age (cf. Milkova and Pekarkova, 2021; Berk, 2010; Feldman, 2010; Wood, Littleton and Sheehy, 2006; Oates and Grayson, 2006

Vygotsky (1962) research focused on the mediation role of language in developing children's cognitive abilities partially answers Piaget's question about tchild's drive to explore and test hypotheses, however incipiently structured, particularly when applied to scientific thinking. Vygotsky dedicated his later years to the research of thinking and speech. "Language is a tool that can magnify and strengthen cognition and that can have many crucial effects on the overall development of thinking" (Vygotsky, 1997). He firmly believed that nurturing a child's understanding through structured and targeted explanations and questions from a trainer (teacher, parent, older sibling, etc), which he coined "scaffolding", can lead to an easier transition into superior reasoning skills. Vygotsky's model of development of reasoning skills better explains the differences between children's performance in scientific thinking than Piaget's age stages can (Berk, 2010; Feldman, 2010; Wood, Littleton and Sheehy, 2006; Oates and Grayson, 2006; Vygotsky, 1962; Wells, 1994).

These classical theories have their merits, as well as limitations. A model which tries to integrate these views is Uri Bronfenbrenner's Process-Person-Context-Time model, as part of his bioecolgical theory of development. Bronfenbrenner proposed that the development of any skill in children and adults alike is a more complex matter.

Bronfenbrenner's model has 5 interdependent systems which affect the way experience (as information processed by the unique processing pattern of the individual) is understood, internalized, and transformed into values and beliefs that underpin further information processing, behaviour and decision-making, thus influencing the entire development of the individual (Rosa and Tudge, 2013; Bronfenbrenner and Evans, 2020). These systems are: the microsystem (items in direct proximity and interaction with the developing individual); the mesosystem (the interactions between two or more microsystems); the exosystem (the system indirectly affecting the individual's development); the macrosystem (e.g. political, educational, social systems); the chronosystem (important historical events influencing the dynamic of the setting in which the developing person is active).

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The role of the individual and the context in one's development was outlined in more detail in his latest theoretical framework, introducing the proximal processes as the driving force of the development, as transforming agents from genotype to phenotype, for promoting competences or creating a maladaptive, dysfunctional pattern of behaviour. The Process-Person-Context-Time model (PPCT) is trying to capture the complexity of the human development Bronfenbrenner recognised the difficulties of researching such a complex reality (Rosa and Tudge, 2013; Bronfenbrenner and Evans, 2020), such is cognitive development. Bronfenbrenner identified many factors influencing the development of our cognition, such as parenting style, genetics, or social policies on the child development (Bronfenbrenner, 1995; Bronfenbrenner and Ceci, 1994). Thus, researching the ecology of logical thinking using the PPCT model must consider certain mandatory characteristics from each of the five levels of the bioecological model which can either encourage or discourage the interaction with and reaction from the environment, and that can promote or obstruct psychological growth. Some of the factors at play appear in the contexts in which these logical thinking develops systematically, and where it is repetitively and rigorously tested, which is the education system.

One aspect in need of clarification in studies of logical thinking development is the use of terminology. McAloon (1966) recognizes the term "logical thinking" is used with an ambiguous content, while Buchsbaum, Pequeno and Pequeno (2007) propose that logic and reason are different concepts and use actual logical functions to demonstrate logical reasoning is different than scientific thinking and how scientific thinking, even in the field of AI which proposed a common-sense reasoning applies to learning. Buchsbaum, Pequeno and Pequeno (2007) conclude that real reasoning is complex, and it may lead to contradictions in the deductive process or in the inference chain of propositions. This phenomenon affects all fields, but mostly social sciences. This is why logical thinking often overlaps in research with scientific thinking, mathematical thinking, algorithmic thinking, and computational thinking, all of which make use of logical operations, but for purposes which usually are domain-specific.

Teachers are the critical agents in developing logical thinking in their students and they shape both the method and the structure of the teaching exercise. Thus, the question that emerged from the reviewed literature was how teachers of subjects which develop and make most use of logical thinking perceive these aspects of logical thinking, namely, the definition and the factors of influence in its development.

The research questions of this study are: How do teachers in technical universities perceive the process of developing logical thinking in their students? How do teachers in technical universities define the term logical thinking?

This study looks into the micro and meso systems of logical thinking development of higher education students, per Bronfenbrenner's bioecological theory to answer the proposed research questions.

MATERIALS AND METHODS

Research Study

The study has a qualitative research design. The data collection is designed as a semi-structured interview with one interviewee at a time. The questions are posed in the same

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sequence to each participant with clarification questions sometimes being asked in between the core questions.

The interviews lasted between 19 minutes and 126 minutes, with an average duration of 52 minutes. The total duration of all 12 interviews was 616 minutes. Certain sections from some interviews, which were unrelated to the asked question, or that the interviewee asked to be excluded from the report, were not considered in coding, but they are counted in the overall duration. The interviews were conducted in Romanian, the native language of both the participants and the interviewer.

The transcription of interviews was performed manually by the author, using OTranscribe web platform. The transcripts were saved in MS Word format, in a lined document. The used quotes in the Results section are identifiable by the text line in the interview. After familiarising herself with the content, the author performed three levels of coding. The coding and the research report were written in English.

The materials and applications used were: iTalk recording application on the interviewer's phone, the interviewer's personal laptop, Zoom application, OTranscribe.com, MS Office, informed consent forms.

The data analysis is performed using a thematic analysis of the interviews' transcription at both a semantic and latent level, following the procedure described in Braun and Clarke (2006).

Research sample

The participants were recruited through the official university database using an official invitation to participate, sent by the research project coordinator. The respondents willing to participate in the study contacted the author (and interviewer) and a time, place and channel for the interview was agreed.

The participants were 12 higher-education (HE) lecturers and professors, 5 females with 1-15 years of teaching experience (average 7.6 years), and 7 males with 2-14 years of teaching experience (average 8.1 years). Due to the COVID-19 pandemic, 6 interviews were conducted via Zoom, and 6 face-to-face. The audio recordings were stored in a password-protected location. Each participant was properly informed by the interviewer (and author of this report) of their rights as a participant in the study and was asked to sign an informed consent form. The study was designed and conducted in accordance with the British Psychological Society Code of Ethics.

RESULTS

The questionnaire has 13 questions and some of them elicited answers more relevant for the first research question than for the second. However, the identified themes use data from answers to several questions, which may be solely assigned to one theme or to more themes. The questionnaire questions are:

Q1. How would you define "logical thinking"?
Q2. How does logical thinking translate in students' performance, at its best and at its worst?

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Q3. How do/does the subject(s) you teach support the development of logical thinking of students?
Q4. How does the Romanian education system support/hinder the development of logical thinking of students?
Q5. What should a first-year student already know in order to perform well in classes making the most use of logical thinking?
Q6. What traits, skills and knowledge should students have so (or are useful for students) that they can graduate from your faculty and perform well in this field of work?
Q7. What do you take into consideration when evaluating the performance of a student?
Q8. Does your university/faculty offer classes to develop those traits and skills needed to understand/master technical subjects?
Q9. Can you characterise the most performant student you have/had? In your evaluation consider all the information you have about them (e.g. background, context, behaviour, etc.)
Q10. Can you characterise the least performant student you have/had? In your evaluation consider all the information you have about them (e.g. background, context, behaviour, etc.)
Q11. Does your university/faculty have a measurement system for the work performance of undergraduates/graduates, such as salary, seniority, innovation-related performance or other?
Q12. How do you think academic performance academic performance translates into work performance and quality of life for the students graduating from your university/faculty?
Q13. Do you have anything else to add about the factors influencing the development of logical thinking of Romanian students?

Only two questions elicited less relevant information for the investigated research questions, namely, questions 7 and 11.

In answering research question 1, there were two themes identified.

Theme 1: The current systemic gaps to developing logical thinking (identified in the answers to questions 2, 3, 4, 8, 9, and 10)

Question 2 reveals that the interviewees believe the current gaps in the Romanian education system are visible in how logical thinking is translated in the performance of students. Many participants named the following manifestations of poor logical thinking: the lack of, or poor, abstract thinking; chasing good grades instead of knowledge and skills; lack of critical thinking.

"I can see that, when people can make inferences fast they also have a faster pace of learning […] they can adapt easily to changing conditions.. […] it's different when the person didn't understand the principles [… they cannot prove them themselves, it's harder to adapt to those.. to those questions or problems.." (Steve, 46-51)

Question 4 points to the systemic causes of the manifestations expressed at Q 2, among which the respondents named: the incentive system which motivates student to target grades instead of knowledge; teaching skills that do not connect theories with their applicability; transferring information instead of explaining it logically; measuring the ability

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to reproduce information instead of comprehension; including in the curriculum subjects without use in the workplace; large differences between rural and urban schools in terms of equipment and instructors' experience; cultural dimension reflected in the level of scholastic honesty of students and teachers alike.

".. in primary school, one of the problems I see is that at certain times there is too much information taught without a logical process…[..] it develops a mechanism of repeating information, but not of actually thinking." (Danny, 70-74)

Question 8 asks whether, in the current education system, the HE offers courses to bridge these gaps in the skills and knowledge of students, but on reflection, most participants stated there was no such class. Certain programs design to cope with the high drop-out rate in the first years of technical HE programs, were not popular and not visibly effective.

"I don't know what to say… but, I mean, I would have to say "No". Mainly.. nuh, not really. No, there are only the [program] subjects. […] And I think we work on the premiss that they, I don't know, they are rather filtered at the entrance procedure." (Frank, 245-247)

Questions 9 and 10 ask about the best and worst performance of students and, surprisingly, logical thinking is not vital for either good or bad performance. The student's motivation, curiosity and perseverance are more often named as critical factors for performance. Most answers focus on the internal motivation and perseverance as the driver for a good performance, and the lack of motivation and resilience as the cause of a bad performance in the subjects taught by the respondents.

"There are these [students] who are passionate about the subject, about technology, and want to learn more, they come to university or attend separate courses for this." (Emma, 203-204)

"..are those who don't care.. […] They don't come to classes, not even.. Basically, they lack interest [in the field] […] I imagine they are forced to come here by parents or other circumstances." (Mark, 767-774)

Theme 2: Improving the effectiveness of our teaching system (identified in the answers to questions 5, 6, 8, 9, 10, 12 and 13)

Question 5 asks about the pre-requisites of a good performance in subjects more heavily focused on logical thinking. Essentially, the participants indicate what students should have learned well in the pre-university educational system to perform better in their classes. The most frequent theme is mathematics, followed by physics and informatics.

"But, overall, what unifies our universe is still mathematics, we could say. Meaning, if you have a logical analytical thinking, as a premise to understand things, you'll do well." (Ross, 157-159)

Following on this thread of inquiry, at question 6 the participants are asks about the skills the students should have sufficiently developed to graduate from technical universities and perform well in the workplace in this field. Their answers indicate there is a combination of soft and technical skills, and personality traits that influences performance.

"..Good communication skills, fast problem-solver.. […] to adapt well to a team. […]..a good combination of communication, technical abilities, creativity, research skills. […].. Oh, and a balanced lifestyle.." (Simon, 289-296)

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However, at question 8, as presented in Theme 1, many of the respondents revealed there aren't classes that develop these useful skills for students . If there is any, its content is not known to everybody, but they are desirable in a better education system.

"We have a personal development class, something like that.. But honestly I don't know what students do there. So, there is something […] in the third year.. Maybe it would be more useful to be taught earlier.." (Denise, 219-221)

At questions 9 and 10 respondents reveal not only the actual good and bad performance of students, as described in Theme 1, but they also characterise the students in these positions. The ideal traits and behaviours are also described in their answers.

"..adaptability.. […] autonomy in problem-solving.. […] 90-95% perseverance.. […] conscientiousness to finish what you started.." (Ross, 193-214)

Question 12 reveals a need to connect better the knowledge and skills developed and measured in academia with the ones needed in the workplace. Most answers reveal that the academic elite is more likely to perform better in the workplace, but it's not a strong correlation between these performances. There are also outliers, with low academic performers being better motivated at work and outperforming high academic performers in the workplace.

"Unfortunately [academic and work performance] are not clearly connected to each other [correlated]. […] I've seen many cases of very good students […] who had grades like extremely high, but in the workplace they couldn't perform at the same level and couldn't cope. And the opposite, too, students with lower grades who then in the workplace did very well." (Renee, 226-229)

At question 13 the respondents were free to present in their own words and logic what they thought about the factors influencing the development of logical thinking in Romanian students. The answers were more heterogenous, but generally they summarised their views on the factors influencing the development of logical thinking in Romanian students as being a complex matter.

"..I think the genetic inheritance is important.[…] my parents were both engineers. […] I think also the background matters, it's important to have a family that cares about you so you can develop. […] What teachers you have matters because they can develop or they can help you develop your logical thinking." (Stacy, 611-619)

Theme 3: It's a broad concept, but logical thinking is discipline-specific (identified in the answers to questions 1, 2, 12, and 13; answers the second research question)

This theme was identified as the main part of the answers to question 1, but it was also identified in answers to question 2, 12 and 13. Whether we are speaking of its definition or how we apply it, logical thinking was not a concept easy to define by HE teachers, even in an unformal way. As aligned with the existing literature, logical thinking was defined using one or more of the following terms: mathematical thinking, algorithmic thinking, analytic thinking, abstract thinking, scientific thinking, procedural thinking or making inferences. The idea of premises and conclusions, which can be reached following a structured process, an algorithm, or sequential steps emerged even from how their process of formulating an answer. The pauses taken in the construction of an answer revealed that at work, research or elsewhere, the concept is taken for granted, but formally it is not defined or assigned a

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theoretical framework. Moreover, the logical thinking measured by academic performance differs from the one in the workplace.

"From my perspective it's about being able to link, in a way that is as natural as possible, the consequences with the elements that generated those consequences." (Jane Bond, 5-7)

"Logical thinking in our faculty is related to ideas and things somehow relatively simple, not with the, say, philosophical problematic." (Richard, 615-616)

The collected data is rich, and it will be analysed further in subsequent studies to answer other research questions, but due to the length limitations of this report only three themes were analysed to answer the study's research question.

DISCUSSION AND CONCLUSION

The interviews revealed a rich picture of what teachers from technical universities in Romania believe the process of developing logical thinking is, based on their teaching experience. The first two themes answer the first research question: How do teachers in technical universities perceive the process of developing logical thinking in their students? and the third theme answers the second research question: How do teachers in technical universities define the term logical thinking?

The first theme revealed the systemic obstacles in the Romanian education system from primary school. The second theme pointed to the desired design of the education system and to a set of traits and skills which would be useful to students of technical universities so that they perform well, especially at subjects employing most logical thinking. The third theme investigates the understanding and use of the concept "logical thinking", that underpins what education systems teach and measure in students.

The data reveals also how teachers' understanding of logical thinking incorporates the existing theories of cognitive development. By supporting an introduction of subjects nurturing the development of logical thinking from primary school, or even before that, teachers go beyond the age groups established by Piaget's model. However, they are also more inclined to believe that high school science subjects are the most useful for developing students' abilities, which are taught in Piaget's the formal operational stage, (Wood, Littleton and Sheehy, 2006; Oates and Grayson, 2006) when children show the highest potential to develop the type of mathematical, scientific, abstract, or algorithmic thinking needed to perform well in technical universities.

At the same time, HE teachers believe that how the material is structured and taught makes a difference in how it is assimilated. It appears that there is a gap in their students' skill of transforming real object into abstract mathematical and digital objects that creates difficulties in assimilating the subject matter. However, for the system optimisation/improvement, the teaching method needs to allow an active teacher-student interaction, as well as the interaction with the content using various applications, and teamwork, which also enhances students' communication skills and their ability to integrate information from other sources into their own solution. This perception of how technical classes should be taught reveals their use of Vygotsky's perspective on cognitive development, as relying on language and scaffolding to perform beyond one's peers level (Vygotsky, 1962; Wells, 1994).

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The results do not stop at classical theories. The education system's design is only one side of the problem and the solution. Another important role is actively played by the students themselves. As recognised by Piaget, curiosity and explorations are a must for the development of logical thinking. And so are certain innate and/or nurtured personality traits and behaviours, such as higher than average intellect, perseverance, openness, resilience, hardworking, etc.. Such traits and skills can be shaped and nurtured through creative exercises that target complex problem-solving thinking, creativity and procedural thinking (Milkova, 2015; Milkova, 2014; Milkova, 2011). Taken together, these findings reveal the micro and meso systems of Uri Bronfenbrenner's bioecological system theory (Rosa and Tudge, 2013; Bronfenbrenner and Evans, 2020), with certain elements from macro system as well, namely, the cultural dimensions affecting the students and teachers' approach to scholastic honesty and failure.

The variety of terms used by the participants to define logical thinking suggests that logical thinking is a broad term that is applicable in different ways to different technical subjects. This diversity of terms is also aligned with the current literature in the field, however scarce, and reveals a need to establish a theoretical framework within which disciplines can more effectively target the development of logical thinking in their related subjects, and the methods to more accurately measure it in school assessments.

Logical thinking is a topic which covers multiple cognitive skills that when used optimally lead to technological, economic, and social progress. Future research can aim investigate the processes which allow logical thinking to develop in humans and to be used optimally in their academic and practical activities, trends which are currently measured by the Programme for International Student Assessment tests in 15-16 year old students. This study is the first part of a larger research project which aims to use quantitative research methods to map the development of logical thinking in students at technical universities using Bronfenbrenner's theory of development. Personality, parental influence, school performance, and culture are among the areas of influence on which the author's future research focuses. Approaching such vital and complex aspects of our cognition needs a realistic framework, which can capture the complexity of reality. Uri Bronfenbrenner's theory meets this requirement and can be useful in a researcher's quest to understand complex human behaviour.

Limitations

There are, however, limitations to the study. The use of a qualitative method limits the sample size, and it is also specific to a culture and context, which separately and together do not allow us to generalise the results in any way.

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Current Issues and Possible IT Solutions for Digital Competence Development

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Abstract

In the COVID-19 period, we had the opportunity to learn about the characteristics and specificities of digital education and the related practical feasibility options in several waves. The first phase was mainly characterised by technological embeddedness and centrality, while the second wave allowed for a fine-tuning of the methodological culture. In the third phase, we had the opportunity to get to know hybrid-based education at first hand, while in the fourth wave we had to adapt and shape to changing needs what we had already experienced. After that, we returned to face to face education, but only within certain constraints and frameworks (Benedek, 2021). In addition to the aforementioned features of the teaching-learning process, we had to face a number of challenges and conditions. A common set of challenges was and at the end of 2021 still is represented by digital competences, which is one of the main focal points of the new European Digital Agenda for Education (2021-27), in addition to providing a modern high-capacity server backbone. The focus of this paper is therefore on digital competences, its role and its potential for development, with a variety of IT solutions in mind. In Hungary, in 2019 and 2020, adapted digital competences frameworks based on the central EU recommendation were completed, the first of which was the digital competences framework for teachers based on DigCompEdu. Teachers' digital skills and ICT attitudes are key to digital education (Szabóné, 2021). This article concentrates on the current role of digital competences and the possibilities for their development, with an emphasis on IT and technology solutions.

Keywords

Digital pedagogy, digital literacy, IT innovations, ICT, DigComp framework.

INTRODUCTION

Today, digital competence development has come to the fore as a result of and in the wake of the Covid epidemic. Although a number of EU efforts, plans and reference frameworks have provided a context for this process since 2013, in our view there have been no real breakthrough and paradigm shift. We are feeling the effects of this, as there are unfortunately many teachers with very low levels of digital competence (Chira, 2020). Although digital competence does not appear as an independent subset of the nine key competences, some indicators measuring ICT competence were previously included in teachers' assessment systems until 2016 (Benedek-Molnár, 2014). While digital competence is now embedded in the key competences, little is known about its assessment, evaluation and development.

In our study, we aim to provide a theoretical framework for the concept of digital competence and its development, and to review and evaluate it in order to identify IT measurement tools that teachers can use to assess, evaluate and develop their own digital competence.

THE NEED FOR DIGITAL COMPETENCE DEVELOPMENT – ITS COMPETENCE DEVELOPMENT POTENTIAL

Education systems worldwide are being modernised to reflect the opportunities and challenges of a digital society. Part of these changes is related to the integration of programming and IT content into primary education. The ways in which this is done can vary considerably from country to country.

The Education Development Guidelines have identified a number of objectives that contribute to the sustainable development of society. One of these was to improve the quality of the educational environment through content development and infrastructure development in order to modernise the education process (Balogh, 2011). Environmental education, as defined in the National Curriculum, is a compulsory element of the pedagogical programmes of domestic educational institutions, with the task of developing environmentally aware attitudes, teaching the concept of sustainable development and organising activities to this end on an ongoing basis (Hankó, 2012). The National Core Curriculum (Nat) also contains references to sustainable development, which is covered in much more depth in the new 2020 version. The Nat formulates the need to educate for sustainability and environmental awareness in the following way: 'The growing generation should know and appreciate the rich diversity of life forms in nature and culture (Szabó et.al, 2021). They must learn to use resources consciously, sparingly and responsibly, with respect for their capacity to renew themselves. The aim is to develop in pupils an attitude of respect for the environment, values and sustainability, based on knowledge and love of nature and the environment. The institution should prepare them to exercise their duties and rights as citizens in relation to the environment. It should seek to familiarise pupils with the economic and social processes that can bring about change and crises, and to involve them in preserving and enhancing the values and diversity of their immediate and broader environment" (p. 10 643). The importance of the subject is mentioned and articulated at relatively many points, but it is more concerned only with content to be learnt in the context of the subjects, and lacks an activity-oriented vision of daily life and the actual environment.

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The new Nat. has integrated environmental and sustainability issues into the curriculum, while remaining within the concept of learning, but does not provide for professional freedom of institutions and teachers (Lükő, 2009).

The wealth of possibilities offered by digital pedagogy can help many teachers to educate for sustainable development. Any of these can be utilized in and out of the classroom in such forms as gamification, mobile applications, Big Data, LMS systems (Balogh et.al, 2019) or various interactive Web 2.0 interfaces.

As we could see, digital technologies now play a key role in our world. Digital literacy is essential in all areas of our lives and work. But not at the same level and in the same way. The public education sphere and the respective teachers have a huge role to play in developing these competences, so it is essential that they themselves become skilled in this area (Orosz-Molnár, 2021). It is not only the task of teachers of ICT and digital literacy to help them do this, but also of teachers of other subjects themselves, as they have to use a wide range of ICT tools and applications in their lessons to learn or solve problems (Gogh-Kovari, 2019).

A major change in teaching will of course take time. The situation of students in different countries, cities, schools and even classrooms will continue to change for years before all teachers have time to make digital literacy and programming concepts part of their everyday work. As the early experience in England shows, adequate financial support is not enough; what seems to be most important is access to high quality, continuous professional development, appropriate teaching materials and support for teachers. In addition, school leadership is crucial, as teachers need time, access to professional development and support to make the most of their new situation and to update their knowledge (Chira, 2020; Szabó, 2019). As self-reporting questionnaire results indicate the primary areas where teachers should improve is content creation and device use. In the European context, the framework for the understanding and development of digital competence (DigComp - European Digital Competence Framework for Citizens) was developed by the European Commission. The aim of the framework was to create uniformity and complexity. It defined and scientifically underpinned what a European digital citizen should be able to do at the given knowledge, skills and attitudinal levels (Vuoricari, 2016). It developed a common European set of values and frameworks, which allocated digital literacy into 21 competence areas alongside five core areas, in an attempt to define the concept as clearly as possible. This model thus gives an overall picture of how we can interpret digital competences as the 5 domains identified should be an important cornerstone in the related developments (Nyitrai, 2021).

In the Hungarian context - the following competency levels have been developed.

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European tools		Domestic tools	
Levels of CEFRL (Common European Framework of Reference for Languages)	**Levels of DIGCOMP** (Framework for Developing and Understanding Digital Competence in Europe)	**Levels of IKER (2015)** (Common Reference Framework for Infocommunication)	**Levels of MKKR** (Hungarian Qualification Framework)
			8
C2	C		7
C1			6
B2			5
B1	B	4	4
A2		3	3
A1	A	2	2
		1	1

Figure 1: Table of digital competences, author's own screenshot

When developing any of these competences, the most important first step is to identify the areas you want to develop. The next stage is the elaboration of a targeted and concrete strategy. In fact, when developing digital literacy, the respective areas are defined by the European Union framework at both learner and teacher level, so we need to choose a measurement tool for specifying the given fields. In order to support this effort, a number of IT-based programmes have been developed. In the following section we would like to present and summarise these measurement tools.

We believe, however, that with the rapid development of ICT tools and the vision of the digital school, a much more complex picture will emerge in the future. Such progress is demonstrated by the use of today's state-of-the-art technological solutions including non-linear curriculum structures, digital resource management, online tests, various collaboration opportunities, electronic whiteboards and digital classrooms.

The five main areas of digital competences, according to DigComp, are:

- Collecting, using and storing information;
- Digital, internet-based communication;
- Creating digital content;
- Problem solving, practical application;
- ICT security.

In the following table, we have structured the IT services and platforms that can be used in education and training to cover the digital competence areas.

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Table 1: IT platforms and services, author’s own table

Competence area	Name of IT solutions	Specific tools, applications
Collection, use and storage of information	Cloud-based hosting, search engines, browsers, databases	For example: OneDrive, ResearchGate, Google, Google Drive, Google Scholar
Digital, internet-based communication	Chat programs, webinar applications, sharing portals, blogs	For example: microblogs, Ustream, Cisco Webex, Google Talk, SlideShare
Digital content creation	Websites, vlogs, video feeds, CMS systems	For example: OpenOlat, Ilias, WordPress, YouTube, Podcast
Problem solving, practical application	Familiar maps, infographics, blockchain platforms, decision graph	For example: BayesCube, Scratch, microbit, Miro, MindUp, XMind, Bubbl.us, Coggle, Piktochart
ICT security	Filtering software, awareness raising, blocking of unsolicited content, internet content flagging	For example: Norton, Norton Family, AdBlock, Cleanfox

TOOLS FOR MEASURING TEACHERS' DIGITAL COMPETENCE

Two major digital tools for measuring digital competences of teachers are widely used in the EU, one is MENTEP and the other is DigCompEdu. These two measurement systems are briefly described below.

MENTEP

The MENTEP (Mentoring Technology-Enhanced Pedagogy) is a self-assessment tool for teachers to assess their digital competence. The tool is an adaptation of the MENTEP TET-SAT (European Schoolnet research project) teacher self-assessment tool, "a major European research project aimed at improving teachers' competence and awareness of the use of Information and Communication Technologies (ICT) in the classroom. The project, which ran from March 2015 to May 2018, explored the possibility of using an online Self-Assessment Tool (SAT) to help teachers develop their competence in Technology-Enhanced Teaching (TET) at a pace of their own choosing." http://mentep-sat-runner.eun.org/dashboard.html

The aim is to assess and analyse teachers' digital competence and, as a result of this process, to develop it. The measuring tools assess 30 different domains in 4 themes, categorised at 5 levels. The system assigns different indicators to each of the four themes and tries to diagnose them. The four main topics covered are:

1. digital pedagogy (domains 1-12 / indicator)
2. use and creation of digital content (indicators 13-17)
3. digital communication and collaboration (18-23)

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4. digital citizenship (24-30)

As a result of the survey (Figure 2.), we can download a pdf document showing our current level of digital competence and areas for improvement.

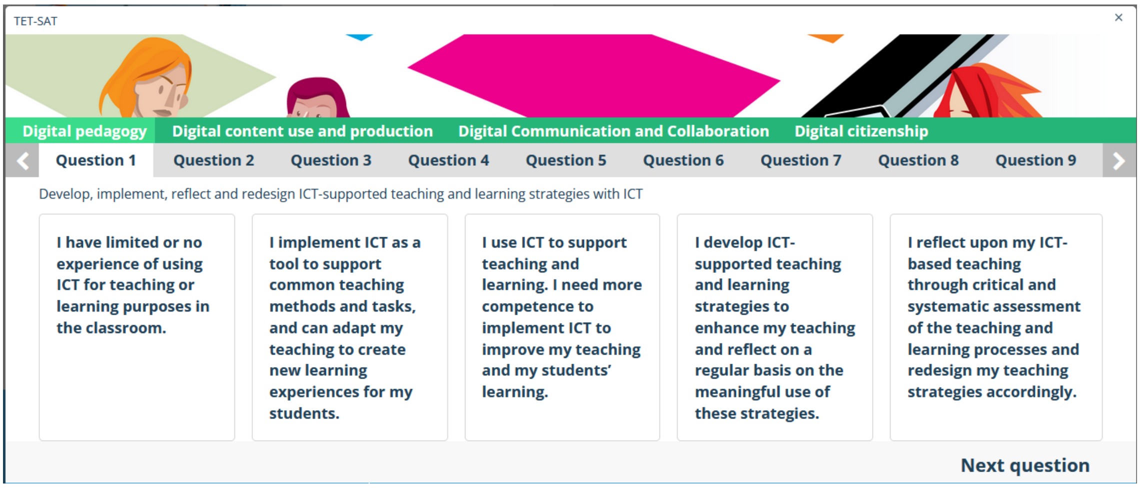

Figure 2: MENTEP platform, author's own screenshot

In the following table we have structured the IT services and platforms that can be used in education and cover the four digital competence areas according to MENTEP.

Table 2: IT platforms and services, author's own table

Competence area	Name of IT solutions	Specific tools, applications
Digital pedagogy	Administration systems, learning support services	For example: Microsoft Teams, Kréta, Moodle, Coospace
Use and creation of digital content	CMS systems and LCMS systems, websites, web pages, portfolio	For Example: edX, Mahara, Canvas Wix, Lino
Digital communication and collaboration	Electronic mail systems, Social media, Webinar systems, Cloud-based presentation software	For example: MaxWhere, Mindomo, Google Meet, Skype, Zoom, Prezi, TikTok, Messenger, Outlook, Gmail, Adobe Connection Pro
Digital citizenship	Social media, Computer software packages, e-government platforms, public service interfaces	For example: OTP Bank online, Erste George, eeszt webpage (Electronic Health Services Space), Ügyfélkapumo.hu (client portal), LinkedIn, Twitter, Pinterest, Instagram, Facebook

DigCompEdu

"This self-assessment tool is based on the European Framework for Digital Competences for Teachers, DigCompEdu. The DigCompEdu defines 6 competence areas, including 22 competence elements, with 6 different proficiency levels (A1, A2, B1, B2, C1, C2). The framework is designed to support and encourage teachers in the use of digital tools

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to enhance and innovate teaching. The self-assessment tool provides you with the opportunity to identify your strengths and weaknesses in using digital technology for teaching purposes. You can use the tool (shown on Figure 3.) to assess yourself against 22 questions related to the 22 competency elements of DigCompEdu. For each question, you will be asked to select the statement that best describes you from a choice of 5 possible answers." https://digcompedu.dpmk.hu/assessment/view.php?id=40

The assessment is displayed on the website as the final result of the survey, which unfortunately cannot be saved directly, but you can save it as a screenshot or copy the results.

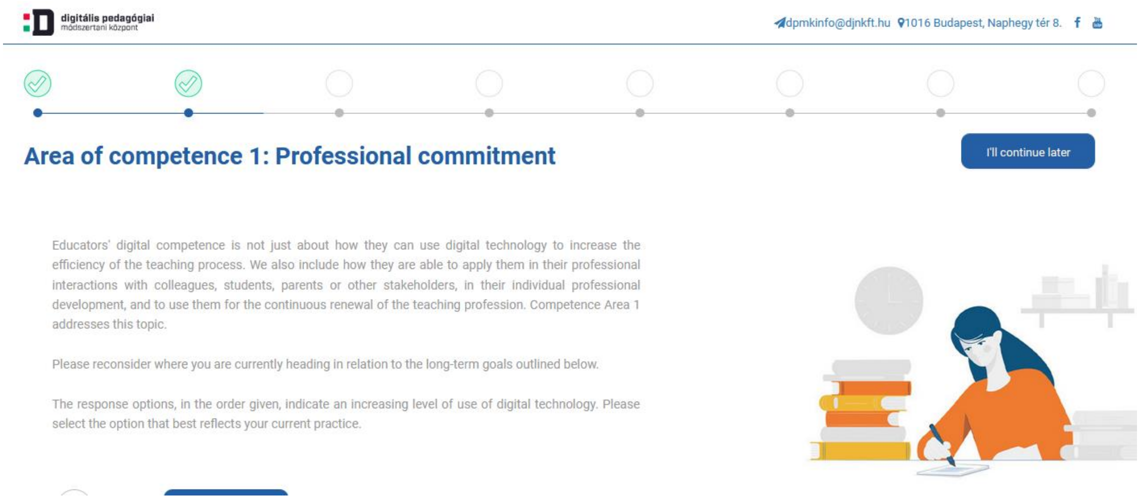

Figure 3: DigCompEdu platform, author's own screenshot

ORGANISATIONAL MEASUREMENTS - Digital Registration Card System

The Digital Names Record (DNR) system (Figure 4.) is a complex institutional feedback and development tool that can be used to determine the level of digital literacy of schools, to help them make the most of the benefits of digitalisation and to develop the digital competences of their pupils. The system has a multi-faceted purpose, providing structured information on the digital maturity of the public education institution and possible steps for improvement through feedback and suggestions for improvement. The DNR is also aligned with the widely known and internationally accepted DigCompOrg framework in the European Union, which has provided the basis for the development of systems to describe and measure digital maturity in many other countries, and is the foundation for the SELFIE European self-assessment tool. In our country, one of the objectives of the Digital Education Strategy was to develop the Digital Label System to provide information on the level of digital maturity of public education institutions. https://dnr.dpmk.hu/page.php?pid=77.

Figure 4: Own editing based on DNR

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This scheme is linked to the digital competences framework for teachers, based on DigCompEdu, where the six levels of the promotion system are designed in a way that is aligned to the five key levels of the framework. The recommendation for a national framework of expectations for digital competences for teachers is consistent with the DigCompEdu framework in terms of the identification of core competences and the competences assigned to each of them. The definition of more specific competence expectations within the core competence areas was guided partly by European trends and partly by the digital competence expectations of the national teacher certification system.

Just like in the case of European recommendations, the description of the expectations of Hungarian teachers in the field of digital competences is in line with the DigCompEdu framework. Furthermore, the categories of the national teacher certification system reflect the levels (A1-A2, B1-B2, C1-C2), and the denotations (Entering, Exploring, Incorporating, Practising, Managing, Innovating) used by the framework. The pictogram illustrates the substantive differences between the levels. Within the main areas of competence, a more specific explanation of the particular competences provides a description of the digital competences that are generally expected of teachers.

SUMMARY

In this article, the measurement of digital literacy levels and the need to develop them is discussed, mainly from the perspective of teachers. Digital literacy is one of the key competences for lifelong learning, for thriving in the information society and in everyday digital life, and is one of the most important determinants of current labour market skills. It refers to the knowledge, skills and attitudes needed to use new technologies to perform tasks, solve problems, communicate effectively, manage information, collaborate and share content efficiently, creatively, appropriately, securely and ethically (Tomori, 2021). The 21st century worker needs to become digitally literate, as the ability to use technology proficiently has become a prerequisite for competitiveness, innovation and growth. In developed economies, one in two jobs now requires some degree of digital literacy, and the proportion of such jobs is projected to rise to over 75%. An adequate level of digital literacy is now a prerequisite for prosperity and progress in all walks of life and is indispensable for everyone. As an effort of the Hungarian Government, the digital competence framework - DigComp - developed under the Digital Well-being Programme will not only function as a reference framework, but also as a unified system for the definition, development, measurement and assessment of digital competence, as well as for the certification and state recognition of digital competence, taking into account validation processes. In support of this, a number of concrete IT platforms and services are presented in this article.

There are significant efforts both at European and international level to ensure that education, in line with the 21st century, is both catching up and meeting societal expectations while harnessing digital opportunities related to the given learning environment (Nagy et.al, 2020). This optimal turn of events has been partly accelerated by the pandemic that swept the world and Europe in 2019 resulting in the rapid development of educational opportunities using digital tools. At the same time the growth process was somewhat hindered as previously known and currently increasing social and economic disparities led to the emergence of social and regional groups faced with lagging behind and isolation, eventually widening the digital divide. Differences in quality of life and well-being,

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which are also indicative of social differences, appear to become increasingly deeper. Unfortunately, in Hungary, too, there are significant differences between regions in terms of the poverty of children and their access to quality education. While the majority of children in the capital city are able to use digital tools and services and have the means to use them for educational purposes, unfortunately in some poor (rural) sub-regions students are deprived of this opportunity because of poverty. For this reason, digital literacy development efforts, which we have explored in our study from several angles, are becoming increasingly important. The authors work at different levels of the Hungarian school system and experience the challenges, problems and difficulties they face. Although the lack of digital competences of teachers is strongly manifested at several levels of the school system, the exact identification of the difficulties is problematic due to measurement and evaluation gaps. The practical utility of this article lies in the fact that it shows teachers how they can objectively measure and understand their own digital skills - not on the basis of self-reporting, as is the case in much research - and thus have the opportunity to improve and address gaps and difficulties. In addition, the theoretical frameworks have been combined in our paper with programmes and platforms that are well suited for everyday educational use and that can help to deepen the understanding of EU and national initiatives, theoretical models and categories.

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ICT Tools in Constructivist Teaching – Webquest and the Assessment by Concept Maps

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Abstract

One of the tools that supports constructivist approach in learning with technology is WebQuest (WQ). A problem remains to measure students' progress appropriate way. It was decided to investigate whether concept maps could be used to check the students' final competences received using WQ oriented chemistry instruction. In our survey we checked compatibility of WQ learning and concept map assessment at individual lower secondary chemistry education (topic: acid/base). It was assumed that a student who creates a concept map containing many concepts, these concepts will be correctly related to each other and sign the relations between the concepts, will have structured knowledge in his head – which will translate into a better result of the final test (post-test). Our results confirmed that the self-creation of "concept maps" by students (n = 79) has a positive impact on assessment of their level of knowledge. The number of terms on the map and the number of drawings are particularly important. The more of them, the better the student's score on the post-test. The other correlations are not that strong. It seems that the problems with building multi-level maps or correctly describing lines may be due to the young age of students (13) or the frequent (even among adults) confusing "concept maps" with "mind maps".

Keywords

WebQuest, Concept maps, Student's assessment in chemistry education.

INTRODUCTION

The constructivist view of learning presents knowledge as a form of mental representation, that is, as a construct of the human mind. This concept emphasizes student activity and autonomy, whereby students construct their own knowledge structures and are not content with recording information provided by teachers (Shapiro, 1994; Lunenburg, 1998). According to the constructivist theory of learning, the acquisition of knowledge is a process that takes place in constant interaction with the environment, which ultimately leads to the reconstruction of knowledge about the world. The constructivist approach corresponds to the methods of activation and creation. According to constructivism,

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teachers must inspire and accept students' autonomy and their learning initiatives. Such behaviour is conductive to developing one's own learning responsibility. Especially now, in times of a pandemic Covid-19 situation, it is clearly visible that in education a lot depends on students and their independent acquisition and construction of knowledge. However, this situation requires the teacher to be able to create the appropriate learning environment and find the right tools for its realisation and assessment.

One of the tools that can be used to organize the learning environment of students in which they gain knowledge on their own is WebQuest (WQ). WQ is an online constructivist teaching strategy used at various levels of education, which describes Zheng, Stucky, McAlack, Menchaca and Stoddart (2005, pp. 41-49) and which suitability included also lower secondary school (Lipscomb, 2003; Bílek and Ulrichová, 2006; Bílek et al., 2008). One can use WebQuest as a kind of mini-projects in which a large percentage of the input and material is supplied by the Internet (British Council BBC, 2004). WQ is possible to use in various course contents. We can identify the use of WQ in maths classes, which one have been described, among others, by Göktepe (2014) or Halat (2008a, 2008b), in English lessons by Zhang, Zhang and Jia (2011) or Saekhow and Kittisunthonphisarn (2015), in history lessons by Lipscomb (2003), known is also the use of WQ in natural sciences, which one was described, for example, by Donovan (2005) or Çığrık and Ergül (2010).

However, the problem remains to measure students' progress (Balogh and Kucharik, 2019; Balogh, Turčáni and Magdin, 2015.). If each of the students constructs their own knowledge, the final results are different. And the teacher may have a hard time comparing them. Additionally, traditional methods of checking students' competences, such as didactic tests, do not work sufficiently in remote education. Therefore, it was decided to investigate whether concept maps could be used to check the students' final competences received using WQ oriented chemistry instruction.

In the literature, we can meet two terms: mind maps and concept maps. These are two different things. Mind maps are a method of graphically recording information that supports creative thinking. This technique allows users to use their brains more effectively, forcing both hemispheres of the brain to cooperate, developing creative abilities and supporting creative thinking. It helps in recording, organizing and remembering information mainly for people with the visual modality. The method was developed by Tony and Barry Buzan (1999). On of possible principle of creating mind maps is: in the middle, we write down the central concept which the map is to refer to, around the central concept there are from a few to a dozen or so main concepts that relate to the middle concept. The next sub-branches again have from a few to a dozen or so concepts relating to neighbouring concepts. Mind mapping is used for taking notes, problem-solving, planning. Mind maps reflect our individual reasoning and our individual associations therefore they cannot be judged! Any mind map drawn is correct.

Concept Maps are most often two-dimensional representations of concepts and their mutual relations. They describe the relationship between concepts and terms from a specific field. The creator of the concept maps is Joseph Novak from Cornell University in 1960 (Cañas and Fermin González, 2004). The rules for creating concept maps are as follows: nodes in maps represent successive concepts of concepts, while edges define relationships between concepts (they cannot be any associations as in mind maps). Edges should be described – relationships between concepts. Concept maps can and should be evaluated. Concept maps can be used in school education, for example: checking students' initial

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knowledge (for example before starting a new department) or "collecting", organizing the acquired information (for example before a test). As a test we can use a concept mapping in three levels of difficulty (to be able to use mind maps as a test, students need to gradually prepare for this) (Nodzyńska, 2007):

- in the first stage, students should be given 10 terms from a given section along with the following command: organize the given terms, give, describe the relations between them;
- in the second stage, students should be given 20 - 30 terms from a given section along with the following instruction: select 10 terms, organize selected terms, give, describe the relations between them;
- in the third stage, the students themselves choose the 10 most important concepts in a given field and then create a map of them.

In our research, we wanted to focus on the second point, which is the use of a concept map to independently collect and group information by students.

METHODS

On the basis of the Polish core curriculum for chemistry in primary school, the concepts and terms related to the topic "acids, bases and acid-base indicators" were selected. Then an on-line WebQuest was created that allows students to learn independently. The prepared WebQuest had a typical structure:

- Introduction - a general, motivating description of the topic,
- Tasks - commands for individual activity, description of the product being created,
- Process - description of steps to be taken to solve the tasks,
- Resources - a list of links to resources available on the web, needed to solve specific tasks,
- Assessment criteria - evaluation and method of evaluation of activities,
- Summary of the topic.

There were many activities in WQ in the topic acids, bases, acid-base indicators, and pH: interactive textbook, lab simulation, song, videos, and interactive exercises (Kopek-Putała and Nodzyńska, 2019). WQ also included on-line pre- and post-test.

During the lessons the task of the students was to read the prepared materials on their own and to solve the tasks and exercises.

After finishing work with WQ, the students prepared a concept map taking into account the knowledge they had acquired. (Students had already created concept maps using ICT before, so they didn't have to be taught how to do this.)

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Research Problem

It was assumed that a student who creates a concept map containing many concepts, these concepts will be correctly related to each other and sign the relations between the concepts, will have structured knowledge in his head – which will translate into a better result of the final test (post-test). It was recognized that the assessment of the student's concept map may replace the assessment of the test.

Research Methodology

The WebQuest has been made available to teachers from various Facebook groups ("Chemistry teachers" 1295 members, "Science teachers" - 1690, "Me teacher" - 10730) with recommendation to use it in chemistry teaching in 7th grade. The examined students were about 13 years old. Interested chemistry teachers recommended WQ to students of the 7th grade of lower secondary school participation in their individual learning process.

Before starting work with WQ, the student's initial knowledge of this topic was checked (by the on-line pre-test placed at the beginning of WQ). The pre-test consists of 13 closed questions and was rated by the teacher (on a scale from 1 to 6, with the lowest grade being 1). The results of the pre-test are presented in Table 1.

After the students had prepared the concept map, their final knowledge was tested, too. (The questions in the post-test were identical to those in the pre-test.)

The number of active students during the study was not the same. The task encouraging to work with WebQuest from the first page of WQ was performed by 362 students. But only 160 students completed the pre-test, which was the first step in the learning process. At the end only 79 students simultaneously created the concept maps and completed the post-test. As you can see, the activity of students in WebQuest has decreased. The reason is that their activity was voluntary, based on their personal interest about content and form of the learning, too.

RESULTS

As in the pre-test the students showed a lack of knowledge about the studied topic, it can be assumed that the knowledge revealed in the post-test comes from their work on WQ. And according to our estimation, it should be equal to the knowledge shown in the concept map. Students passed the post-test and their results were very different (Table 1).

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Table 1: Results achieved by students in the pre-test and post-test

Number of points in test	0	1	2	3	4	5	6	7	8	9	10	11	12	13
School grading (best is 6)	1	1	1	1	1	1	2	3	3.5	4	4.5	5	5.5	6
Percent of students who achieved result in pre-test	0.0	0.6	2.5	6.3	3.1	8.1	7.5	11.3	12.5	8.8	11.3	7.5	6.3	14.4
Percent of students who achieved result in post-test	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	10.3	21.8	19.2	19.2	1.3	11.5

The results achieved by the students in the post-test and concept maps they made were compared. The maps were assessed based on the proposal of Novak and Gowin (1984). The following elements were taken into account in the map assessment: the number of terms used in the map, the fact of describing the line of the map, the number of pictures, the number of branches and the number of "map levels (Table 2). By the qualitative way were evaluated also student's creativity, aesthetics etc. (see Figure 1).

Table 2: The analyse of created concept maps by course finalised students (n = 79)

Concept Map assessment	*Minimum*	*Maximum*	*Average*
Map assessment I whole by grading (best is 6)	3	6	4.3
The number of terms used in the map	7	90	26
The fact of describing the line of the map (number of maps)	20		
The number of pictures	0	31	5.3
The number of branches deviating from the central (primary) concept	1	16	4.5
The number of map levels	1	6	3.0

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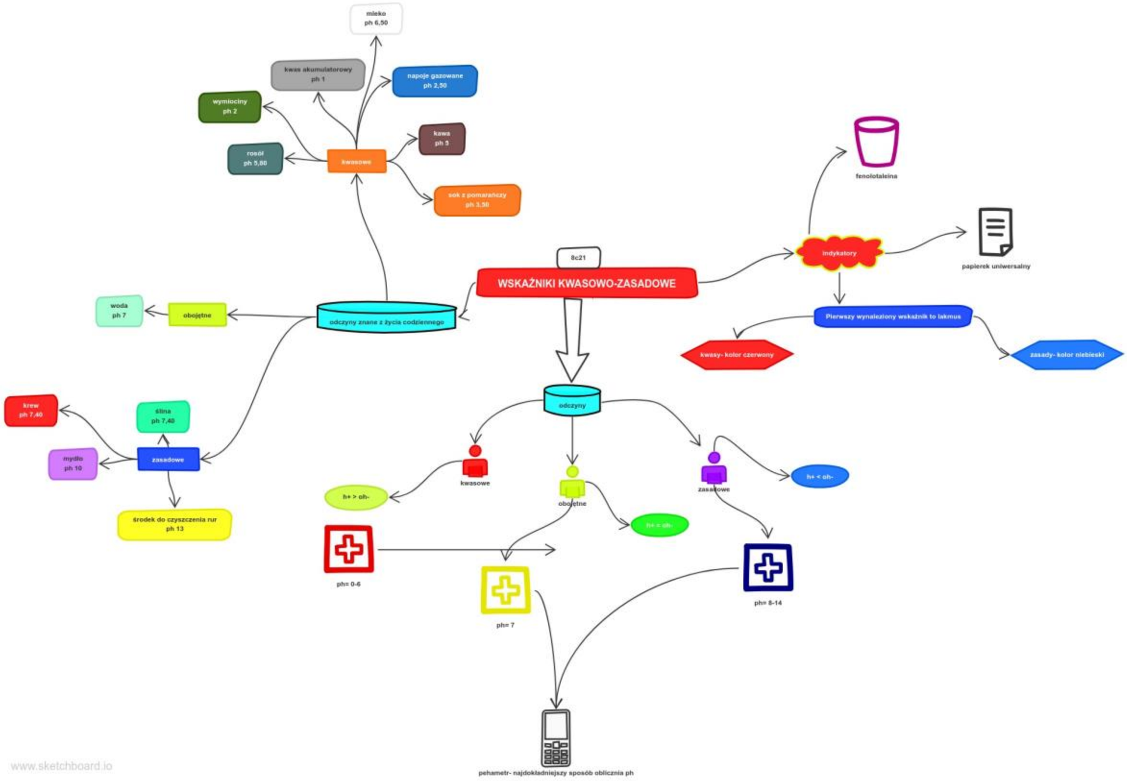

Figure 1: Example of the concept map made by the student

The Spearman correlation was used for the calculations of the relation between post-test score and concept map parameters. It is one of the nonparametric measures of the monotonic statistical dependence between variables.

Spearman's correlation between the school grading and the number of concepts is 0.7. This means a high correlation (significant correlation). A similar high correlation (0.6) can be seen between the school grading and the number of drawings used in the map. Moderate correlation (significant relationship) can be seen between the school grade and the maximum number of map levels (0.5) and the number of lines described (0.4). Low correlation (clear relationship) was calculated between school grade and the number of branches in the map (0.2).

Because the found relationships did not fully satisfy us, it was decided to check if there are any correlations between the various map elements. All correlations are presented in Table 3.

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Table 3: Correlations between school grading and variables in concept maps and between couples of variables in concept maps

	school grading	*number of concepts*	*number of drawings*	*maximum number of map levels*	*number of lines described*	*number of branches*
school grading		0.7	0.6	0.5	0.4	0.2
number of concepts	0.7		0.6	0.4	0.1	0.2
number of drawings	0.6	0.6		0.1	0.0	0.2
maximum number of map levels	0.5	0.4	0.1		0.4	-0.2
number of lines described	0.4	0.1	0.0	0.4		-0.1
number of branches	0.2	0.2	0.2	-0.2	-0.1	

Explanations of the correlations in the table: below 0.2 weak correlation (practically no relationship), 0.2-0.4 low correlation (clear relationship), 0.4-0.6 moderate correlation (significant relationship), 0.6-0.8 high correlation (significant correlation), 0.8-0.9 very high correlation, 0.9-1.0 the relationship is practically complete.

DISCUSSION

Research has confirmed that assessing student-created concept maps as proposed by Novak and Gowin (1984) can replace assessing students with tests. There was a correlation between the grade from the final test and the map created by the student. Students who used many terms on the maps passed the test better and obtained better grades (high correlation 0.7). As proposed by Novak and Gowin (1984), a high correlation (significant relationship) between the final score and the maximum number of map levels was expected. It was believed that a more structured map, with more levels, should indicate a better understanding of the subject by the student. And the student should pass the exam better. However, post-research confirmed this hypothesis. Therefore, it seems that high scoring in the map assessment of this element is unjustified.

We also found that the ability to describe the correlation between concepts does not significantly affect the assessment.

It also confirmed the widespread belief that concept maps are particularly useful for students with visual modalities. Students who used many drawings on the maps passed the test better.

It can therefore be concluded that the assessment of maps made by students can be simplified. Instead of fully evaluating which includes evaluating: valid propositions, levels of hierarchy, number of branches, crosslinks, specific examples, the number of drawings and the number of link descriptions, you can only evaluate the number of terms appearing on the map.

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It seems that the problems with building multi-level maps or correctly describing lines may be due to the young age of students (13) or the frequent (even among adults) confusing "concept maps" with "mind maps".

CONCLUSION

Our results confirmed that the self-creation of "concept maps" by students has a positive impact on assessment of their level of knowledge. The number of terms on the map and the number of drawings are particularly important. The more of them, the better the student's score on the test. So, it seems that sometimes the test can be replaced by the creation of "concept maps" by the students. The other correlations are not that strong. However, our concept seems to have proved successful. Pupils individually, each at their own pace, got acquainted with the topic prepared by the teacher. Then they made a concept map on their own. This map was adequate to the knowledge they had gathered. Therefore, we can propose the following learning path:

- The teacher prepares the learning materials (i.e., WQ)
- Students learn on their own
- Students independently create a map of concepts
- The teacher evaluates the concept map (taking into account, first of all, the number of concepts and drawings, and then the number of levels of the map and whether the lines are described)
- The students can explain own view on self-created concept map and discuss differences with the teacher and by occasion with all students.

Finally, students don't need to perform the test if they learned by the constructivist way and are assessed by the same approach!

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Markers of the Pedagogical Activity System Evolution in the Digital Environment: Case Study

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Abstract

The article provides insights into the systemic approach to teaching master's degree students to analyse and project teacher activities in the digital environment. Students' research for the master's degree involves projects based on key considerations of changes in the pedagogical activity functional components. Learning outcomes may be evaluated by applying content analysis to textual descriptions of teacher activities that determine the effectiveness of the project. The content analysis of projects showed that master's degree students majoring in digital learning environment and digital technologies in education are at the level searching for ways to optimise educational interaction through digital communication. The prospects for further professional development is a purposeful introduction of digital innovations.

Keywords

Pedagogical activity, digital environment, master's degree students.

INTRODUCTION

Digitisation processes in education are especially relevant in all countries. Great attention is paid to the training of teachers of the digital age, and a lot of research is being done on educational activity under new circumstances. Special education programs and advanced teacher training programs are in progress. The following names of master programs may be cited as examples: Master in Educational Technology and Online Education (IMF Business School), MSc in Smart-EdTech, Co-Creativity and Digital Tools for Educational Innovation (Université Côte d'Azur, France), Digital transformation of education (High School of Economics, Russia), etc. The problem is that in many programs the emphasis is placed mainly on the ability to use digital tools, resources, and new learning interaction forms. However, the innovative result of the teaching activity is determined not only by the means employed but also by their combination with the priorities in setting the objectives and the chosen teaching methodology.

In several studies, professional activity, including pedagogical activity, is considered a system. New qualities of the system are revealed by analysing the specificities of the components of the activity and the relation between them under various conditions. In Engeström's et al work on activity theory, the activity is presented in the form of a scheme, including generalised categories such as tools or mediation instruments, subject, object, outcomes, rules, community, division of labour, and the relationship between the shaping

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and transforming through activity (Engeström et al, 1999). J. Garraway and C. Winberg highlighted the role of the activity system in understanding activity issues more systematically and theoretically (Garraway & Winberg, 2020). This model has been repeatedly applied by researchers as an international theoretical framework for studying changes in teacher work and professional development activities (Russell & Schneiderheinze, 2005; Karanasios et al, 2018; Khalil, 2019). The authors of the model must emphasise the tools special influence on other activity components and stress the applicability of the model for the analysis of activity "in its dynamics and transformations, in its evolution and historical change" (Engestrom, 1987, p. 61).

Kuzmina also incorporates a systemic approach to teaching activities into educational system theory. This theory is the most significant for the Russian studies of pedagogical activity. It enables us to analyse the teacher's activity as a system of functional components and interpret "sustainable basic connections of the main structural components of the pedagogical system that emerge in the course of activity" (Kuzmina, 2002, p. 142). The arrangements of the theory allow exploring pedagogical activity as a holistic phenomenon considering its multifaceted nature as a complex object with many connections between components that are influenced by new factors of an evolving educational reality.

Thus, with the difference in researchers' approaches to the systematic analysis of teachers' activity (Yin & Huang, 2021) the key idea is the need for inter-related changes in all its components in response to incentives that drive education development.

The paper outlines the findings of a conceptual case study devoted to training master students with the use of a systemic approach to analysing and designing a teacher's work in the digital learning environment.

MATERIALS AND METHODS

The analysis of the pedagogical activity evolution in the digital environment is one of the key ideas of the master programme "Digital Learning Environment and Digital Technologies in Education" at Herzen University. The training is project-based. While making their research for their master's degree, students develop and implement digital learning environments of various sizes and purposes in partner organisations. The master projects rely on data obtained during students' self-assessment of their professional activities in the digital environment.

The paper's objective is to demonstrate the methodology for identifying the problems of teaching activity in the digital environment that students revealed during the implementation of master's projects.

Students start their projects' design with a theoretical study of the methodological foundations of the digital learning environment. They are also provided with two cases - experimental data obtained through two diagnostic tools:

- student survey on expectations and generalised intentions when learning in the digital environment;

- teacher survey, demonstrating the generalised attitudes to different aspects of teaching activity in the digital environment.

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In this paper, we focus on data obtained through teacher surveys (teachers' reflexive assessment of their activities in the digital environment) that master degree students used for the design of their projects. The questions for teachers were formulated according to the logic of the influence of digitalisation factors on the functional components of pedagogical activity. The seven-component model of the Kuzmina's pedagogical system comprises gnostic, prognostic, conceptual (designing), constructive, communicative, organisational and evaluative components (Kuzmina, 2002, p. 145, 151).

The gnostic component, which is associated with cognition and research, is the principal within the structure of teaching activity. It not only characterises professional knowledge and skills but also includes actions related to the constant acquisition of new knowledge about the evolving educational system.

The prognostic component comprises skills that are correlated with the process of obtaining advanced information on the results of the teacher’s actions. It is especially important considering the variability of the education system.

The design component involves the teacher’s ability to create a prototype (project) of the educational process tailored to the innovative capabilities of the digital environment.

The constructive component involves the teacher’s ability to meet the tactical goals set during design. This includes the ability to design educational interaction and activity at the level of certain fragments of the educational process. In the digital environment, the educational process framework should differ significantly from the traditional one, since conditions are created for distance or blended learning, and mostly independent, personalised students’ activities.

The communicative component considers the significant differences between networked communication and face-to-face educational communication. It is important to emphasise the behaviour of net-generation students.

The organisational component defines the specificities of the educational process in new spatial and temporal coordinates with a change in the roles and rules of interaction.

The assessment component is implemented through feedback from students, colleagues, and on the basis of pedagogical reflection. Its specificity in the digital environment is largely driven by interactive digital tools and the ability to use automated diagnostic procedures and learning analytics.

The survey model is based on the assumption that while teachers strive to discover the multi-faceted educational potential of the developing digital environment, significant specificity and new features appear in all functional components of their professional activity.

Table 1 presents the markers of systemic changes in teaching activity in the digital environment, which form the semantic basis of the questionnaire for teachers (Pavlova, 2021, p. 1083). By considering the responses to the questions, the representatives of the teaching community determine the importance and manifestation of their activities in the digital environment.

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Table 1: Markers of systemic changes in teaching activity in the digital environment.

The functional components of the teachers' activity	Markers of the system evolution of pedagogical activity in the digital environment
The gnostic component (professional knowledge and skills to acquire it)	(G1) knowledge about the digital space of the teacher's activity
	(G2) knowledge about the new goals and objectives of the teacher's activity
	(G3) knowledge about changing pedagogical methodology
	(G4) awareness of the developmental characteristics of the digital generations of students
The prognostic component (obtaining advanced information about the results of pedagogical actions in the digital environment)	(Prog 1) predicting digital changes in education
	(Prog 2) predicting personality development patterns in the conditions of digital learning environment
	(Prog 3) predicting how the educational process will evolve in the digital environment
The design component (the ability to build a comprehensive project of educational interaction in the digital environment)	(Proj 1) establishing learning goals and objectives appropriate to the innovative capacities of the digital environment.
	(Proj 2) selecting learning strategies by focusing on individualised learning.
	(Proj 3) selecting learning strategies with digital skills development as a priority
The constructive component (the ability to design educational interaction and his activity at the level of certain fragments of the educational process).	(Constr 1) selecting effective teaching technologies according to the project of educational interaction in the digital environment
	(Constr 2) selecting and creating digital resources for distance and blended learning
	(Constr 3) selecting digital tools for education interaction
The communicative component (the capacity to establish educational communications within a digital environment)	(Com 1) considering communicative behaviour of digital generations of students
	(Com 2) identifying and resolving learning tasks within joint network activities
	(Com 3) defining instructional tasks for soft skills shaping
	(Com 4) ensuring information security in the network space
The organisational component (the opportunity to organise students' and teachers' activities in the digital environment)	(Org 1) organising students' autonomous extracurricular work with digital resources and web-based interaction
	(Org 2) organising e-learning formats (network projects and co-workings, network discussions, interaction with a virtual agent, simulated activity in virtual worlds, peer learning, peer assistance, mentorship in online educational communities, etc.)
	(Org 3) organizing and creating digital education resource
	(Org 4) organizing interaction with other stakeholders of the digital environment
The assessment component (the ability to evaluate educational outcomes and the pedagogical process in the digital environment)	(Ev 1) applying formative assessment in the digital environment
	(Ev 2) providing flexible management of educational interaction (adaptive automated control and contextual support, virtual assistants, self-assessment and peer evaluation services, digital portfolios, gamification, etc.)
	(Ev 3) assessing digital components of educational outcomes
	(Ev 4) assessing educational interaction in the digital environment for the reflexive management of professional actions (monitoring of learning activity, learning analytics, analysis of digital footprints, etc.).

Students not only analyse ready-made cases with survey data but also answer the questions on their own (self-assessment). The survey employed a five-point Likert scale (1 –

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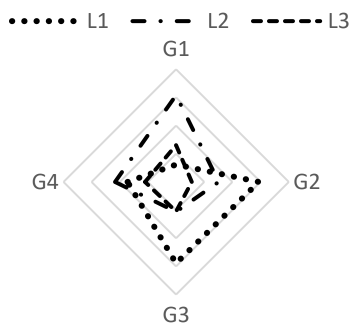
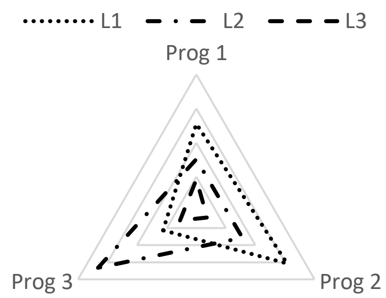
absolutely irrelevant, 2 – irrelevant, 3 – sometimes relevant, 4 – relevant, 5 – very relevant). The data obtained are conditionally classified into three levels: fragmentary testing of digital pedagogical techniques (L1), search for ways to optimise educational interaction through digital communication (L2), and purposeful introduction of digital innovations (L3).

Research sample included 119 teachers and 25 master's degree students (particularly, their master's degree project texts).

One component of the evaluation of completed projects is the analysis of descriptions of teacher activities that determines the effectiveness of the project. To obtain data, a content analysis toolkit was developed, based on the model of changes in the functional components of pedagogical activity in the digital environment. Semantic text analysis was performed using the istio.com software. The keyword tables were constructed for further processing and to design a semantic map of each text. This accelerated the process of contextual correlation between text fragments and units of analysis. The top-down codification applied to the texts was made according to the developed list of categories and codes, which corresponds to changes in the components of the teacher's activity. Data analysis was conducted using a two-cycle approach for thematic quality encoding (Miles, Huberman, & Saldana, 2014). The data were inductively encoded in the first cycle to determine the original subjects. In the second coding cycle, the first cycle codes were inductively encoded to identify crosscutting issues.

RESEARCH RESULTS

The analysis of the survey data enables master students to identify, discuss and concretise the problems they will tackle in their projects. In Figure 1, the generalised results of the teacher survey are provided.

The gnostic component (G1 - 4)	*The prognostic component* (Prog 1 - 3)
	
The design component (Project 1 – 3)	*The constructive component* (Constr 1 - 3)

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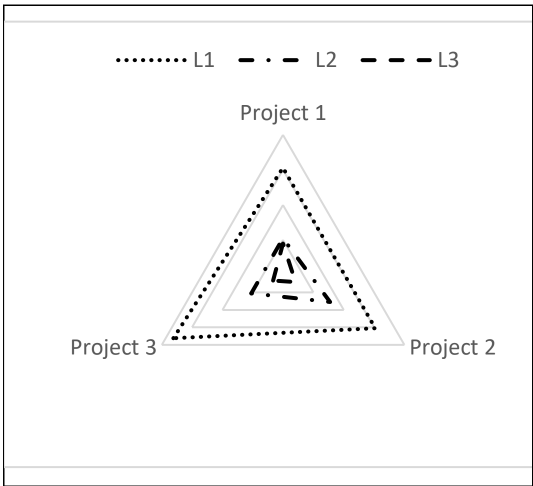
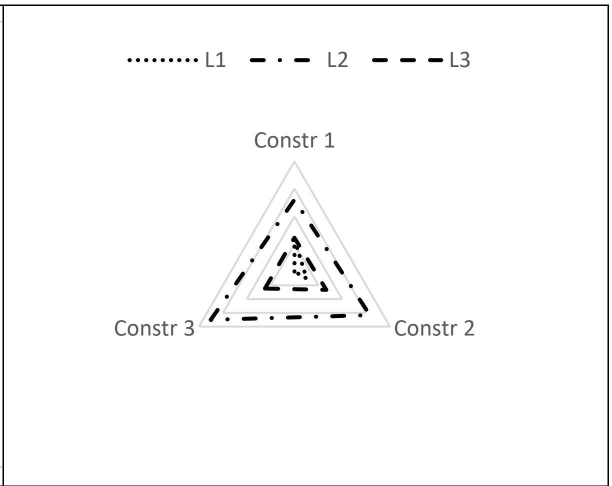
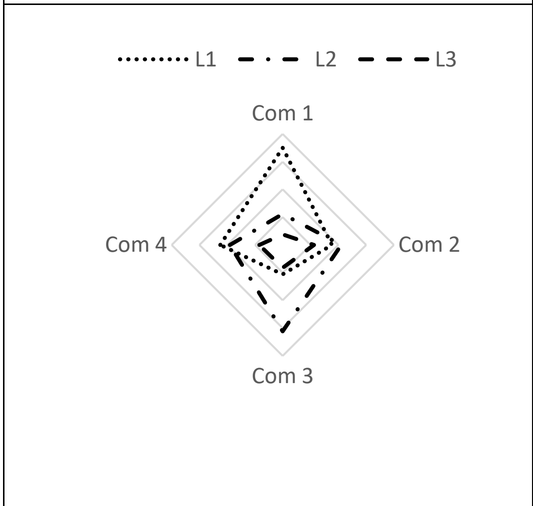
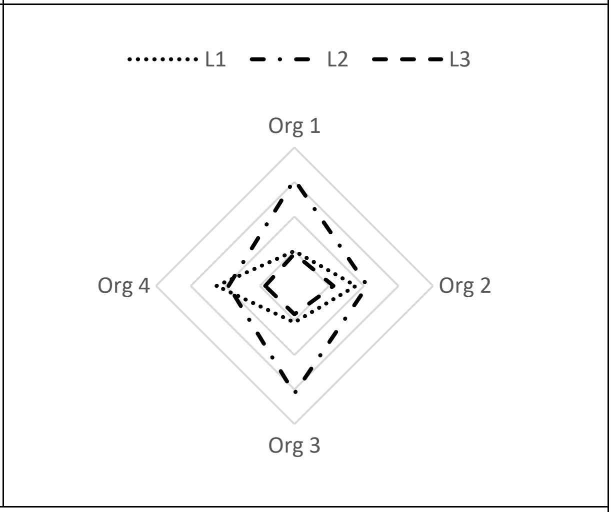




The communicative component (Com 1 - 4)	*The organisational component* (Org 1 - 4)





The assessment component (Ev 1-4)

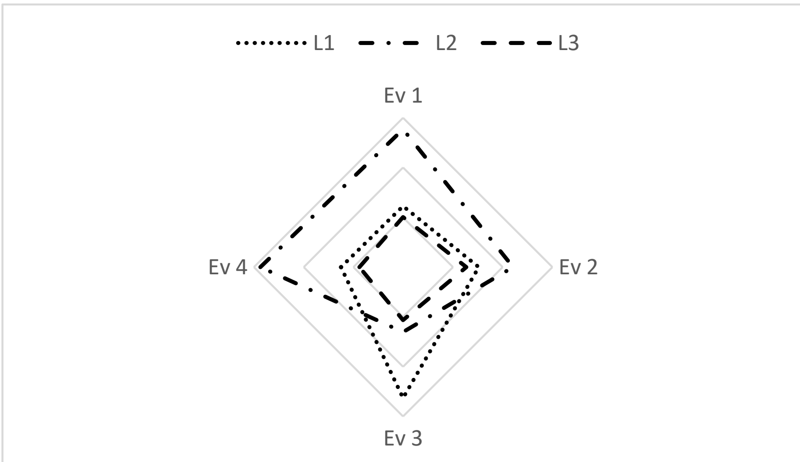


Figure 1: Generalised results of the teacher survey.

Students identify and articulate characteristics of changes in specific components of teacher activities in the digital environment. The visualisation of the survey data

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demonstrates the inequality of these changes in terms of the markers that characterise each component of the activity. For example, in the discussion before the design process, particular attention is paid to the components of the activity, when a major area is occupied by the L1 level. Students propose the possible reasons for the unequal distribution of survey results for those components, which create a methodological basis for changing teaching activity (the gnostic, prognostic, and design components). Following this, students clarify the goals and objectives of designing a digital learning environment in the selected area.

The results of the analysis (Fig. 2) show that the developed projects mainly require the activity of the teacher at the level L2 (optimisation of educational interaction using digital communication) and L3 (the targeted introduction of digital innovations).

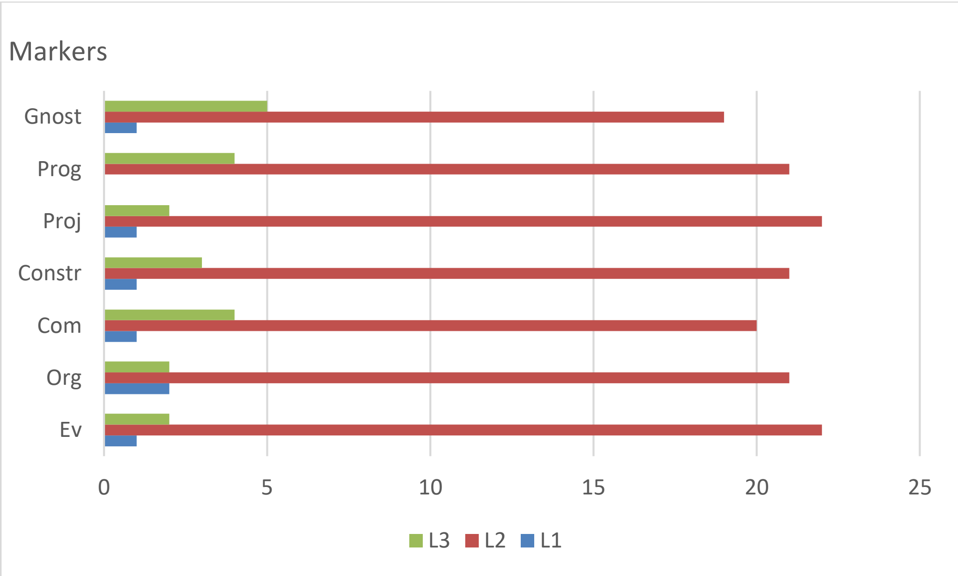

Figure 2: Results of the semantic analysis of project texts.

In all master's projects, the need to manifest new pedagogical skills associated with the various components of activity is justified. For example, there is an expectation of systemic change in teachers' activities in the digital environment. However, at the same time, in several projects, a teacher's activity was described as a sum of existing and new instructional skills, in most formulations, there was the word «enhancement». This indicates a lack of understanding by students of the methodological changes, which determine the new efficiency of the teaching system.

DISCISSION AND CONCLUSION

The evaluation of the student's projects of the master program "Digital Learning Environment and Digital Technologies" allows asserting that the skills (competencies) of the graduates are trained in an innovative context. These results are provided by a leading systematic approach that provides the design of digital learning conditions not as an improved version of traditional educational interaction, but as an educational entity with new relationships between the evolving elements of the educational system. A major contribution to the students' understanding of systemic changes in the pedagogical activity in the digital environment is made by the scientific definition of the new professional goals and sub-goals (to meet the changing demand of society for education; to use digital

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educational resources efficiently; to take into consideration the digital needs and preferences of modern students) that lead to the revision of all functional components of professional activity.

The principal results of the students' projects are linked to the solution of real problems of teaching activity in the digital environment. The learning outcomes evaluated with the content analysis of project descriptions demonstrate a relatively high level of understanding of systemic changes in educational activity in the digital environment by students. However, the dominant L2 level for all functional components of the activity confirms that even for future teachers with specialised training, rapid changes cannot be accepted entirely. A process of gradual mastery of the innovative digital pedagogical reality is essential.

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Software Tool for Students' Assignments Management

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Abstract

The main goal of this contribution is to present a current development state of a software tool developed for students' assignments management. This tool provides two main functionalities among other things, specifically firstly creation of parametric and non-parametric assignments and their generation and management for individual students and groups of students. This includes possibility for teachers to manage groups of students, create assignments, specify parameters and their possible values, and the generation itself together with storing and exporting them in specified format. The second main functionality is automatic anti-plagiarism system build within this tool to simplify plagiarism detection. This includes possibility for students to submit their work through this system and for teachers to specify students' assignments for plagiarism check and storing of these results. The usage of this tool is mainly focused on the operating systems course at our faculty, but this system can be easily extended for other courses as well. The implementation of this system is realized as web application using Nodejs and React, which simplify horizontal scaling of this application and for the anti-plagiarism system, JPlag is used. In the current state of this tool, all main functionalities are implemented.

Keywords

Web application, Students' assignments management, Informatics teaching, Anti-plagiarism.

INTRODUCTION

In these days, with the growing number of students it is more challenging to manage and process students' assignments. This includes all part of these assignments processing, starting with their creation, collection from students, checking for plagiarism and cheaters to providing feedback from teachers to students' submissions. Currently the main tool used for this problem in our university and also in other universities is Moodle platform (Moodle.org, 2022). This provides functionality for creation of personalized teaching environments. With Moodle it is possible to manage courses and courses materials, organize them into groups, for example based on actual week etc. The next useful and often used functionality is management of question bank and their usage in assignments preparation, i.e., it is possible to prepare test with random questions of selected category etc. As Moodle provides tools for creation also custom activities, it is possible to create many kinds of assignments. On the other hand, this platform doesn't cover all requirements and specifications of each course and provided functionalities are not sufficient in some cases.

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For example, it is possible to generate test with random questions for each student, but it is not possible to prepare assignment with randomized parameters (define static and random parts of assignment). There are also web applications that allow to generate random sets and random numbers based on given criteria. These applications can be theoretically used for mentioned purpose, although they are not usable as is and addition work will be required for processing their results. The amount of work requiring to integrate such extern service into our application is higher that the amount of work to implement such service directly in our application. For that reason, we decide to design and implement a software tool for managing students' assignments suitable for our environment and for the purposes of operating system course at our faculty. In this paper, the current implementation state of this tool is presented.

The organization of this paper is following. The first section is focused on presenting target course more deeply and system requirements for our application outgoing from this course. Except management of students and their assignment, there is for example requirement to provide functionality to generate unique assignments and check students' submissions using anti-plagiarism system.

The next section shortly presents system design, architecture and used technologies. This section continues by proposing data model, that covers all requirements for our application with focus on its future extension, for example allowing teachers to prepare study materials for students etc. This section is closed by presenting the main functionality of our application, i.e., students' assignments creation and generation and presenting functionality to perform anti-plagiarism check.

The implemented system provides also additional functionality, not mentioned properly in this paper, but either necessary for this system to work or usable in the future. This system can also work as a source of large amount of data (mainly text data or source code data). These data could be used to perform different types of analysis, mainly methods of data mining and text processing.

SYSTEM REQUIREMENTS

Before implementation of this system, several goals were set and summed as requirements, proposed system should offer. There requirements originate from students' assignments in analysed course. Through this course, there are 3 to 4 students assignments, all of them focused either on scripting in Bash or programming in C language with the focus on multi-threading, multi-processing and network communication using sockets. It also should be noted that one of these assignments is group project and the rest are individual.

All these specifications had to be taken into account and the following system requirements was set according to them:

- Application should allow teachers to create parametric questions. In these questions teacher should be able to specify which parts of it will be generated using specific criteria (range, set of values, etc.) and which will be the same for all students.
- Application should allow teachers to create standard questions (non-parametric).

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- Teacher should be able to generate assignments using one or more parametric or non-parametric questions using by either selecting specific questions of whom the generation will be executed or questions of specified category. These assignments will be assigned to specific students or randomly for specific group of students (for each student in this group assignment will be generated).
- Teacher should be allowed to modify generated assignment and export it to specified format.
- All assignments need to be stored together with their assignment to students, for teacher to verify the correct assignment and its correct parameters that was assigned to the student.
- Application should provide functionality to create and plan schedules for students and assignments.
- Teachers should be able to grade students' assignments and provide feedback for them.
- Application should allow teachers to check assignments for plagiarism using anti-plagiarism system.
- Students should be able to see their assignments together with special instructions for them, deadlines etc.
- Students should be able to upload and manage their submissions for each assignments.
- Students should be able to see feedback from teacher for their submissions.

DESIGN AND IMPLEMENTATION

The final application should cover all requirements, mentioned in previous section. We decide to implement it as web application for its advantages, such as its usage without the necessity of its installation, usage on all platforms etc. The application itself is divided into server part, implemented using Nodejs framework (Node.js, 2022). Nodejs is event based and thanks to its architecture, it is easy to scale it horizontally. Event loop of this framework can be seen in Figure 1. Using this model, it is possible to handle many user requests including I/O operations, working with database etc. in single thread. Over this single thread application, there is load balancer responsible to scale it horizontally, i.e., create more processes depending on the number of requests targeting this application. Client side of this application is implemented using React framework (React, 2022) and these two parts are connected using Rest API (restfulapi.net, 2022).

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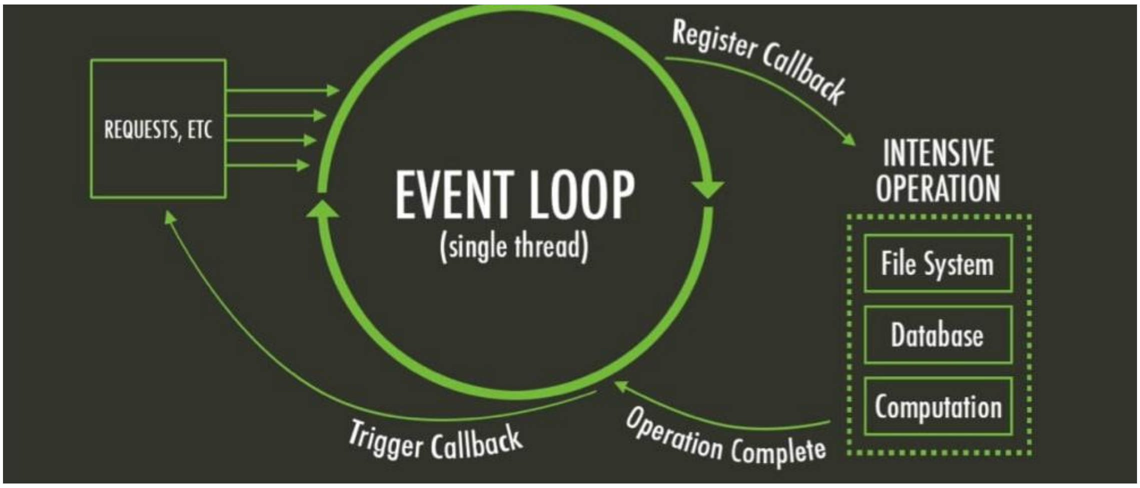

Figure 1 Event loop in Nodejs (Santos, 2020)

Data management

The first implementation of this system will be tested and used in one specific course at our university and mainly for students' assignments. In the future, we plan to extend its usage also for other courses and for management of other information required for these courses, for example study materials. Therefore, we decided to consider it also when designing data model. The proposed model can be seen in Fig. 2 and should cover all information needed in current state of application, such as users, teachers, courses, questions and assignments, submissions, teachers' feedback for them and also match between them. Currently this data model is realized using PostgreSQL database system, however as in our application this layer is connected using ORM or Object Relation Mapping framework Sequelize (Sequelize ORM, 2022), it can be easily replaced using different database system. This technique maps tables and relations from database into proxy objects in our application and the direct work with database is therefore performed using Sequelize. Diagram of this technique can be seen in Figure 3.

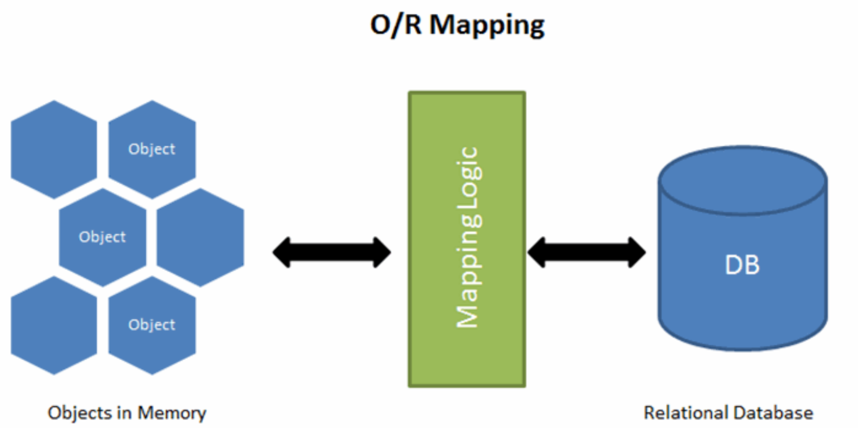

Figure 2 Object Relation Mapping (Shapovalov, 2022)

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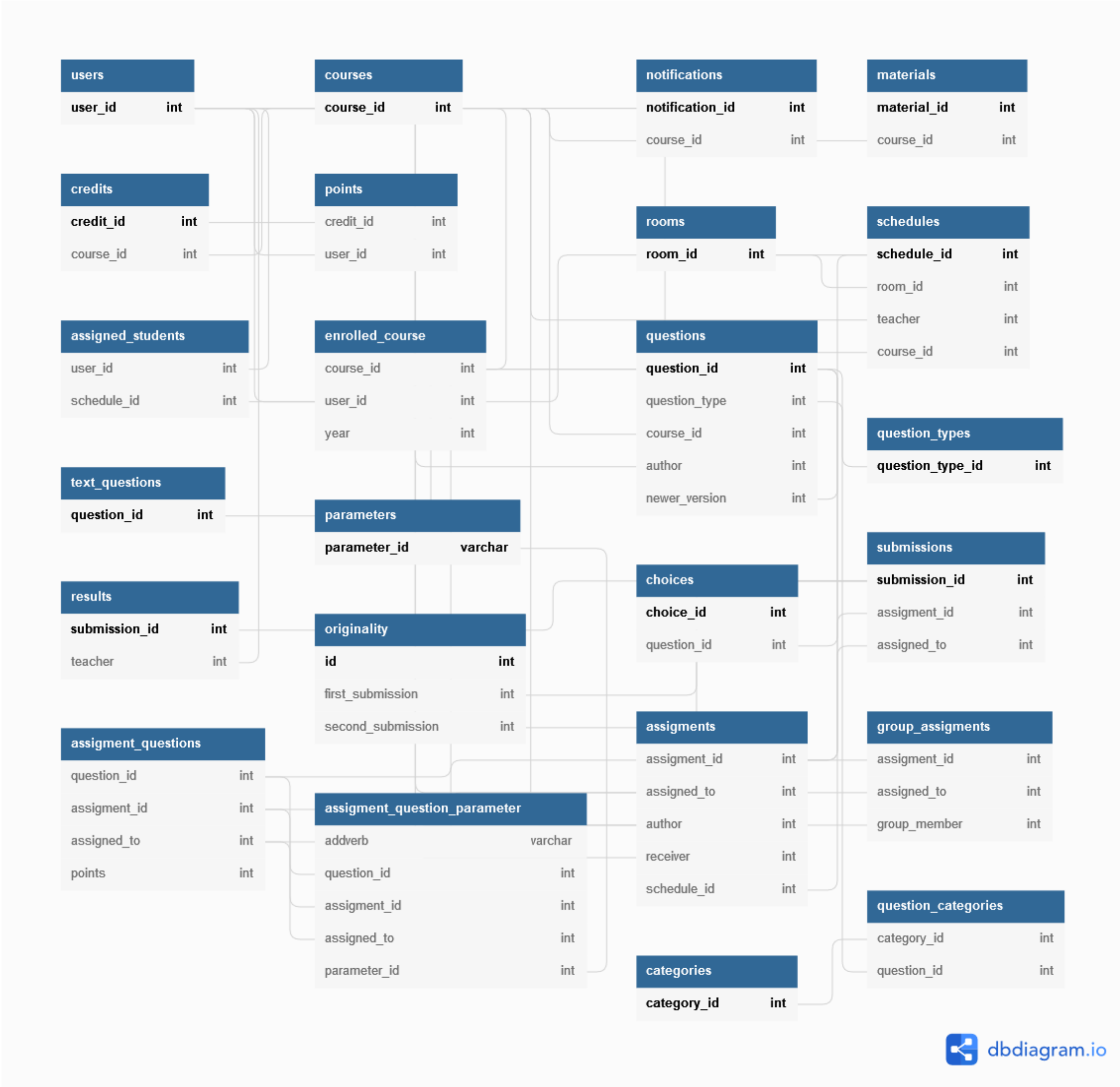

Figure 3 Part of proposed data model

Assignments' generator

One of the main functionalities, required from this system is an assignments generator. This part of the implemented system allows teachers to create and modify assignments. The remove of created assignment is allowed only in case this is not assigned to any students. Teachers are able to manage all assignments and determine exactly which assignment together with specific set parameters was assigned to a specific student. The process of assignment generation consists of two steps.

In the first one, teachers create assignment. There are two types of assignments that can be created using this application. The first one, already mentioned is parametric assignment. This assignment can contain specific string literals, that will be identified as parameters in the process of generation of this assignment. Except these string literals, this assignment can contain other information such as static text (that will be constant for each student), media such as images etc. Example of this process can be seen in Figure 4.

The second assignment type consists of one or more non-parametric assignments or questions. It is possible to select both – open questions and questions with choices

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(alternatively combination of these). In case questions with choices are present, they are after assignment submission checked automatically.

The second step is the generation of assignment. In this step, created assignments from the first ones are used and specific assignment for each student is prepared. Using the first type of created assignment and conditions for each parameter, specific value of each parameter is generated, and the final assignment using these values is prepared. Using the second type of created assignment, final assignment is generated from pool of these questions. In this case it is necessary to specify the number of questions, categories, and their weight in the resulting assignment. Using these parameters together with selection of a group of students, application generates specific assignment for each student from this group.

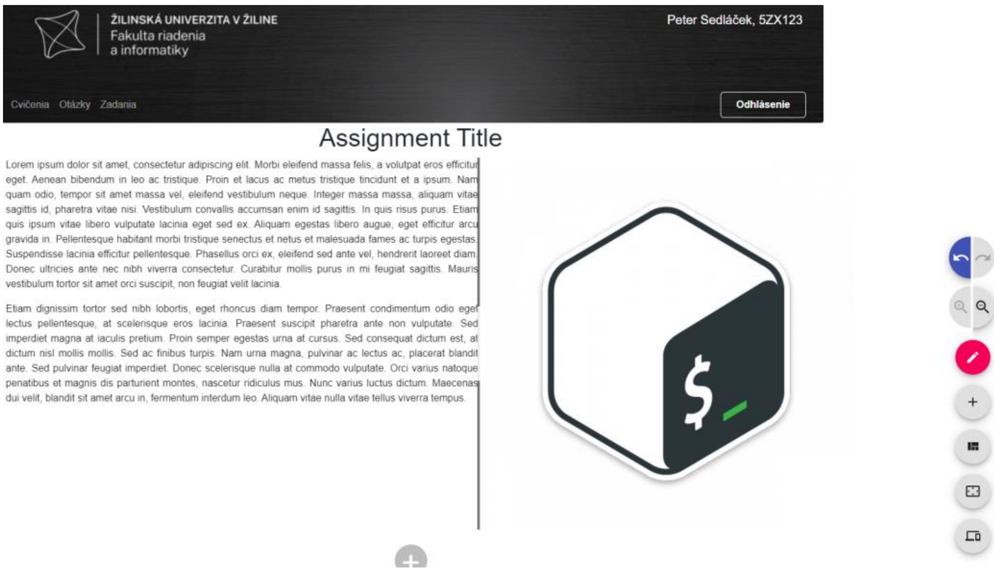

Figure 4 Example of assignment creation

All generated assignments are stored in corresponding tables in proposed database and can be exported into specified form. Currently supported formats are html, pdf, txt and docx. The visibility of an assignment is ensured using its relation to specific schedule, which contains, among others, information about the start of this assignment and its duration. The process of generation is an asynchronous operation and teacher is notified about its result when this process ends. Example of assignment generation can be seen in Figure 5.

The duration of process of generating students' assignments depends on two variables – the number of students for whom the assignments have to be generated and the number of parameters assignment consists of. This was tested on group of 100 students and assignment with 5 parameters (in this course, the group of students this process is performed consists usually of about 20 students). In this case the process takes about 2 seconds. Please note that in case more than one teacher will perform this action, these tasks are independent on each other and in worst case load balancer will create another instance to perform these tasks and the only limiting factor will be hardware configuration of server, this generation will be performed.

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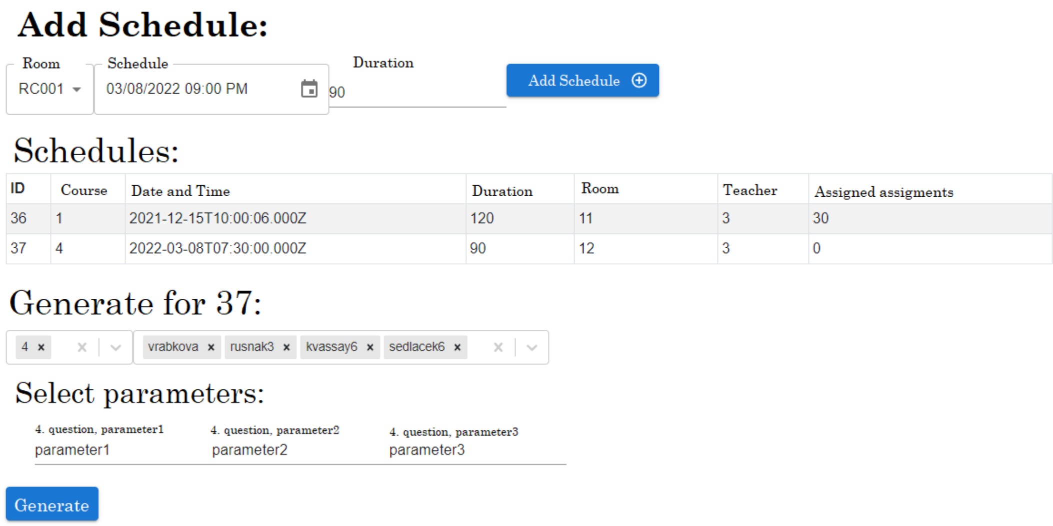

Figure 5 Example of assignment generation

Anti-plagiarism system

The next functionality required from our tool is for teachers to grade students' submissions. Within this process they are able to perform anti-plagiarism check of these works. This check is executed using JPlag anti-plagiarism detector (Prechelt & Guido, 2003). Before the check itself, all source code from students' submissions is pre-processed and special characters are removed (as JPlag is not able to process them). JPlag is called as extern application from our system and the results of this check are then processed using our application and stored in the database. The process of anti-plagiarism check is performed asynchronously, and teacher is notified of its result. The output of this check is percentage match between each submission and also blocks of code, that was detected as matching. Teacher can then manually review these submissions and take according steps.

According to (Prechelt & Guido, 2003) the anti-plagiarism check using JPlag is in most cases not time-consuming process. They made tests on sets of different sizes (the largest one consists of 99 programs) and the resulting time was about 6 seconds using 700 MHz processor. The anti-plagiarism check of students' assignments performed by us (on the tested group of students with the size of about 300) was instant and there was no need to wait for them. Therefore, the limitation of this process in real environment is negligible.

It should be noted that this anti-plagiarism check is allowed only for supported types of assignment. For example, JPlag is not usable for detecting plagiarism among bash scripts. For that reason, in the future, we plan to use also different methods for plagiarism detection as was presented in publications (Duracik, et al., 2020) and (Duracik, et al., 2020). The other solution is to use another possibility, this application provides to us – by collecting many students assignments and existing anti-plagiarism system results, it should be possible to analyse its output using methods of data mining and data processing to search similarities in these submissions (Bohacik & Zabovsky, 2019), (Bohacik, et al., 2020). However, this path needs to be explored more deeply.

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CONCLUSION

In this paper software tool for students' assignment management was presented. The main idea behind this project was to design and implement a way that minimises the problem of cheating among students in two ways. The first one is precautionary allowing teachers to prepare larger number of unique assignments, therefore students should be less likely to copy their submissions from each other. This is executed using assignment generator. Using this part of application, teachers are able to create parametrized assignment, that are withing generation process prepared for each student separately. Teachers are also able to create pools of questions, that will be randomly assigned to students within the process of generation. The second way to minimise the problem of cheating among students is repressive way allowing teachers to automatize assignments checking for plagiarism. This tool is focused mainly on the field of informatics, however thanks to its design it is possible to easily use it also in other fields. For the current implementation tool JPlag is used (Prechelt & Guido, 2003). Using this tool, it is possible to obtain percentage match between students' submissions and with its high value teachers can confirm it manually and furthermore take action against it.

ACKNOWLEDGEMENT

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Basic Numbers – Application to Support Gamified Teaching of Basic Numerical Operations at the First Stage of Primary School with Options for Remote Online Teaching and Blended Learning

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Abstract

The multiplatform app, Basic Numbers, was developed to practice basic math operations. It is therefore intended primarily for students in the first stage of primary school. Basic Numbers combines the main advantages of competing applications, but also brings some innovative features of its own to make teaching, self-study and testing in the subject more effective. In addition to the classic setting of numerical operations and the range of members of the generated problems, it allows complex definition of the overall structure of the problem so that the assignment suits the various types of tasks. Continuous monitoring of solution results brings elements of gamification. Basic Numbers also supports an online mode in which the teacher can prepare an assignment for students to training of knowledge on their devices. The teacher can then simply give the students a short unique code that makes the assignment available to them under the set conditions, and they can practice solving the generated problems independently. The application then sends the results of their efforts via a cloud server back to the teacher's device, giving them feedback that can help them adapt their lesson plan. The application can also be used for formal testing, both remote and in-person. It is possible to set restrictions on switching between apps. The development of the app is still ongoing, but in its current version it is already proving to be a solid and useful tool for a modern way of effective teaching in the field of basic mathematics.

Keywords

Mobile Learning, Primary school, Mathematics, Gamification, Testing, Blended Learning.

INTRODUCTION

The Basic Numbers application was created as a tool for practicing basic mathematical operations, especially for first grade primary school students. It has unique setting options for generating random problems, thanks to which it is possible to prepare practice and testing of various types of tasks with elements of gamification (Hubálovská and Hubálovský, 2016). The examples are marked with coloured icons, each step is accompanied by sound effects and there are also step-by-step hints, which, however, take away the stars in the rating on the individual example pages (see Fig. 8). Another useful feature that was added

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during the quarantine of COVID-19 is the option to test students online. No competing application yet has such detailed options for setting up an example generator in combination with the possibility of online pupil testing. The Basic Numbers application can be used by students and teachers on Android smartphones, but is also available on Windows 10 devices, i.e. PCs, laptops and tablets.

METHODS

The Basic Numbers application was created in the Xamarin.Forms multiplatform technology (Hermes, 2015). This allows the development of native apps for Android, iOS[1] and Windows operating systems through a single common code in the C# programming language, and the XAML markup language, which allows for a single design definition (Voborník, 2020). SQLite (Winslett and Braganholo, 2019) is used as the local database on the end-users' devices, while the central (cloud) database on the server is provided by SQL Server (Bernstein, et al., 2011). The server part of the application was then created in ASP.NET Core 3.1 (Lock, 2021) and gradually updated to newer versions, with custom implementation of secure API communication. Data transfer is secured by the https protocol with a secure SSL certificate and token-based authentication via ASP.NET Core Identity.

The generation of the input problems is provided by a custom algorithm based on backtracking (Civicioglu, 2013; Coufal, et al., 2021a). It proceeds from left to right, i.e., by generating individual members and selecting operators between them (there can be more than just two members in the example). Everything is done completely randomly within the chosen bounds, but the constraints for the intermediate computations and the overall result are constantly monitored. Thus, if a newly added member exceeds the constraints for the result between calculations, it is immediately replaced by another (Coufal, et al., 2021b). If it fails to find a suitable member within a certain number of attempts, the generator backtracks one step, tries to change the operator between the members, and repeats. If even this change does not work within a certain number of attempts, the generation is returned one order of magnitude lower, i.e. to the previous member of the problem input (Coufal and Trojovský, 2021). To verify the result of the generated examples, the same algorithm for evaluating mathematical expressions as in the Algorithms program (Voborník, 2007) described in (Voborník, 2006) was used (Voborník, 2019). The generation of examples takes place on the client side, thanks to which the server is not unnecessarily burdened and it manages to handle more requests.

RESULTS

The main result of this work is primarily the Basic Numbers application itself. Secondary results are the extension of the possibilities of improving children's knowledge in the field of basic mathematics. Another positive benefit is also the option of using the application in lessons, which would lead to its diversification, gamification and, for example, in the case of real testing, to facilitate the work of teachers and the implementation of the Strategy for

[1] Version for iOS was not released yet, because it is closed system and requires a Mac for debugging and compiling, which author of the app doesn't own.

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the Education of the Ministry of Education, Youth and Sports of the Czech Republic (MŠMT, 2020, p. 31–33; Němec, 2019).

History of development

The basic feature of the Basic Numbers application is that it generates sets of random examples based on the set criteria. In the first phase, it was possible to define a range for the individual members of the examples and of results, and also a range of intermediate calculations for problems with more than two members. To support real-world testing, protection against application switching (so that the student cannot switch to a calculator or chat, for example) and the ability to lock settings with a password were also added later (version 1.2). This functionality has already been described in (Voborník, 2019).

In April 2020, the app was expanded (version 1.3) to make it usable for home teaching of primary school students during quarantine measures due to the COVID-19 pandemic (Němec, et al., 2020; Jahodová Berková and Němec, 2020). The application settings have added the option to define ranges for individual members of problems and also the so-called control conditions. These conditions are logical expressions written in a simple mini-language (Tab. 1 and Fig. 4), and are used to make the examples generator settings even more specific to suit various task types[2]. Parents could then set the app to generate sets of examples exclusively for the currently discussed material during maths lessons at home (Voborník and Němec, 2019). Pupils could then practice independently and, thanks to the feedback provided by the app, work according to their individual needs until they had mastered the material.

Table 1: Examples of control conditions for classic problem types.

Types of examples	Range A	Range B	Control condition
Subtraction to 100 with transition over 10	21–99	2–9	A % 10 >= 1 & A % 10 < B
Addition to 100 with a transition over 10	11–99	11–99	A % 10 > 0 & B % 10 > 0 & A % 10 + B % 10 > 10
Addition and subtraction to 100 of double-digit numbers, where one of them is a multiple of ten (the second for subtraction)			AB='+' & (A%10=0 & B%10>0 | A%10>0 & B%10=0) | AB='-' & A%10>0 & B%10=0
Integer division to 100	2–100	2–50	A % B = 0 & A != B

Over time, however, another need emerged, namely to shift the necessity of setting the application to the appropriate types of problems, controlling the frequency of practice and assessing the level of knowledge of individual students back to the teacher. Although they could have prepared the setup, sent instructions to the parents and then had them send, for example, a screen shot with a list of the tests that had been run, such a process would have placed an unnecessary burden on the parents and left room for potential errors. For this reason, support for online testing was added in the next version (1.4), which allows

[2] The mini-language for determining the conditions of the example generator can be difficult for someone, but these settings can already be passed on using a test code. In the future, it is also planned to prepare a website with a database of these codes for various type settings of examples discussed in primary schools.

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teachers to have complete control over the entire assignment and assessment process, giving them many additional options, including support for remote assessment, and making things easier for parents, who only need to supervise students/children working independently (Hubálovský, 2013).

Online testing

The process of online testing of students by teachers through the Basic Numbers application since version 1.4 is summarised in the following diagram (Fig. 1) and its description.

1. **The teacher prepares a test**, i.e. settings for examples generator and under it the time limit as well as setting the conditions for its completion.
2. **The teacher sends the test to the cloud server**, obtaining its unique **code**.
3. The teacher will **distribute this code to the students** via any channel (e-mail, Microsoft Teams, WhatsApp, Skype, Messenger...), or give it to the students in some other way (publish it in the school LMS system or on the web), or write it in the classroom on the blackboard if it is a full-time examination.
4. **Students launch the online testing function in the app**, where they enter the test **code** and the test parameters specified by the teacher are downloaded from the cloud.
5. Students **complete the test** on their mobile phone or computer.
6. **Test results** (total score and analysis of individual examples) are **sent** to the cloud.
7. **The teacher downloads the students' test results** from the server to their device. The teacher can then export the results to MS Excel.

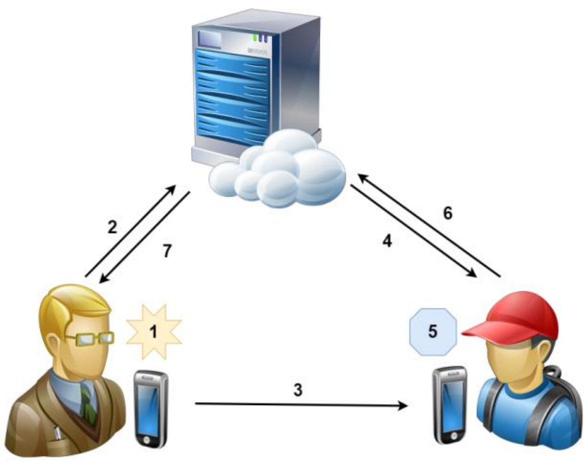

Figure 1: Flowchart of communication during online testing.

Teacher's procedure

While for online testing, the student only uses the last button (Test) instead of the first button (Start) in the initial menu, the student enters the code and then starts the test immediately, the teacher works with three types of records, hierarchically arranged under each other (Fig. 2). These are the conditions **settings** for the problems generator, **the tests** with the given settings and **the results** of the given test from each student.

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You can switch to teacher mode by clicking the less prominent three dots button on the right side of the top bar on the app's home page. The first time you use it, you need to either log in or register. The teacher is then taken to the first overview with the example's generator settings.

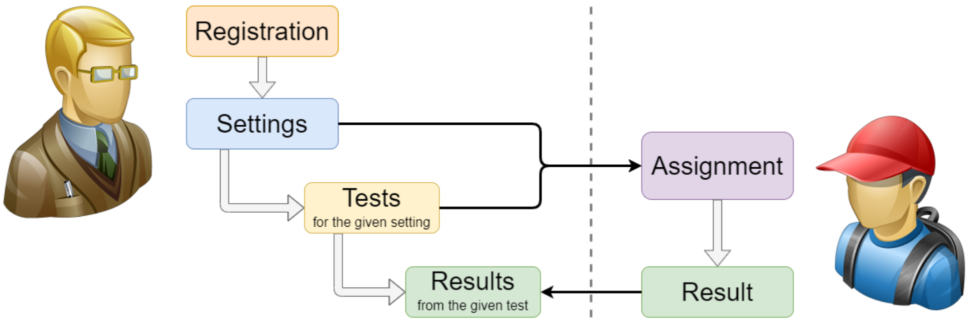

Figure 2: Flowchart of navigation in the application during online testing.

Settings

The overview of settings is initially empty until the teacher creates some, or downloads from the server the settings they created earlier on another device by calling synchronisation. After selecting a setting, the row with it in the overview is highlighted and additional icons for working with the selected record appear in the top panel (Fig. 3).

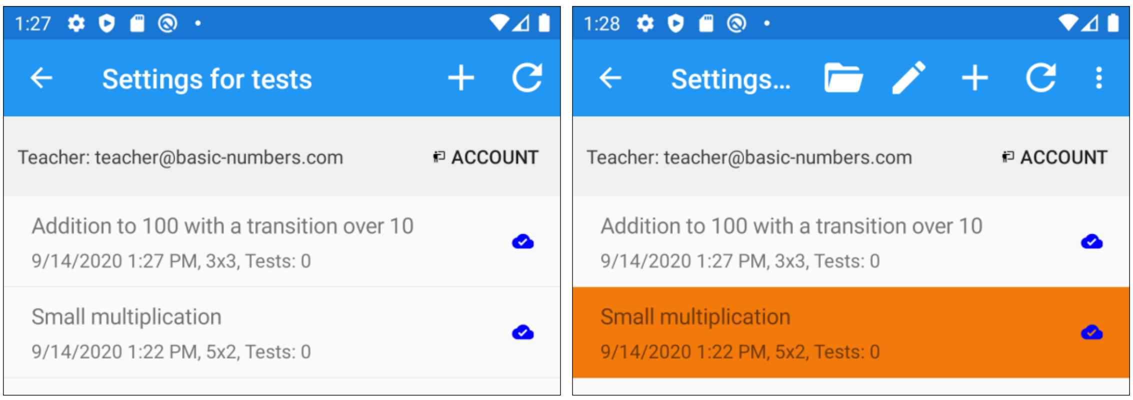

Figure 3: Overview of problems generator settings.

When creating a new setting or editing an existing one, a form identical to the one available in the main part of the application opens (Fig. 4). The only thing missing here is the option to lock the settings with a password, because the student cannot affect the settings for the online test, and if the student were to download the password-protected settings and save them as the main settings, this would lock the ability to change them later.

After leaving this page, it will first attempt to generate problems in the background for the set assignment, and if this fails, the teacher will be prompted to first modify the generator conditions. If successful, it continues by automatically saving the settings to the device and also to the cloud server.

If the device does not currently have an internet connection, the settings are only saved locally on the device and can be resent to the server later. Settings that are synchronized

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with the server are marked with a blue cloud icon with an OK symbol in the overview on the right, while settings that have been changed and not sent to the server have a grey crossed-out cloud icon. To upload, just open the settings for editing and close them again, or use the button for two way synchronization of the entire overview of settings in both directions. When the settings is changed, the newly started tests will be generated with the new settings, but the records from the test results already generated will not be changed.

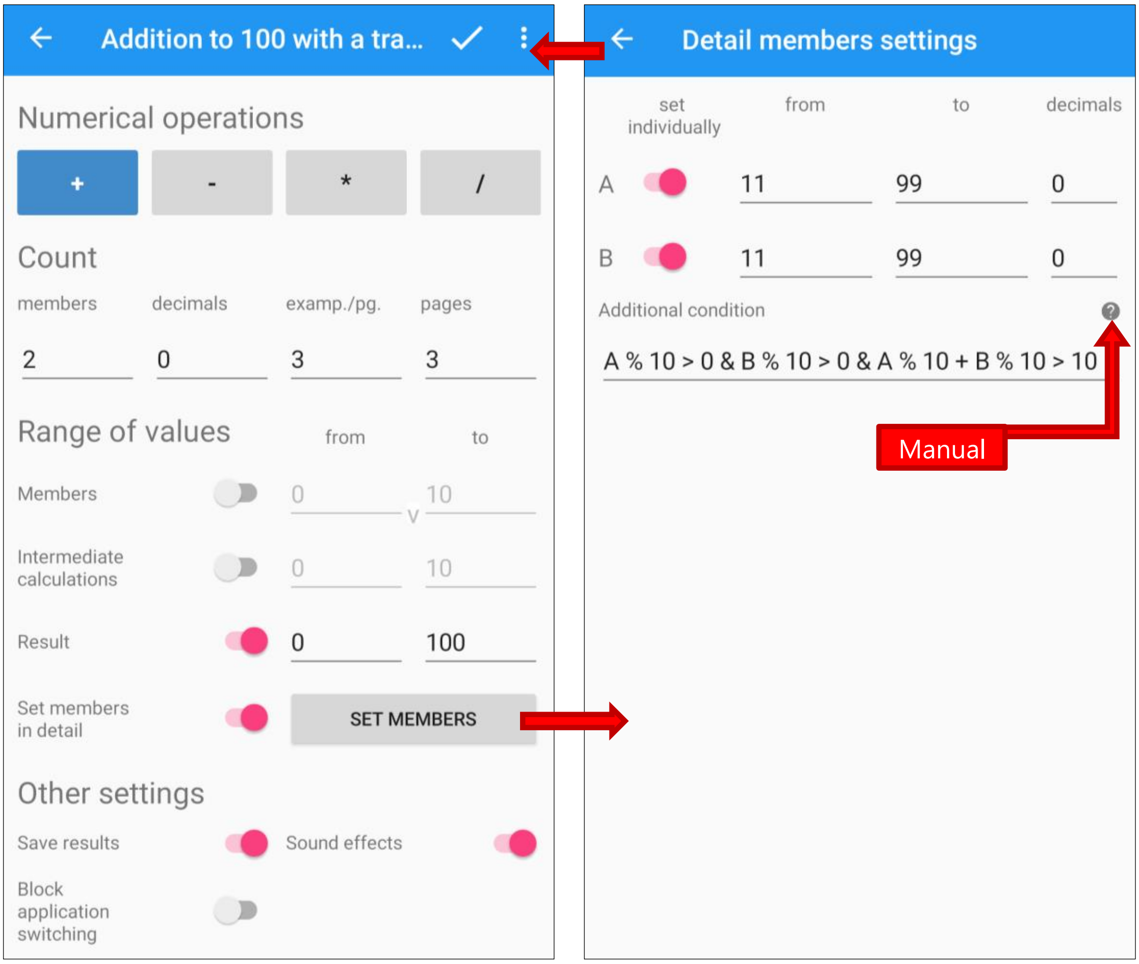

Figure 4: Overview of problems generator settings.

Tests

Selecting a setting and clicking the *Tests* button will then display another page with an overview of the tests for that setting. The name of the selected setting under which the tests fall is listed below the top panel. The controls here are the same as in the settings overview. You can create a new test, load tests from the server, or synchronize unsubmitted changes in these tests (Fig. 5).

On the page for creating a new test or editing an existing one (Fig. 6), you can define the name of the test (by default it is taken from the name of the test settings, which is also listed below the form), the instructions for the test, limit or not to limit the date and time from which the test will be available, limit or not to limit the date and time until which the results of the test can be saved, and if these results should be saved on the server at all. If the results are stored, from a GDPR perspective (Albrecht, 2016), you must also set a date

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by which they will be stored on the server and after which they will be automatically deleted, with a maximum storage period of 1 year. The option to *Allow take settings* allows students (but not only them) to copy settings from a test whose passcode they know into their application without necessarily having to run the test at all.

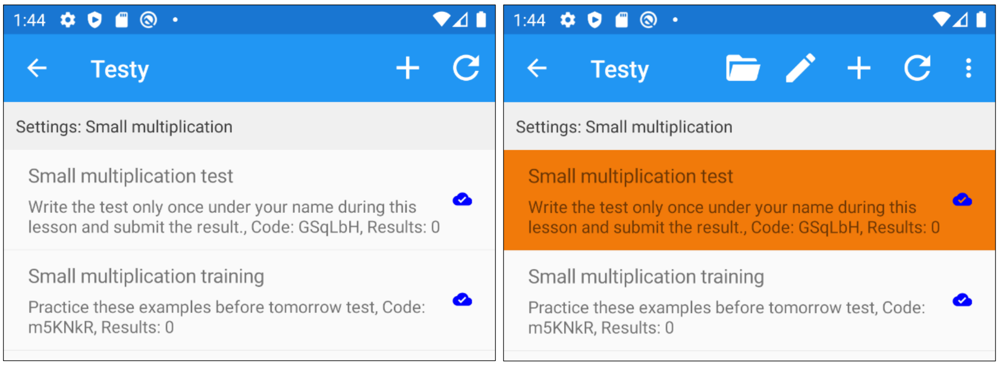

Figure 5: An overview of tests falling under the selected settings.

After the test is saved and sent to the server, a unique code is assigned to the test, which is displayed in read-only mode the next time the test detail is opened. This is the code students need to run the online test, so there is a button to quickly copy it to the clipboard or share it using the app of your choice on your device. This also allows you to share test settings between teachers.

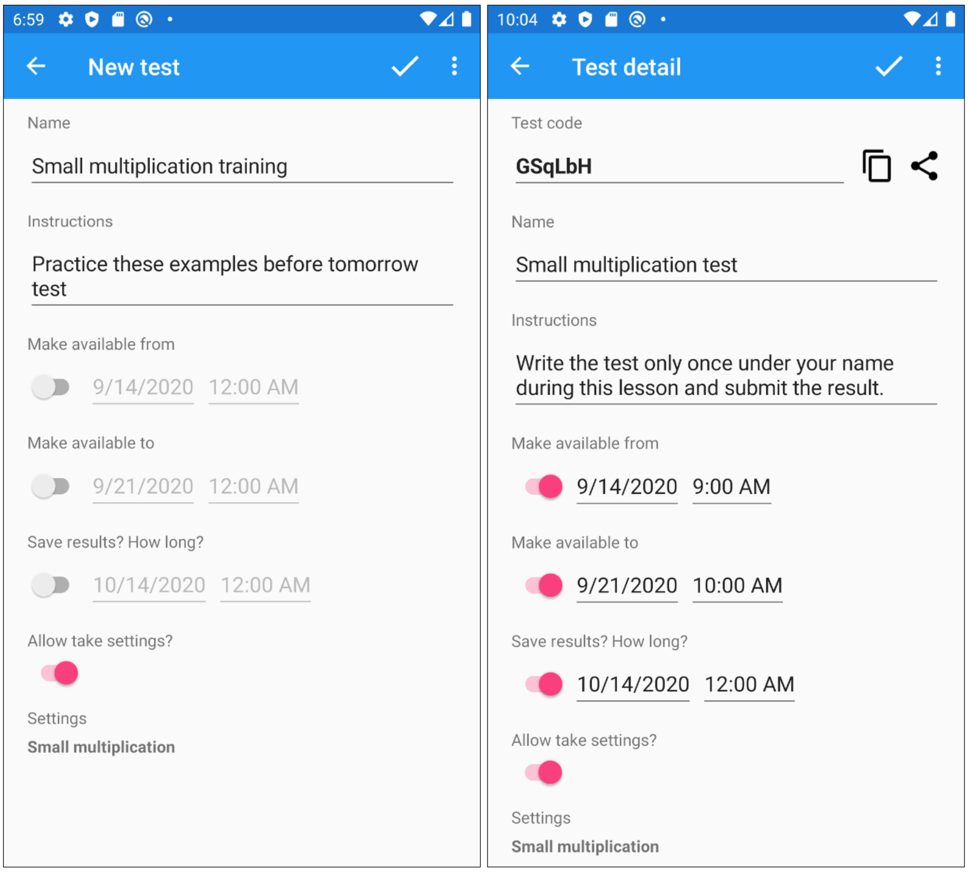

Figure 6: An overview of tests falling under the selected settings.

Results of the test

Selecting a test and clicking on the *Results* button will then display another page with an overview of the results from that test (Fig. 7). For each test, you can already see the name of the student or the designation the student entered before the test, the date the student sent the result to the server, the total time (minutes and seconds) the student spent on the test and the total score the application gave to the student's performance.

This time, the cloud icon indicating the synchronization status indicates that the last time the data was restored, the status of the result stored on the server and on the device was the same, or that the result downloaded to the device was deleted on the server. The deletion can occur either automatically when the deadline for deleting the result is reached (set in the test details, maximum 1 year) or by the student from his/her application, who has the right to delete his/her assessment from the server at any time in terms of GDPR. However, a copy of the result remains on the teacher's device until they delete it as well. In fact, the teacher can also delete the results from both his device and the server in the extended menu, but if he has used more than one device, the result can still be stored on the other device.

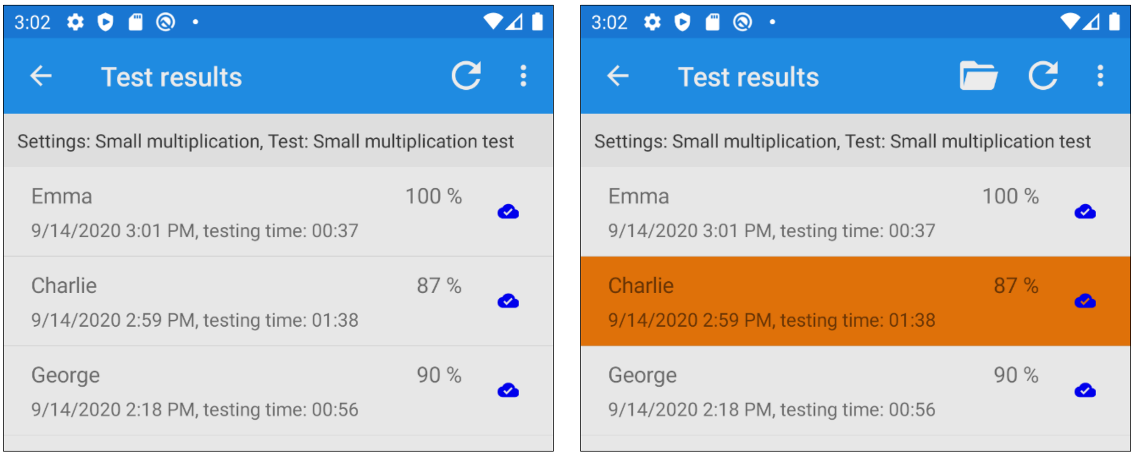

Figure 7: Summary of results from the selected test.

A list of all test results currently downloaded on the device can be exported to CSV format (e.g. for MS Excel) using the button in the extended menu. For this export file, the classic file sharing menu opens, so that you can, for example, send it to an e-mail or save it in another folder of the device or in your own cloud service.

After selecting one of the test results in the overview, you can also open its detailed breakdown. The teacher can then see the problems that were generated for the student in this test according to the conditions the teacher set, what the correct solution was, what variations of the result the student tried before successfully completing the page with the examples and how many motivation stars the student received for the given set (page) of examples (Fig. 8). Students can also view the same detail analysis of their test on their facilities.

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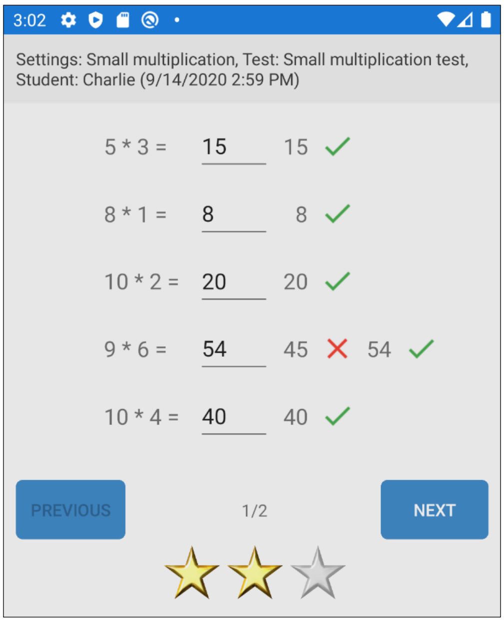

Figure 8: Detailed analysis of the selected test.

CONCLUSION

Together with previous versions of the application, such as the option of defining control conditions for the generated examples, which allow to specify virtually any type of assignment, or the protection against application switching, the option of online testing provides great variety of uses not only for teachers.

For example, teachers can prepare sets of examples for their students to practise both at home and in class (blended learning), they can continuously test their progress on different types of assignments, remotely and in the classroom for full testing, where teachers can ensure that pupils don't cheat, while taking full advantage of the automatic generation of unique assignments, as well as automatic scoring and results collection. The remote testing capability can then be of great benefit to students who are absent for long periods of time or during quarantine measures.

It is not strictly necessary to use just a mobile device for preparation and control, but there is also a Windows version of the app that can be used to control everything conveniently via a PC or laptop, while ensuring full synchronisation of all data between all devices.

At the same time, teachers can send settings they have already created to each other, thanks to the *Download Test Settings* function. Simply create a test for a given setting where this option is enabled and provide the code to your colleagues. Instead of running the test under this code, they can copy the settings to their device and, by saving and loading them, transfer them back to their own tests, either in their original or modified version.

In the application, the assignor of the tests is referred to as a teacher, but this is only a role under which anyone can register, including, for example, parents of students, friends or tutors who want to help them with their elementary mathematics studies, can prepare various exercises for them remotely and analyse their results with them.

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In the next version, it is also planned to be possible to transmit (display, send, share and retrieve) the access code to the test using a QR code and administration of groups (classes) of pupils, to whom it would be possible to enter tests even without a code.

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Section:

Intelligent Computing

Effectiveness of Selected Wireless Sensor Protocols and Their Security

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Abstract

In the field of wireless sensor networks (WSN), there are several important factors that affect it, but security is the most important. This is because WSN is a big part of our daily lives and the data it spreads is essential to protect. It is in everyone's interest that our sensitive private data is not leaked. For this reason, prevention and protection against possible attacks is most important in communications, in the networks used. The article describes selected protocols of the application layer of wireless sensor networks, analyzes and examines security risks based on selected categories. In our own sensor network, we focused mainly on the MQTT and HTTP protocols, which are currently the most usable in WSN.

Keywords

Wireless sensor networks, Security, Attacks, HTTP, MQTT.

INTRODUCTION

Wireless sensor networks (WSN) are sensor devices that can be used to monitor and record a wide range of environmental conditions. Among the most important are sensors that can save human lives. We also include sensors, where the measurements can be used to improve living conditions and to obtain information from nature, such as measuring air temperature. We come into contact with these sensors and WSN every day, so it is important to address their safety (Francisti and Balogh, 2018).

A WSN is a network that consists of distributed sensors and one or more interceptor nodes. Sensors located in the network record physical conditions such as temperature, movement or vibration. They monitor these conditions in real time and generate sensory data from them. The sensor node can act as both a data creator and a data router. The sink node or master node is used to collect data from the sensors. In the case of event tracking, sensors are required to send data to master nodes when they detect the occurrence of interesting events. The master node can communicate with the end user via the Internet, satellite, direct connection, or any wireless connection (Senouci and Mellouk, 2016; Stastny and Skorpil, 2016; Molnar and Orosz, 2020; Demeter and Kovari, 2020).

The article deals with selected protocols of the WSN application layer, their security and efficiency of protocol use in devices connected to the network. (Balogh et al., 2018).

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RELATED WORK

In wireless sensor networks, sensor nodes are distributed across the sensor array (Figure 1). Each node uses its capabilities to collect and route data. The goal of their work with data is to create a global view - a given field. The information can be routed directly or via other sensors, in the case of a multi-step architecture, to a collection point, otherwise known as a base. The base can also serve as a gateway node whenever communication or connection to an external network is required, for data analysis or decision making. (Hamami and Nassereddine, 2020; Kovari, 2020).

The master node can communicate with the user via the Internet, wireless network (e.g., Wi-Fi or Bluetooth) or satellite. Nodes have a dual function: they are the originator of the data, but they also route them further. The source nodes transmit information to the main node and their function is mainly communication. Sensor nodes help redirect packets from other nodes and their function is routing (Vuran and Akyildiz, 2010; Kovari, 2018).

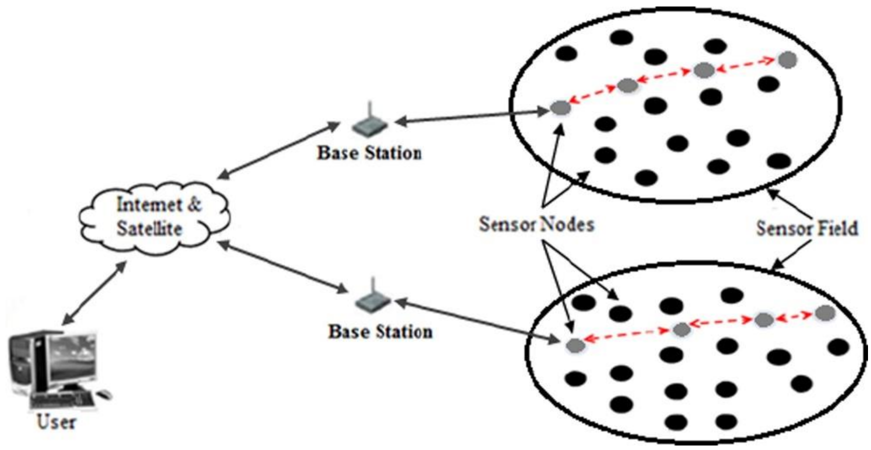

Figure 1: Wireless sensor network (Hamami and Nassereddine, 2020).

The architecture of wireless sensor networks consists of five layers (Figure 2). The physical layer contains, compared to a traditional network, more threads, for the purpose of protection against tampering and wireless data transmission. Typical physical layer attacks include signal interference and sensor replacement. The link layer is responsible for streaming multiplexing, data frame recognition, media accessibility, and error checking. Network layer threads focus predominantly on intrusive data and energy-efficient multi-step routing, which is a key principle in WSN. Common network layer attacks include attacks such as "spoofing", "flooding" or "sinkhole" attacks. The transport layer is mainly used to maintain the flow of data, which is important when entering from the external networks to the WSN. The application layer depends mainly on the scanning tasks and the application software runs on it. Many WSN applications rely heavily on coordinated services such as location, time synchronization, and network processing. These services present new capabilities for attackers, such as entering fake data, badly synchronizing time, or filtering fake data (Tan and Merrett, 2010; Minarik and Stasny, 2008; Benko and Munkova, 2016).

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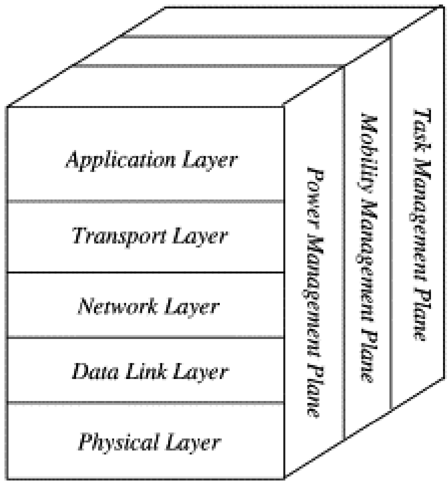

Figure 2: WSN layered architecture (Akyildiz et al., 2002).

WSN Security

The lack of physical security with unsupervised operations means that sensor nodes are prone to compromise in most cases. Broadcast data over a wireless network can result in an invasion of privacy, due to the sensitivity of the information during its transmission. For this reason, the WSN security issue, which is the subject of much research, is in order. The exact location of critical tasks in WSN applications is important. For example, location information can be found in geographic routing protocols to make it easier for sensor nodes to make decisions. Data aggregation is also important, as it has proven to be an important element in reducing communication costs and saving energy. The aggregation node collects raw data from other nodes, aggregates it and transmits it to the base. However, an attacker can relatively easily disrupt one or more of these nodes and enter false data or non-existent events into the network. The goal of WSN's defense against attack is to protect integrity, authenticity and confidentiality (Sun et al., 2008).

Integrity in wireless sensor networks ensures that the data we transmit cannot be changed during transmission until it reaches its original destination. If compromised, an attacker could modify the data to cause clutter throughout the network, such as by adding a fragment or manipulating the data (Rouissi and Gharsellaoui, 2017).

Confidentiality ensures that messages are hidden from passive types of attacks. It is very important to create a secure channel in the network, because sensors can send highly sensitive data, such as key distribution. To some extent, the identity of the sensors and the public keys should be encrypted (Chen and Zhong, 2007).

A threat is defined as the ability or intent to adversely affect the operation, system, or equipment on a network (Gao et al., 2018). We can divide the attackers according to the approach of amateurs, professionals or well-founded hackers. Amateur types of attacks include denial of service or "sniffing". The professional type of attacker usually launches more sophisticated attacks such as "hijack", "man-in-the-middle" or "Sybil" attack. In the case of a well-founded attacker, highly sophisticated attack tools such as node capture, "wormhole" or "rushing" attacks must be considered. (Gao et al., 2018).

The aim of the article is to describe selected protocols of the application layer of wireless sensor networks, to analyze them, based on selected categories and to examine

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security risks. Depending on the results of the analysis, the protocols examined, evaluate and recommend their use and verify their security risks through attack.

MATERIAL AND METHODS

In the article, we focused on creating our own sensor network, in which we practically verified the security of the sensor network and compared it with available results from other authors. We compared MQTT, CoAP, DDS, AMQP and HTTP protocols. In our own sensor network, we focused mainly on the MQTT and HTTP protocols, as they are currently the most applicable in WSN, as evidenced by a survey by the authors (Al-Masri et al., 2020), shown in Figure 3.

We evaluated the selected protocols according to the following metrics:

- latency,
- security.

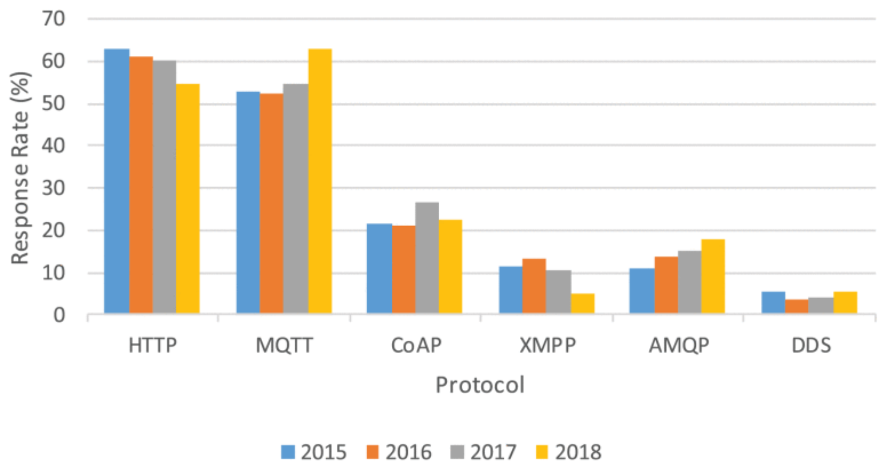

Figure 3: Protocol usage rate (Al-Masri et al., 2020).

Latency is the time it takes from sending a message, in our case for a specific protocol, to its delivery. We measure it in milliseconds (ms). In a work (Cui, 2017), the author tried to compare the CoAP, MQTT, AMQP and DDS protocols. The author divided the measured values into two categories according to the size of the data, namely: messages with low data content (10 - 1000 Bytes) and messages with large data content (2000 - 100 000 Bytes). The author (Naik, 2017) in the work examined the protocols HTTP, AMQP, MQTT and CoAP in several aspects. One of the studies of the author was the magnitude of latency in these protocols. The CoAP protocol with the lowest measured values appeared again, followed by the MQTT and AMQP protocols, and the HTTP protocol turned out the worst. In another paper, similar research was conducted by the authors of the article (Proos and Carlsson, 2020), who examined the MQTT, AMQP, and CoAP protocols. They carried out their research in the automotive sphere, the so-called IoV (Internet of Vehicles). For smaller reports, the latency values turned out to be similar, the CoAP protocol was slightly faster. For larger reports, the gap widened and CoAP again proved to be the fastest.

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Energy consumption is a very important factor in WSN and is also affected by the protocols used in the application layer. The author of the article (Naik, 2017) compared the protocols CoAP, AMQP, MQTT and HTTP. The author found the HTTP protocol to be the most energy-intensive. The MQTT and CoAP protocols, on the other hand, appeared to be the most effective, the differences between them being minimal, but the CoAP protocol performed slightly better. In the second case, the protocols MQTT, CoAP and HTTP were investigated by the authors (Joshi, et al, 2017). In their research, the individual protocols sent messages for 1 hour, during which they monitored the number of messages sent and the amount of energy consumed. Most messages were sent by the MQTT protocol (263,314 messages), so it was more energy efficient than with other protocols. Relatively similar power consumption values between the MQTT and CoAP protocols were reaffirmed. The most energy-efficient was the HTTP protocol, although the author sent the least messages, so the difference in energy consumption was significant.

EXPERIMENT AND RESULT

We used the ESP 8285 module and the Raspberry Pi 3 model B+ to create our own network. We chose these devices because of the good availability of sensors and their ability to communicate with multiple operating systems. In the projects, we used a DHT11 sensor to measure temperature and humidity, an LED to indicate and resistors to change the resistance.

We used the home Wi-Fi network to connect to the Internet, which was needed to create an access point for IoT devices (Francisti, 2020). We did not connect to it directly to prevent unnecessary packets from being intercepted from other devices connected to the network. We used the Windows 10 environment to create the access point, which provides us with this option in the settings.

ESP 8285 was used and a computer running Windows 10 to examine the HTTP protocol. 2 LEDs with two resistors with a resistance of 100 Ω were connected to the ESP module.

In the second case, when examining the MQTT protocol, the wiring was different, as we also used a Raspberry Pi and a temperature and humidity sensor.

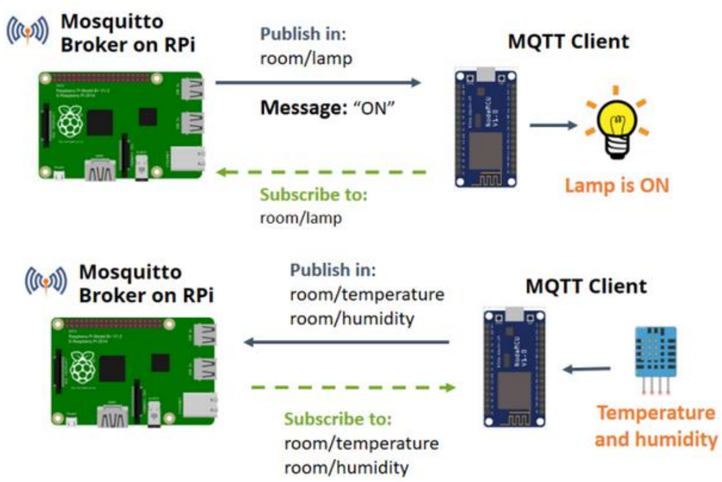

Figure 4: Wiring diagram for Raspberry Pi and ESP 8285 (own model).

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In the case of the MQTT protocol, before uploading the program to ESP, we first ran Mosquitto Broker on a Raspberry Pi using the mosquitto -d command. Then we connected the ESP module to the laptop using a USB cable and we could go to uploading programs. After uploading the program, we launched it on ESP and at the same time we launched the Wireshark program to capture communication. Subsequently, we started testing the programs, with commands to turn on / off the LED light and to send messages. Humidity temperature data was sent separately at a certain time interval, which was defined in the programs. We repeated these tests several times.

After performing tests with both protocols, we proceeded to the analysis of the collected data. We recorded the data in a table and evaluated them. We only analyzed data from HTTP and MQTT protocols, which we filtered in the Wireshark program according to the IP addresses of our devices.

HTTP protocol testing

We needed an ESP module and a laptop to test the protocol. We turned on a mobile hotspot on the laptop to share the connection and then uploaded the program to the ESP module.

Name of device	IP address	Physical address (MAC)
MSI	192.168.137.43	dc:53:60:c2:eb:4c
ESP-D7F568	192.168.137.239	60:01:94:d7:f5:68

Figure 5: IP addresses of connected devices (own model).

The first object was an LED bulb, which we turned on and off via an HTML page. We opened the page in a laptop browser, where we turned the light bulb on or off using the program-defined buttons. Communication between the notebook and the ESP module took place via the HTTP protocol. We repeated the test ten times and then ended the packet capture in Wireshark. The values measured during communication were then entered into a table in which we recorded the time of sending the protocol when the LED bulb was turned on and off, as well as the size of the packets when sending this protocol.

The second object we examined was a temperature and humidity sensor. We proceeded similarly to the previous object. The difference in the program when examining the on / off of the LED bulb and the temperature sensor was that the temperature sensor value was automatically written to the page and it was not necessary to use the button. We also repeated this test ten times. We recorded the measured values in the table. Because the communication between the devices took place automatically, it did not take long to obtain a sufficient amount of measured data for analysis.

From the analysis of the obtained data, we found that the protocol provided relatively stable results for all categories, we recorded the largest deviations when sending text messages. We recorded the fastest shipments when measuring temperature and humidity, when a speed of 8.499 ms was recorded. In this same category, we also recorded the fastest transfer, which lasted 4.933 ms. We also attribute this fact to the fact that when sending temperature and humidity, the packet size was the smallest among the other measured categories. During analyzing the data we obtained by sending the text, we learned that the size of the text is not a decisive factor in measuring the latency of this protocol. In the case

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of measuring the size of the sent text, we found that increasing the volume of the text also increased the number of sent packets, but the average sending time of the text with a length of 100 characters was the smallest. However, we do not rule out that we would get the same results with much larger reports.

MQTT protocol testing

We also connected the Raspberry Pi to the ESP module and laptop, which served as our MQTT server. We re-recorded the IP addresses of the tested devices. We turned on a mosquitto broker on Raspberry, uploaded the program to the ESP module and started testing. We have divided the devices into the same categories as in the previous protocol. We tested them in the same order as in the HTTP protocol and we also repeated the tests several times.

Connected devices: 3 z 8

Name of device	IP address	Physical address (MAC)
raspberrypi	192.168.137.240	b8:27:eb:8e:bb:43
ESP-D7F568	192.168.137.166	60:01:94:d7:f5:68
MSI	192.168.137.43	dc:53:60:c2:eb:4c

Figure 6: IP and MAC addresses of connected devices (own model).

In the first case, we again paid attention to capturing communication when turning on and off the LED bulb. As we communicated via the MQTT protocol, no website was required. In this case, we turned on the light bulb using the command we entered in the Raspberry Pi console. We also examined the packets sent when measuring temperature and humidity using the DHT11 sensor connected to the ESP module. After turning on the program in ESP, communication between ESP and Raspberry started automatically, but it was necessary to specify the Raspberry IP address as the IP server in the program. In this case, we didn't have to execute any special commands from the command line, just run Mosquitto Broker on the Raspberry Pi.

When testing the packets in the third case, we used a laptop to communicate with Raspberry. We were able to send text messages between Raspberry and the laptop using the MQTTBox program. Again, it was necessary to define the Raspberry IP address as the IP address of our server. We tested texts of several lengths for both the HTTP protocol and the MQTT protocol.

An analysis of the test results of the MQTT protocol showed that its most advantageous use is in short text messages. The average measured latency was 3.838 ms, and in this case the smallest packet size was sent. It is relatively advantageous to use this protocol when sending information about temperature and humidity, as we measured latency values very low, usually less than 0.2 ms. We noticed only 2 anomalies here, based on which we believe that the ESP module reestablished the connection to the MQTT server and for this reason we got high latency values. We recorded the highest measured latency values when sending the command to turn the LED bulb on and off. We attribute this fact to the fact that with each command the connection between the devices was interrupted and did not go as continuously as when sending temperature / humidity data. When sending text messages,

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we found that the size of the messages had an effect on latency, but this effect would be more pronounced for larger messages.

Security of WSN

There is a demonstrable security risk with both protocols, as there is no encryption during communication. We see a security risk mainly when sending messages and sensitive data. In the Man-in-the-middle attack, we successfully tried to intercept the communication, and in its analysis, we, in the role of the attacker, obtained all the information sent using the MQTT protocol. The HTTP protocol works similarly. The success of the attack and its low complexity also tell us about the weak security of the protocols. With the help of "ARP poisoning" attack, we got into the network between the communicating devices and subsequently there was no problem with its capture. In the case of the HTTP protocol, we were also able to find out more detailed information, such as which browser the victim uses. We can state that in both cases we saw the sent message in its full extent.

In examining the latency, we noticed a weak security of both protocols, as they are not encrypted. When capturing the communication, we were able to read the logs in the Wireshark program, as well as we could see the data from the temperature and humidity sensor or information about turning on / off the LED bulb.

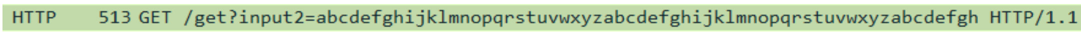

Figure 7: Recorded packet from Wireshark (own model).

In the case of the HTTP protocol, other information was also seen, such as the web browser used or the protocol version. The text of the message was visible in the MQTT protocol, but also the "Topic" name, in which the communication between the devices took place. The interception of the communication with its decrypted packets could be seen only if the commands were executed on one of the devices that was a participant in the communication. If we tried to intercept the communication from a device that was connected in the network, but was not a direct participant in this communication, then we did not see it, as it took place only through encrypted protocols.

CONCLUSION

We chose two of the most used protocols for analysis and tested them in several categories. We performed the tests multiple times in each category to ensure a greater number of results for more detailed and deeper analysis. We used the ESP 8285 and Raspberry Pi devices for the tests, which proved to be easy for handling the sensors with good user environment. We used the Wireshark tool for the analysis, due to its good availability on Windows and Linux, which we used in our work. We tested each protocol individually as well as each category to avoid possible testing disruptions and skewed communication results. In both cases, the tests were completed without disruption and the results were evaluated.

The MQTT protocol is better for use in the WSN realm in terms of latency and several factors. The differences in the measured values were not large in the overall results, but in

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the individual testing categories it turned out to be faster. We noticed its speed shortcomings mainly during tests with an LED bulb.

The HTTP protocol is similar to the MQTT protocol in terms of security, both protocols are unencrypted, so we could easily see the content of the communication during the analysis. Based on the visibility of the communication, we tried to perform a MITM attack on the wireless sensor network. VPN tools, which are used to encrypt communications, have proved to be very useful for improving security. WSN is a big part of our daily lives and the data it spreads is essential to protect. It is in everyone's interest that our sensitive information about ourselves is not revealed. For this reason, prevention and protection against possible attacks is paramount in the communications we use.

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Comparison of Novel Approach to Part-Of-Speech Tagging of Slovak Language

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Abstract

The aim of the paper is to compare Part-of-Speech tagging tools on a more complex language: Slovak language. The tools for creating a morphological annotation of words in sentences were using various techniques. In the past many authors used for automatic tagging rule-based approaches, Hidden Markov models, Support Vector Machines, and morphology driven taggers. Nowadays neural networks obtain more and more attention and are also implemented into Part-of-Speech tagging. In this paper we compared two different approaches to Part-of-Speech tagging: based on recurrent neural networks and Hidden Markov model. The examined dataset consisted of 10 604 sentences in Slovak language where the words have been manually annotated by at least two evaluators. The results showed a significant improvement in performance of the neural network based approach. The accuracy of the two taggers was at first different but after modifying the output of the older tagger we achieved similar results approaching 96% accuracy.

Keywords

Natural language processing, POS tagging, morphological annotation.

INTRODUCTION

Natural language processing is a field that is expanding very fast and consists of many various subfields. Working with texts and analysing them is one of them. Its part is a very important task: Part-of-Speech (POS) tagging. POS tagging takes each word from a sentence and gives it a tag that represents its word form (noun, verb, adjective, etc.). POS tagging as a task for human evaluator is very time consuming as tagging each word is very detailed task (Munkova et al., 2021). Because of that many researchers tried to come up with algorithms that would help to solve this problem. This article aims to compare the novel approach of automated POS tagging using neural networks and comparing the output with the previous state of art approach. The POS tag consists of symbols with exact meaning. For example, we can take Slovak word “výkrik” that in English is translated as “cry.” The tagger categorizes the word with the symbols SSis1. This means, that the word is a noun (S), with a substantive paradigm (S), masculine inanimate genus (i), singular (s), nominative (1). Slovak language

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contains a complex POS tags that consist of various categories. The experiment in this paper will be done for a specific language – Slovak language, as a flective language type.

The article is divided into several sections as follows: first section is focused on related work where we introduce the various approaches to POS tagging, second section describes the methodology of the experiment, and the results are dealt with in the following section. The last section deals with the discussion and conclusions of the article.

RELATED WORK

Automated POS taggers were first focused on a linguistic approach and later the focus went towards a statistical approach (Màrquez, Padró and Rodríguez, 2000). POS tagging for the English language is almost perfect and nowadays the accuracy of the models is more than 97% (Bohnet et al., 2018). POS tagging is part of the preprocessing phase of working with texts. There are many approaches to how to automate the POS tagging. One of them is a Rule-based POS tagger that consists of a dictionary of possible tags for each word (Jurafsky and Martin, 2009; Schmid, 1995). Next approach is based on Statistics where for the analysed sequence of words the most probable sequence of tags is selected. These taggers are also known as stochastic or probabilistic taggers (Schmid, 1994). The most common models of statistics POS taggers are n-gram models and Hidden Markov Models (HMM) (Kapusta and Obonya, 2020; Balogh and Kucharik, 2019; Francisti and Balogh, 2019; Jurafsky and Martin, 2009; Schmid, 1994; Minarik and Stastny, 2008; Magdin et al., 2021). Memory-based POS taggers has a set of cases consisting of a word, its context and suitable tags, stored in memory. The examined sentence is tagged based on the best match from cases in the memory. It is a combination of the probabilistic and rule-based POS taggers (Daelemans et al., 1996). Another combination of the rule-based and probabilistic POS taggers are Transformation-based taggers, where the rules are automatically induced from the data. Tagging is done using broad rules and then transformed by applying narrower rules (Jurafsky and Martin, 2009). The novel approaches are focused on neural networks: recurrent neural networks (RNN) and bidirectional long short term memory (LSTM). Schmid (2019) uses a bidirectional LSTM to process the character sequence of each input word where the final states of both directions are concatenated to form the word representation. The sequence of word representations is processed by another bidirectional LSTM and outputs a contextual representation of each word by joining the state of the forward and backward LSTM. Then the contextual word representation is passed through a linear layer followed by softmax function over all possible POS tags. Schmid (2019) trained the system using stochastic gradient descent to maximize the log-likelihood of the gold standard tags.

Other authors that dealt with evaluation of the POS taggers accuracy are described in the following section. Abuzeina and Abdalbaset (2019) focus on Standford Arabic model tagger and its accuracy of identifying the imperative verbs in historical texts. The used Standford tagger is created with JAVA programming language and is based on HMM (Toutanova et al., 2003). The results of the experiment showed that training domain has significant influence on the accuracy of the tagger. The disadvantage is that a comprehensive tagset requires an extensive control of the transition probabilities between all tags because zero probabilities cause errors in HMM based taggers. Kumar and Josan (2010) introduced a survey of POS taggers for morphologically rich languages in India. The authors looked at Malayalam language where they dealt with stochastic HMM of accuracy

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around 90% and Support Vector Machine (SVM) based POS tagger that achieved 94% accuracy of tagging. For Bengali they compared three different POS taggers: HMM based tagger achieved around 88%, SVM based tagger had similar accuracy of 86%, and last was Conditional Random Fields (CRF) based approach with accuracy above 90%. The Hindi language was analysed by four POS taggers: Morphology driven tagger with average accuracy of around 93%, Maximum Entropy based tagger was less effective with around 88% accuracy, HMM based tagger achieved a little less than 93% accuracy, and CRF based tagger achieved only 82% accuracy. Kumar and Josan (2010) showed that various POS tagger approaches achieve different accuracy for various Indian languages where machine learning based approaches showed better results. Munkova et al. (2016) used a HMM based POS tagger to create a system for post-editing and automatic error classification of machine translation. The aim of the paper was to propose design a system for the purpose of determining which error types cause a problem for a given machine translation system, when translating a text of various styles (administrative, scientific and publicistic) into an inflectional language such as Slovak. Hladek et al. (2015) focused on Slovak language and a statistical way to analyse a given lexicon and extract list of common suffixes and list of common rules for suffix identification. They compared the HMM based POS tagger with different algorithms. The proposed Dagger algorithm adjusts the final state-observation probability to take suffix of a word into account (Hladek et al., 2015). The Dagger algorithm was compared with the TreeTagger POS tagger (Schmid, 1995) and achieved similar accuracy. The proposed approach is language-neutral and might be used also for other languages where most of the morphological features are hidden in the suffix of the word.

METHODOLOGY

The experiment of this article was focused on the difference between the state of art POS tagger and the previous POS tagger. For this case, it was used the POS tagger from the same author – TreeTagger (Schmid, 1994, 1995, 2018). This POS tagger can be also used for Slovak language where the training of the tagger was done on the Slovak National Corpus as for the HMM based POS tagger so for the bidirectional LSTM POS tagger. It is assumed that the newer POS tagger based on neural networks should perform better than the latter. We tested this assumption for Slovak language as a complex language that has different language shapes. We used a dataset that has already annotated texts (Gajdošová et al., 2016) – Slovak Dependency Treebank, that was created as part of the Slovak National Corpus. The annotation was assigned manually to every word. The used dataset is a subset of the original treebank and contains only sentences where two human annotators perfectly agreed on the analysis. The downside of the dataset is that it contains mainly short sentences. The readability feature of the dataset is described in Table 1 and lexico-grammatical feature is mentioned later in comparison to the POS taggers output in Table 4. The dataset consists of 10 604 sentences where most of them are shorter with length less than 10 words per sentence.

Table 2: Readability features of the reference dataset

Feature name	**Dataset**
Average sentence length	9.0002
Count of short sentences (n<10)	6588

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Count of long sentences (n>=10)	4016

The aim of the selected dataset was to compare the accuracy of the two examined POS taggers for Slovak language as it contained the manual annotation of words. For the experiment was used an older notebook of the following configuration: Intel® Core™ i5-4210U CPU @ 1.70GHz x4, 11,1 GiB RAM, NVIDIA GeForce 840M, OS Ubuntu 21.10 64-bit. Both POS taggers were run through the terminal and measured also the time spent on the task.

RESULTS

First, we looked at the time consumption of the tasks for both POS taggers. Schmid (2018) states that the RNNTagger – a Neural Part-of-Speech Tagger should have compared to TreeTagger, a HMM based POS tagger utilizing ID3 regression tree (Schmid, 2015), higher tagging accuracy but be slower without GPU. As mentioned in the previous section we annotated Slovak language text in a one txt file with the same Slovak parameter file used for tagging by both POS taggers. We used the unix function time to measure the tagging command for both POS taggers (Table 2). The time function measures three times in minutes and seconds:

- real time – the total execution time that is the time elapsed between invocation and termination of the command,
- user CPU time – the CPU time used by the process,
- system CPU time – the CPU time used by the system on behalf of the process.

Table 3: Benchmark of the examined POS taggers

	TreeTagger	RNNTagger
Real time	56m 56.511s	6m 40.705s
User CPU time	56m 55.737s	13m 14.358s
System CPU time	0m 0.843s	0m 2.214s

As can be seen in Table 2 the RNNTagger achieved better performance. That may have been caused by the usage of the graphics card. We used the default configuration of both POS taggers. After that we looked at the accuracy of the tagging. There was a significant difference between the accuracy of the TreeTagger and RNNTagger (Table 3). We compared the results on three levels: whole tag, first letter of the tag that represents the word shape and lemma.

Table 4: Accuracy of the POS taggers output in compliance with the reference annotation

	TreeTagger	RNNTagger
Tag x Reference	0.8597	0.9610
Tag Word Shape x Reference	0.8882	0.9942
Lemma x Reference	0.9437	0.9892

Very strange was the difference between the tag and lemma compliance by TreeTagger. TreeTagger identified rather the correct lemma than the tag. As can be seen there were no

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significant differences between the three levels for RNNTagger. This made us curious to look in more detail how this was possible. Once again, we looked at the lexico-grammatical distribution for the two POS taggers (Table 4).

Table 5: Lexico-grammatical feature of the reference dataset and POS taggers outputs

Feature name	**Dataset**	**TreeTagger**	**RNNTagger**
Frequency of nouns	25434	35937	25427
Frequency of adjectives	7628	7592	7560
Frequency of adverbs	3299	3315	3328
Frequency of verbs	17217	17210	17218
Frequency of pronominals	8622	8671	8633
Frequency of participles	1156	1197	1220
Frequency of morphemes	3092	3098	3087
Frequency of abbreviation	387	384	391
Frequency of numbers	928	927	930
Frequency of undefinable POSs	154	156	140
Frequency of particules	1868	1828	1866
Frequency of foreign words	188	193	189
Frequency of interjections	65	71	75
Frequency of numerals	1066	1077	1071
Frequency of prepositions & conjunctions	13502	13486	13476
Frequency of interpunction	18353	7817	18349

As we can see in Table 4, there is a significant increase of nouns and decrease of interpunction in the case of TreeTagger. This was because the end of the sentence was classified not as tag Z for interpunction but as information SENT. That way the algorithm has taken the first letter as a part of the tag representing a noun. RNNTagger does not contain the information SENT anymore and classifies the interpunction at the end of sentence as Z. Because of that we updated the TreeTagger output to transform the SENT tag into Z. The accuracy of the TreeTagger was far better than before the modification (Table 5). As can be seen, now there is no significant difference between the results of the two POS taggers in case of accuracy. But it is necessary to check the results of the TreeTagger as the SENT tag can affect the morphological analysis of the examined text.

Table 6: Accuracy of the POS taggers after the modification output in compliance with the reference annotation

	TreeTagger	RNNTagger
Tag x Reference	0.9504	0.9610
Tag Word Shape x Reference	0.9904	0.9942
Lemma x Reference	0.9437	0.9892

DISCUSSION AND CONCLUSION

The automated POS tagger as shown in this paper has an accuracy close to 97% as is the benchmark for annotating English texts. In the experiment we used a manually annotated text of Slovak language and used two different POS taggers. Despite that the

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older TreeTagger took almost one hour to annotate 10 000 sentences the accuracy was similar to the RNNTagger. This POS taggers used in this experiment were based on a Slovak National corpus and the results showed that there were only small differences. The main issue with the TreeTagger was an obsolete usage of tagging the end of sentences using a SENT tag. This created at first a lower accuracy but after our modification it obtained a 95% accuracy. In the case of lemma identification there were not identified significant differences but the RNNTagger achieved almost 99% accuracy of lemmas. Same goes for the word shape tag where both POS taggers obtained more than 99% accuracy. The limitation with the experiment was that the used texts contained mainly short sentences. Slovak language is characterized by compound sentences and these sentences create issues for machine translation. In the future it will be interesting to focus only on compound sentences and whether this could make issues for the POS taggers.

Future work will be focused on comparing more various POS taggers for Slovak language. We will focus on more specific text styles where the POS taggers should have issues. The POS taggers of interest could be RNNTagger, Stanza, Morphodita, and similar that support the morphological annotation for Slovak language.

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Current Metrics for Automatic Evaluation of Machine Translation

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Abstract

Natural language processing involves several phases, one of which is the validation phase of machine translation. For this purpose, the field of machine translation uses so-called evaluation, which can be divided into manual, performed by a human, and automatic, performed by a machine. Currently, mostly automatic evaluation and its metrics are used. This paper offers an overview of selected current metrics for determining the correctness or error rate of machine translation. In addition to segment-oriented metrics, we investigate the success of metrics working with individual features, such as the Chr-F or CharacTER metrics. The dataset we worked with in the experiment consisted of English-language texts of the journalistic genre that were translated by a neural machine translator and a human translator. The results of the experiment showed that some of the metrics were too strict and identified many erroneous segments, in some cases even an extreme number of erroneous segments. On the other hand, the Chr-F metric, which deals with text at the character level, approximated a normal distribution of erroneous segments over the set under study.

Keywords

Metrics of automatic evaluation machine translation, Automatic evaluation, Machine translation, BLEU, METEOR, ROUGE, Chr-F.

INTRODUCTION

Evaluation is an important process in the development of new models not only in Machine Translation (MT) but in most Natural Language Processing (NLP) tasks. In general, it can be divided into two types, manual (human/human) and automatic, with manual evaluation providing a reasonably accurate assessment of the translation. On the other hand, it is time-consuming and costly, as it requires multiple bilingual evaluators, whose evaluation is moreover subjective (influenced by vocabulary, experience, fatigue, etc.) and cannot be repeated (Munkova et al., 2021).

The first metrics for machine translation evaluation purposes are as old as its first models. For many years, only human evaluators were used (manual evaluation), but as data grew, it was necessary to consider a way that would be more efficient. The mentioned imperfections of manual evaluation have given rise to automatic evaluation metrics, which

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can address shortcomings such as subjectivity, time-consuming and non-repeatability (Papineni et al., 2002).

The automatic evaluation metrics can be divided into metrics derived from precision metrics, metrics derived from recall metrics, metrics derived from F-measure metrics, and metrics derived from edit distance metrics. Edit distance refers to the minimum number of changes (insertion, deletion, replacement, or shift) that need to be made to make a machine translation (hypothesis) equal to a human translation (reference) (Munk et al., 2018).

Accuracy, recall, and F-measure are referred to originally as automatic evaluation metrics and were originally used in the field of machine learning. Precision is defined as the total number of matching unigrams (words) divided by the total length of the hypothesis (*h*), coverage is defined as the total number of matching unigrams divided by the total length of the reference (*r*), and F-measure is defined as the harmonic mean of precision and coverage. Together, these measures served as the basis for the creation of other machine translation machine evaluation metrics (Munk et al., 2016).

The aim of this paper is to present selected currently used metrics for automatic evaluation of machine translation and to compare the scores of the given metrics for the English-Slovak language pair.

The paper is divided into the following sections: the first section deals with the analysis of the current state of the art, in which we describe the selected metrics of automatic machine translation evaluation; the second section describes the procedure of achieving the goal of the experiment. The next section describes the results of the experiment, and in the final section we discuss the conclusions of the paper.

RELATED WORK

In the next section we focus on frequently used metrics for automatic evaluation metrics.

BLEU

The most well-known metric for automatic evaluation of machine translation is the BLEU (Bilingual Evaluation Understudy) metric. BLEU is an accuracy metric based on lexical similarity, i.e. the closer the machine translation is to the human translation, the better it is. The problem is that each translator has a different vocabulary and formulates the sentence in a different way, so it is almost impossible to get identical translations. Papineni et al. (2002) focused their research on comparison of translations at the n-gram level. The correspondence of these n-grams in translations is characterized by the so-called n-gram accuracy, which can be calculated for individual segments or even for the whole text.

Ideally, the length of the hypothesis would be equal to the length of the reference translation. Therefore, if a hypothesis is too long, it is penalized with a modified n-gram precision ($precision_n$), which is calculated as follow (Štancel, 2007; Stastny and Skorpil, 2007):

$$precision_n = \frac{\sum_{H \in corpus} \sum_{n-gram \in H} count_{clip}(n-gram)}{\sum_{H \in corpus} \sum_{n-gram \in H} count(n-gram)}, \qquad (1)$$

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where $count_{clip}$ is the number of clip n-grams for all sentences of the hypothesis, h is the hypothesis from the set of these translations. In the case of multiple hypotheses, we proceed sentence by sentence. First, we compute the n-gram matches for each reference translation, then add the numbers of clipped n-grams for all hypothesis and divide it by the number of hypothesis n-grams in the test corpus.

When evaluating an entire corpus, it is customary to work with multiple n-gram types, which BLEU combines using the geometric mean (Jurafsky and Martin, 2008):

$$precision = \sqrt[N]{\prod_{n=1}^{N} precision_n}. \qquad (2)$$

On the other hand, MT may generate a translation that may be too short. In this case, a brevity penalty (BP) is applied to prevent the generation of such translations.

$$BP = \begin{Bmatrix} 1 & ak\ h > r \\ e^{(1-r/h)} & ak\ h \leq r \end{Bmatrix}, \qquad (3)$$

where *h* is the total length of the hypothesis corpus and *r* is the effective length of the reference translation, calculated using the length of the reference translation closest to the hypothesis (the optimal translation length, which is calculated in the case of multiple reference translations) (Štancel, 2007).

We then compute the BLEU itself as:

$$BLEU = BP * \exp\left(\sum_{n=1}^{N} w_n logprecision_n\right), \qquad (4)$$

The resulting score ranges from 0 to 1 where 1 means that the hypothesis and the reference are identical (Papineni et al., 2002).

Recently, BLEU has been criticized for poor sentence-level scoring, ignoring referential agreement of terms in the text, equality of different types of errors, and so on. The mentioned shortcomings often arise when the BLEU metric is not respected by the language pair, domain, exact evaluation set or on the type of engine. Thus, without the necessary context, the results of the metric seem to be insufficient. As an example, the research of Popel et al. (2020), in which an English-Czech MT system achieved a BLEU score of 0.26. At first glance, the score seems low, but the system was able to produce outputs comparable to human translations. In evaluation of translation adequacy by non-professional translators, the MT (specifically CUBBITT) was evaluated as significantly better than the human reference, with 52% of sentences rated in favour of the system and only 26% of sentences rated against. Human evaluators considered human reference to be more fluent, rating the system (CUBBITT) better in 26% of the cases and worse in 48%.

Despite its imperfections the BLEU metric is still popular and used within the translators, but new metrics are developed every day that try to solve the mentioned problems such as METEOR or ROUGE metrics (Popel et al., 2020).

ROUGE (Recall-Oriented Understudy for Gisting Evaluation)

The ROUGE metric was originally designed for the document summarization domain, working with long text consisting of multiple sentences or paragraphs. It has also found application in area of working with short text, such as evaluating the quality of machine translation, creating captions for images, or generating queries.

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The ROUGE metric designed by Lin (Lin, 2004) includes several automatic evaluation methods such as ROUGE-N, ROUGE-L, ROUGE-S, ROUGE-SU, and ROUGE-W. Most of them are based on the similarity between the MT output n-grams and those produced by the translator. The evaluated n-gram is usually a sequence of words or a pair of words (Celikyilmaz, Clark, Gao, 2021).

The ROUGE metrics use precision, recall and F-score metrics and their calculations are different for each variant of ROUGE. In a separate study (Lin and Och, 2004), it was also shown that specific ROUGE-L, W, and S are very effective in automatically evaluating machine translation (Hernández-Castañeda et al., 2022).

ROUGE-N

The ROUGE-N metric use smaller parts of text, n-grams, where N is a natural number that specifies the size of the n-gram (1=unigram, 2=bigram, ..., n-gram). The goal of the metric is to calculate how many n-grams are the same for the hypothesis and at the same time for the reference.

We have a variable $Count_{match}(gram_n)$ that specifies the maximum number of n-grams that can be found together in the reference and in the hypothesis. Let the variable $Count(gram_n)$ that determine the number of n-grams in the reference translation, then relation (5) holds:

$$ROUGE - N = \frac{\sum_{S \in \{references\}} \sum_{gram_n \in S} Count_{match}(gram_n)}{\sum_{S \in \{references\}} \sum_{gram_n \in S} Count\ (gram_n)}, \quad (5)$$

The above relation (5) holds if we focus on only one reference translation. In the case of multiple references, we compute ROUGE-N_{multi} as the highest value from the pairwise translation of ROUGE-N between hypothesis (h) and each reference r_i (6).

$$ROUGE - N_{multi} = argmax_i ROUGE - N(r_i, h) \quad (6)$$

ROUGE-L

The ROUGE-L metric compares machine translation with human translation based on the Longest Common Subsequence (LCS). A longer common sequence indicates greater similarity between the two sequences.

Given a reference (*r*) of length *i* and a hypothesis (*h*) of length *j,* then:

$$LCS(r_i, h_j) = \begin{cases} 0 & \text{if } i = 0 \ or \ j = 0 \\ 1 + LCS(r_{i-1}, h_{j-1}) & \text{if } r_i = h_j \\ \max\left(LCS(r_i, h_{j-1}), LCS(r_{i-1}, h_j)\right) & \text{if } r_i \neq h_j \end{cases}, \quad (7)$$

To compute the precision, recall and f-measure metrics we replace each n-gram match with an LCS value which we compute for each sentence of both the reference translation (*r*) and the hypothesis (*h*) as follows (8, 9):

$$R_{lcs} = \frac{LCS(r,h)}{r\_length}, \quad (8)$$

$$P_{lcs} = \frac{LCS(r,h)}{h\_length}, \quad (9)$$

The harmonic mean is then calculated as:

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$$F_{lcs} = \frac{(1+\beta^2)R_{lcs}P_{lcs}}{R_{lcs}+\beta^2 P_{lcs}}, \qquad (10)$$

where β is a positive real factor (β is set that recall is considered β- times more important than precision) for which:

$$\beta = P_{lcs}/R_{lcs}, \qquad (11)$$

One of imperfections of the ROUGE-L metric is equally evaluated for all sequences, regardless of whether they are sequences with many gaps or consecutive hits. This imperfection is solved by the ROUGE-W metric, another version of the ROUGE metric that requires all n-grams to be ordered in sequence (Lin, 2004).

ROUGE-W

The ROUGE-W metric uses the Weighted Longest Common Subsequence (WLCS) method, an improved LCS method that can distinguish whether a sequence is contiguous or discontiguous, to compare translations. WLCS works with a weighting function that can take various forms, e.g., $f(k) = k^w$ which for a given input returns its w-th power where the recommended weight is $w = 1{,}2$. We use precision, recall and harmonic mean metrics to calculate the agreement between the hypothesis and the reference. The calculation of the harmonic mean is the same as for the ROUGE-L metric but for the precision and recall metrics the following holds (Mička, 2019):

$$R = f^{-1}\left(\frac{WLCS(r,h)}{f(|h|)}\right), \qquad (12)$$

$$P = f^{-1}\left(\frac{WLCS(r,h)}{f(|r|)}\right). \qquad (13)$$

ROUGE-S

The ROUGE-S metric searches the reference for any pair of words separated by one or more other words that appear in the hypothesis. Based on the co-occurrence of skipped bigrams it compares the hypothesis with the reference. Like ROUGE-2 use word pairs, except that ROUGE-S allows arbitrary gaps between words in a sentence. This makes it possible to detect similarities between phrases that differ by adjectives or by only small changes.

In this case the precision (14) and recall (15) are computed as the ratio of the total number of possible bigrams *SKIP2(r,h)* divided by the combinatorial function *C(n,2):*

$$R_{skip2} = \frac{SKIP2(r,h)}{C(h\_length,2)}, \qquad (14)$$

$$P_{skip2} = \frac{SKIP2(r,h)}{C(r\_length,2)}, \qquad (15)$$

where *r_length* a *h_length* represent the length of the reference and the length of hypothesis.

We compute the skip-bigram based F-measure as:

$$F_{skip2} = \frac{(1+\beta^2)R_{lcs}P_{lcs}}{R_{skip2}+\beta^2 P_{skip2}}, \qquad (16)$$

where β is a positive real factor that controls for the relative importance of P_{skip2} and R_{skip2} (Cohan and Goharian, 2016).

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The disadvantage of the metric is that if a sentence does not have a common skip-bigram we assign it a score of 0. This problem is solved by an extension of the ROUGE-S metric, ROUGE-SU which use common unigram if the sentence does not have a common skip-bigram.

BLEU and ROUGE are closely related to each other. As in the case of precision and recall the same relationship holds that if one metric scores high, the other metric will score low. For example, if many words from a reference appear in the system results, then the BLEU score will be high and the ROUGE score will be low, and vice versa.

The harmonic mean of the BLEU (precision-based) and ROUGE (recall-based) metrics is calculated as (Mička, 2019):

$$F1 = 2 * (BLEU \ * ROUGE)(BLEU + ROUGE), \quad (17)$$

METEOR

The METEOR (Metric for Evaluation of Translation with Explicit Ordering) metric was designed from the beginning to correct BLEU errors, such as the need for complete word matching, correct word order, counting BP if one component of the n-gram gets a score of zero, and others.

METEOR was designed to compare translations at the sentence level where it compares individual words with one or more reference translations. The difference is, compared to the mentioned metrics, that METEOR also considers a synonym or a word with the same meaning as the word in the reference as a correct translation. This makes it possible to reduce the number of references against which a hypothesis is compared. In the case of multiple references, the hypothesis is compared with each of them and the one with the best result is selected (Štancel, 2007).

The basic step is word alignment (a one-to-one mapping of words in the hypothesis and references), which results in each word in one sentence matching a word in the other sentence or 0. The alignment is created sequentially through a series of stages in which the following is observed:

1. exact word matching - a word is matched if and only if it is identical to a word in the translation reference,
2. word stem matching - a word is matched if the words match in a word stem obtained using a linguistically appropriate stemming tool,
3. synonym match - a word is matched if it belongs to a synonym database (e.g. WordNet) for a particular word reference.

In the case of multiple alignments is selected the one that best preserves the order of the words in the sentence.

The precision, recall and harmonic mean are then calculated as:

$$P = \frac{count}{h\_length}, \quad (18)$$

$$R = \frac{count}{r\_length}, \quad (19)$$

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where *count* is the total number of unigram hits, *h_length* is the number of words in the hypothesis and *r_length* is the number of words in the reference (Denkowski and Lavie, 2010).

$$F_{mean} = \frac{P*R}{\alpha*P+(1-\alpha)*R}. \qquad (20)$$

One of the imperfections of the BLEU metric was the computation of the multiple factor (BP) using the average length computed from the length of the entire corpus. If one part of the n-gram is equal to 0 then the whole n-gram is also equal to 0. This method affects the evaluation of individual sentences of the corpus and corrupts otherwise acceptable translations (Štancel, 2007).

Chr-F

The Chr-F metric offers an alternative to the BLEU or TER (Translation Error Rate, Snover et al., 2006) metrics. It correlates better with human ratings than the mentioned metrics at the sentence level. It is one of the character n-grams that use with characters instead of words which for technical reasons makes it easier to work with morphologically rich languages such as Slovak, Czech, Japanese, Chinese, etc.. N-grams have so far been used as part of more complex metrics; according to Popović (2015), they may also have potential as stand-alone metrics.

Let *ChrP* be the percentage of n-grams in the hypothesis that also occur in the reference, let *ChrR* be the percentage of n-grams in the reference that also occur in the hypothesis, and let β be the importance parameter, then their harmonic mean is computed as:

$$ChrF\beta = (1+\beta^2)\frac{ChrP * ChrR}{\beta^2 ChrP + ChrR}. \quad (21)$$

It follows from relation (21) that recall is β- times more important than precision. If β=1 then both are equally important.

CharacTER

The CharacTER metricis like TER based on the edit distance, i.e., the *Levenshtein* distance. (Wang et al., 2016) investigated different normalizers such as the average, maximum, or minimum length of the reference sentence and the hypothesis, with the best results obtained when using the length of the hypothesis in the normalization instead of the reference sentence. Hypothesis length was found to be a better normalizer for both TER and CharacTER metrics, compared to reference sentence length.

$$CharacTER = \frac{shiftbcost+edit\_distance}{\#h\_length}. \qquad (22)$$

The TER metric takes into account the word-level shift, CharacTER takes these words and splits them into characters. The edit distance is then calculated, treating spaces in the sentence as an additional character. This approach seems to be suitable for translation from English into German, Russian, French or Czech.

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METHODOLOGY

The experiment in this paper aimed at comparing selected metrics for automatic evaluation of machine translation. The dataset consisted of English-Slovak texts of the journalistic genre. Hypotheses were output from Google Translator, a tool based on Neural Machine Translation (NMT), and references were obtained from students of translation studies at the Constantine the Philosopher University in Nitra. The corpus consists of 66 documents - 2038 segments. We used BLEU-1, BLEU-2, BLEU-3, BLEU-4, METEOR, and NIST as metrics of accuracy, ROUGE 1, ROUGE 2, ROUGE L, TER, and CHrF as error rate metrics. All metrics were computed using the Python programming language and the libraries to compute the given metrics (*nltk*, *rouge_scorer* and *pyter*) over the given segments.

RESULTS

We investigated the success of selected automatic evaluation metrics on an English-Slovak corpus of the journalistic genre. Table 1 provides an overview of the average scores of the metrics of accuracy and the error rate metrics. The BLEU 1 and METEOR metrics show similar translation quality for the corpus under study, less than 50% accuracy. The translation achieves less than 10% accuracy on average for BLEU 4 metric. The NIST metric offers results from a different scale than the other metrics, which are from the interval [0,1], nevertheless, the higher the NIST score, the better the translation. NIST is often combined with the BLEU metric.

Table 1 Average score of the automatic evaluation metrics for the language pair English - Slovak

Correctness metrics		Error rate metrics	
BLEU-1	0.4782	**TER**	0.6230
BLEU-2	0.2620	**CHR-F**	0.5099
BLEU-3	0.1549	**ROUGE 1**	0.0544
BLEU-4	0.0902	**ROUGE 2**	0.0544
NIST	1.8204	**ROUGE L**	0.0851
METEOR	0.4440		

TER and CHR-F came out as the most stringent metrics of the error rate metrics, identifying an average error rate greater than 50%.

Figure 1 describes the frequency of correct translations in the corpus. Range of correct translations is divided into 10 categories according to the score achieved, for example, the BLEU score for a particular segment *"Karl Lagerfeld organizes a Chanel toga party in Paris"* is equal to 0.3309 that means the machine translation of a particular segment is correct in 33%, so it belongs to the 30-40% category.

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We can see that the selected correctness metrics show a low proportion of sentences that were correctly translated at 80-100%. An interesting point is the very high proportion of incorrect sentences with 0-10% accuracy, specifically in the case of the BLEU4 metric.

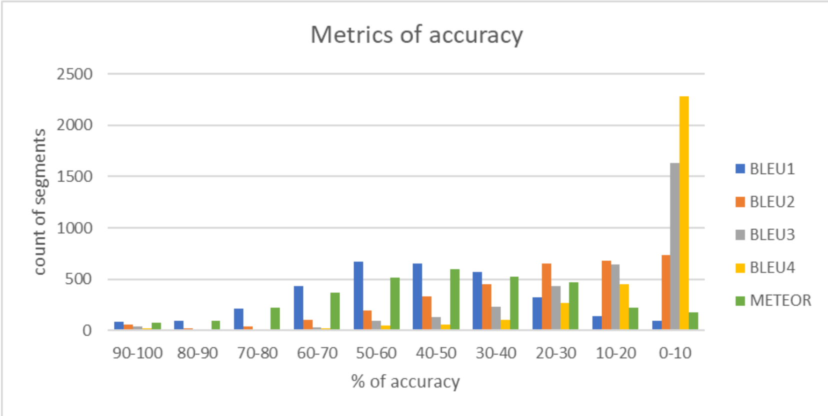

Figure 1: Frequency of correct segment divided in to 10 categories (author).

We followed a similar approach for the error rate metrics (Figure 2). The ROUGE metrics appear to be balanced. On the other hand, the Chr-F metric on the selected corpus for the English-Slovak language pair, showed a larger variance of scores, suggesting a normal distribution.

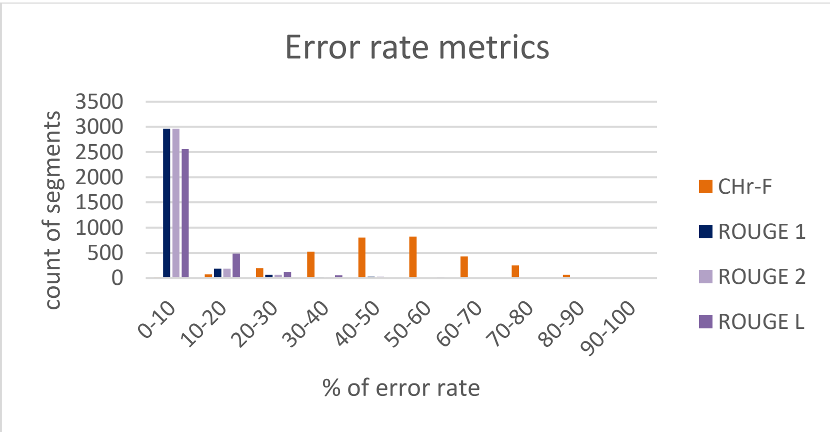

Figure 2: Frequency of error segments divided in to ten categories (author).

CONCLUSION

In this paper we offered an overview of selected metrics of automatic evaluation MT. The constant emergence of new metrics suggests that we have not yet succeeded in creating a metric that can completely replace manual evaluation for every genre and language. As mentioned in the case of the BLEU metric, context is important, and a metric that performs well in one case may not be suitable for evaluating another case. The Slovak language which belongs to the category of flective languages can be complicated for machine translation, but it seems that automatic metrics operating on character-level such as Chr-F or CharacTER may be the solution for a suitable automatic evaluation of given language (translation direction) and style. The experiment presented in this paper is the beginning of a comparison of several metrics and their suitability for the Slovak language. Further research

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will focus on a more detailed examination of the results of each metric and their evaluation against manual evaluation.

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Smart Cities in Romania – Post-Pandemic Perspectives

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Abstract

The smart city is a modern concept that is well appreciated in any public administration, business environment, or civil society. The impact of the Internet of Things is quite visible at every step of our lives, including smart education as we progress in our professional career. From smart education to a smart city, the scope of this work is to provide an answer about the huge role to play in catalysing this association process between education and the development of a sustainable economy in Romania, and raising the quality of life. In this context, smart projects have been implemented with the main purpose of increasing the digitalization of public services in urban areas. Despite the pandemic crisis, today in Romania, the Smart City marketplace is at the laboratory degree with many pilot projects. The last 2021 Romanian report has been based primarily on an inventory of 860 projects (planed, in progress, or finalized) related to 124 large, medium, and small cities, compared to the 594 projects related to 87 cities that had been subject of the 2020 report. In order to provide an increasing to the digitalization of public services in most of the urban areas, the paper proposes an integrated system architecture, a solution that can be adapted according to the particularities existing in the field by any local public administration, in line with the European Commission's development strategy and policies for a future digital Europe.

Keywords

Smart City, Smart Education, System Integrated Architecture, Sustainability.

INTRODUCTION

From the first city of Uruk, considered the oldest, which has physical evidence and written documentation (https://www.worldhistory.org) to Tokyo, which is the most advanced in applying today the Internet of Things (IoT) concept, being considered the most populated and safest city in the world (Wilson, 2021), the history of cities dates back more than 6,000 years.

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Research by (Soeiro, 2021) on urban living observed: "Technological innovation is at the forefront of smart cities" and, in (Wilson, 2021) the author appreciated that living in cities could be considered as the most important invention of mankind.

In the same context, the study of (Ridley, 2020) states that innovation is "the phenomenon that defines the modern age and changes our lives". Cities are connected to people; people are connected to their needs and desires to survive. It is not at all unexpected that smart people have created throughout history the inventions that shaped the world through the industrial revolution, as the most important period of transformations and of technological advances that then spread everywhere. In the encyclopedia, Timelines of Everything. From Woolly Mammoths to World Wars is explained in the chronology of the 1700s to the 1900s that the British Industrial Revolution began changing cities around 1760 with the invention of the spinning wheel, to the first power plant in 1889 (Figure 1) (DK Ltd., 2021).

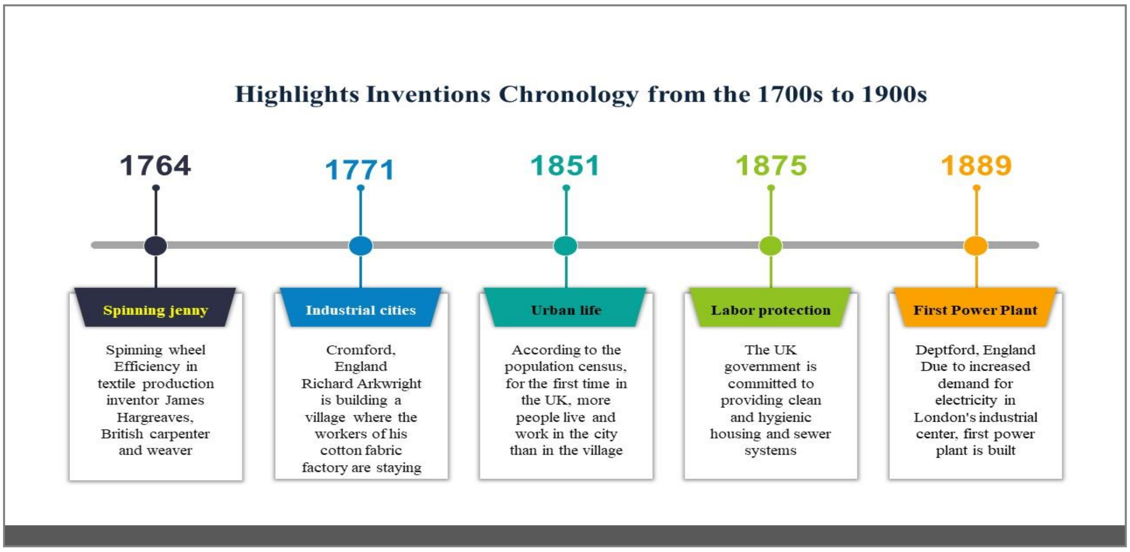

Figure 1: Timelines from the 1700s to the 1900s

The online publication dedicated to the *Learning Space* highlights the European Union chronology from the 1900s to the present. In 1958, the invention of the monolithic integrated circuit (the so-called *chip*) was considered in science, one of the greatest inventions of the twentieth century. The Internet revolution began in 1961 with ARPANET and ended in 2017 with the Internet of Things and facial recognition, but it does not stop there (Figure 2) (DK Ltd., 2021). According to (Lee, Zo, & Lee, 2014), the concept of smart education is based on smart learning through, but not limited to, IoT devices and other Information and Communication Technologies (ICTs), and it is closely related to the literature on smart cities. The definition of *smart city* was difficult to identify. However, the study (Albino et al., 2015) offers a structured path by clearly stating the main dimensions and the characteristics of the framework. Furthermore, a concept of the *smart and sustainable city* (Draghici et al., 2020) was shaped using the most important changes and innovations that led to the lifestyle of today in urban areas. Moreover, in Draghici et al. (2020) is emphasized the connection between sustainability and education, as pillars of understanding the smart city concept: learning about environmental responsibility, economical responsibility, transportation, fair trade, green production, all related to civil society.

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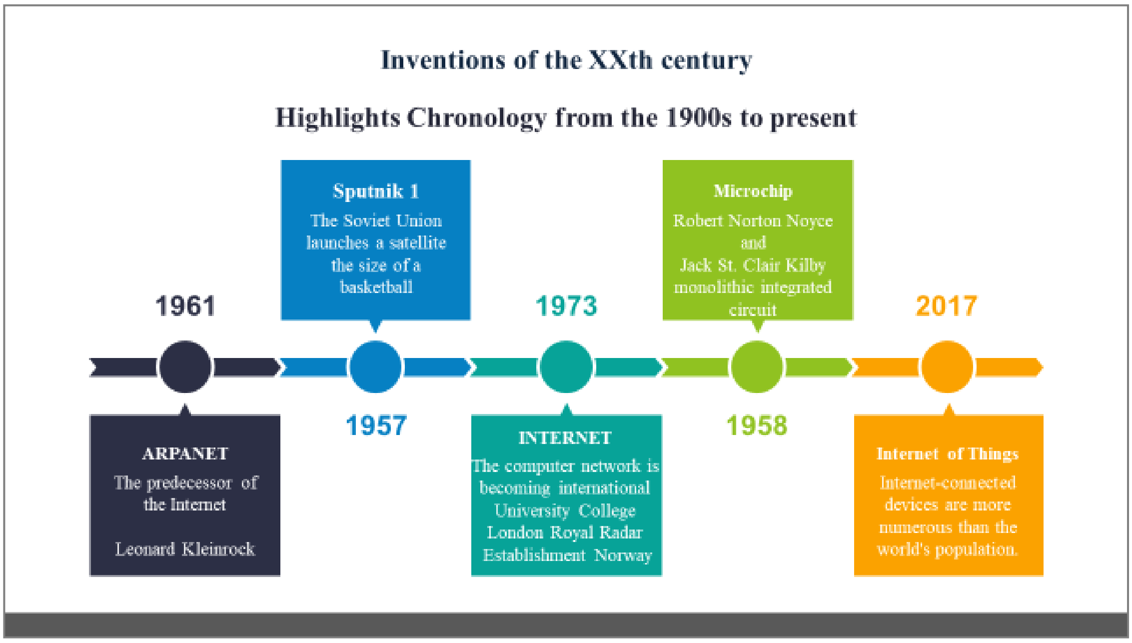

Figure 2: Timelines from the 1900s to the present

In this context, the paper opens a future debate on the following questions: what would be the condition of integrated *smart education* in a *smart city*?, what could be the connection between the *smart city* and the *education* received by *smart people* (or not) who live in the city?, and an answer to an 'x-ray *of smart cities'* in Romania, which indirectly reflects the impact of education on cities from a smart perspective.

SMART CITIES IN ROMANIA

General context

In today's reality, Romania is confronted with many constraints, complexities, prohibitions and needs, different crises started in various fields (from economic and political perspectives) because of the activities digital or non-digital transformations during the Covid-19 pandemic. Furthermore, an aggressive innovation process and openness to the adoption and implementation of 'SMART' solutions appear to be developing to support sustainable development communities (Baltac, 2019; Toma et al., 2019; Ivan et al., 2020; Fotache et al., 2020; Tantu and Santa, 2021).

The Romanian Smart City Association, (https://romaniansmartcity.ro/webinar-smart-city-romania/) (ARSC) involving various members from different fields, was a big promoter of the Smart City. Success stories, best-practice scenarios, or reason of projects failure were also shared during the Smart Cities of Romania (https://scorcluster.ro/en/) organized by the Smart Cities of Romania Cluster – SCoR CLUSTER. The stated mission of SCoR CLUSTER is to facilitate the participation of its members in this process, to stimulate close cooperation between administration, academia, research, and industry, and to establish cooperative relations with national, European or international clusters. Furthermore, at the national level, Vegacomp Consulting Company provides a deep analysis by "Mapping of Smart Counties, Cities and Villages in Romania". The 2021 report indicated a total of 860 projects

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in various stages of development, envisaging the implementation target in 124 cities, in rise numbers, compared to the similar report for 2020, with 594 projects and 87 cities.

In 2021, in his article (Pira, 2021), proposed a taxonomy concerning indicators of new dimensions of a smart city, as presented in Figure 3, also.

Smart strategies

- **Smart Governance**
  - City, civic alerts
  - e-citizen
  - Town hall web page and online transparency of the public decisions
  - Digitalization of tax colection

Smart project

- Smart environment (outdoor air quality, pollution, water management, waste management, recycling)
- Smart infrastructure
- **Smart mobility** (transportation, car sharing, parking solutions, eco mobility)
  - ICT infrastructure
  - Smart and green building (public and private)
- **Smart communities** (innovation labs, professional hubs etc.)
- **Smart living**
  - Smart eduction (digitalization of all activities in the schools)
  - Smart healthcare (prevention, monitoring, assitive technlogies, ageing population, inclusion)
  - Smart tourism (mobile applications, 3D city attractions maps)

Smart performance

- Smart and sustainable indicators

Figure 3. The adopted framework for smart city transformation (taxonomy of smart dimensions)

In the last 10 years, smart projects have been implemented with the main purpose of increasing the digitalization of public services in most urban areas. The public budgets of Romanian cities are under pressure due to the pandemic crisis, but the digitalization processes were accelerated due to the adoption of ready-to-use high-tech solutions to improve public services, such as public payments and procurement, transportation, lighting, or water distribution (Fotache et al., 2020).

Furthermore (Figure 3), the same study has supported the idea of a Romanian approach to smart city development already existing (detailed also by Camboim et al., 2019): (1) smart governance initiatives focused mainly on smart governance dimension; (2) infrastructure development of infrastructure and solve local issues related to basic public services (usually focused on transportation, mobility, environmental quality monitoring, and living conditions); (3) smart performance focused on sustainable socioeconomic development.

The analysis of different smart projects implementation in Romania have revealed that most of them have no rigorous planning, thus having a lack on providing feasible solutions (and sustainable) needed to enrich the smart city capabilities (as also presented Kumar et al., 2020). In addition to this, many cities have been confronted with organizational gap, and only from the last five years have there been nominated a county manager position for smart transformations.

Analysis of the progress of Romanian Smart Cities during the pandemic

The European Commission launched the *100 Carbon Neutral Cities by 2030 initiative* (Figure 4). The aim of the mission is to provide 100 cities in terms of climate by 2030 that will become a model for other European cities to follow suit by 2050. (https://ec.europa.eu)

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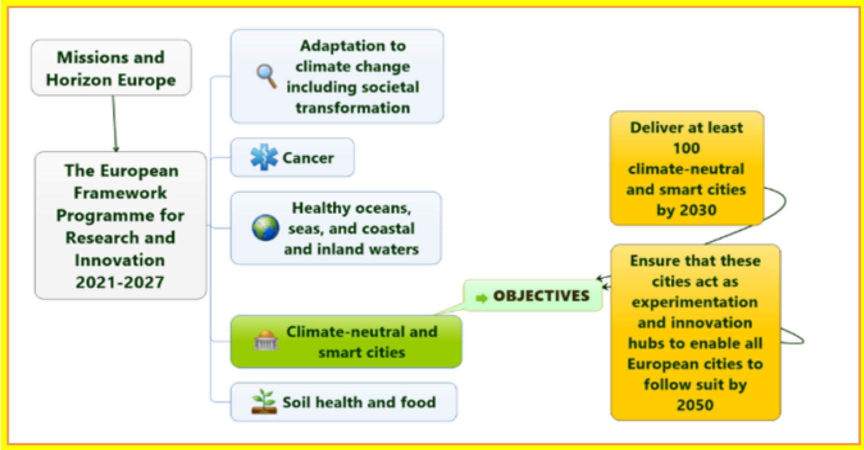

Figure 4. The five European Union missions

In this context, cities with more than 50,000 inhabitants can participate, the National Institute of Statistics (NIS) shows that there are 45 eligible cities in Romania, which already have Sustainable Mobility Urban Plans (SMUPs) and Sustainable Energy Action Plans (SEAPs), documents that include all the data needed to apply for Carbon Neutral Cities by 2030. Cities in the counties of Iasi, Cluj-Napoca, Timis, and Brasov have already announced their intention to apply for this opportunity. (https://insse.ro). All national approaches to the digital transformation of cities and local communities are in line with the European Commission's development strategy, with Shaping Europe's digital future policy, initiatives that are presented in The Digital Europe Programme. According to this European Commission's development strategy, the six Smart City Industry Verticals identified in Romania are presented in Figure 5 (Smart City Verticals ranking, taking into account the projects already implemented). (https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities). As presented by the Vegacomp Consulting Company analysis, the first place is taken by the Smart Mobility vertical, with a totally impressive 260 number of projects, due to the impact of the pandemic on transportation, regarding safety and health concerns. The second place, as the total number of projects (226) is revealing another vertical of the Smart City in response to the e-Governance. The last place on the podium is completed by Smart Living (174 projects). However, the Smart Economy is not far away with 99 projects, followed by the Smart Environment (64 projects) and Smart People (37 projects).

This initiative is part of the overall picture of global organizations, global markets, alliances, associations, or groups that propose to become SMART, answering the questions: Who initiates the process? Who finances it? Who runs it? The analysis performed by consulting companies in Romania, integrators of smart solutions, provide recent information through so-called smart city radiographs. The structure of funding sources mentioned private funds, various European funding programmes, local and governmental budgets (https://vegacomp.ro/wpr/wp-content/uploads/2021/07/mapping-of-smart-counties-cities-and-villages_2021.07.16.pdf)

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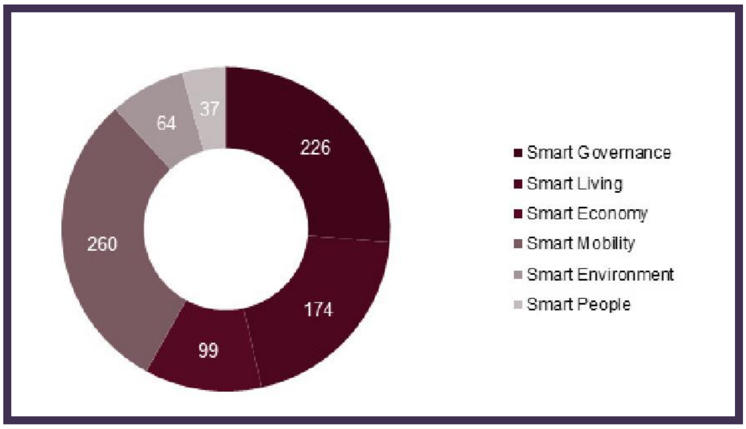

Figure 5. Clasification of projects in Romania by Smart Cities Verticals

An answer provided by the Ministry of European Investments and Projects, which has published in this regard the map of financing from European funds until June 30, 2021, and taking into account 7 performance indicators (table 1), the top 10 mayoralties in Romania are: (https://mfe.gov.ro/harta-finantarilor-din-fonduri-europene-pana-la-data-de-30-iunie-2021)

Tabel 1. Performance indicators for the best performing mayoralties in Romania

City	Population 2020	EU funds contracted 2014-2020 (estimates) (euro)	Gross domestic product (GDP) per capita (euro) 2018	Baccalaureate Promotion Rate 2018	Share of revenues from local taxes in total revenues (Average 2016-2019)	Population per civil servant 2018	Capital expenditures 2014-2020 (euro)
Cluj Napoca	327.985	237.362.636	45.486	81%	14%	435	129.154.654
Oradea	221.015	284.349.066	27.003	71%	16%	529	100.961.653
Reșița	83.878	138.956.527	30.283	64%	12%	429	33.927.929
Buzău	130.437	82.338.422	33.936	74%	16%	474	23.671.745
Turda	55.089	73.625.045	10.104	70%	14%	394	14.293.281
Sector 3 București	474.870	275.273.925	45.944	69%	17%	689	279.584.017
Brașov	289.122	115.517.951	28.951	76%	24%	1296	85.906.038
Iași	388.294	186.576.200	27.485	77%	16%	802	110.540.198
Constanța	310.182	78.550.361	33.193	68%	21%	514	93.749.065
Dej	37.911	66.508.380	18.010	77%	12%	330	19.898.625

According to the same source, regarding the contracts signed for the projects financed from European money, for the period 2014-2020, the top 5 counties in Romania are: Bucuresti, Ilfov, Iasi, Constanta, Cluj. Following the interrogation of various sources of information, their collection both from media sources and from the websites of the Romanian town halls, in the midst of a health crisis, a booming Smart City market is presented; the difference between 2018 and 2021 is substantial (in terms of number of completed projects, under implementation, or initiatives at the project stage). The development of all projects is well addressed and supported by the ISO 37120 standard SR ISO 37120 standard, with improvements in 2018 compared to its first version in 2014, published by the National Standardization Agency (ASRO) in December 2020: "Sustainable cities and territorial communities. Indicators of urban services and quality of life". According to ASRO, this standard applies to any city, municipality, or local government that is committed to measuring its performance in a comparable and verifiable manner, regardless of size and location. (https://www.asro.ro/sr-iso-371202020-fost-adoptat-recent-la-nivel-national).

To find a solution in the local Romanian public administration, a proposed framework is next presented.

METHOD

Implementation of an integrated management IT solution in the local public administration: A proposed framework

Research of (Popa et al., 2017) started a project about the implementation of an IoT platform to be integrated in any smart city infrastructure, referring to the subject of waste management. But to implement a viable solution in a smart city, with regard to the local public administration, it is necessary to carry out a unitary project that considers both the local resources and the needs of the respective citizens. The evolution from isolated systems, with outdated technologies, to a unitary and efficient system is as natural as possible for the needs of a society that tends towards modernization and collaboration. The need to integrate information into different systems and subsystems is already an inevitable reality, and under these conditions architecture and technology are the key points of a proper software solution. A demonstrative organization chart can be adapted to be built based on an in-depth analysis of the existing problems in the local public administration, so that all functional and integration needs are foreseen from the beginning (Figure 7).

Based on the observation of difficulties in the activity of a local public administration, ADVANtage is a unitary solution, with a modern and high-performance architecture, which contains a set of modules designed to integrate natively and allow collaborative work between different departments. This solution can be adapted according to the particularities existing in the field by any local public administration. Data can be gathered from an IT point of view, so it can be correlated, extracted, and verified very quickly.

The study aims to incrementally develop, in several stages, an IT structure capable of supporting the growth of the activity and its alignment with image standards adapted to the current society.

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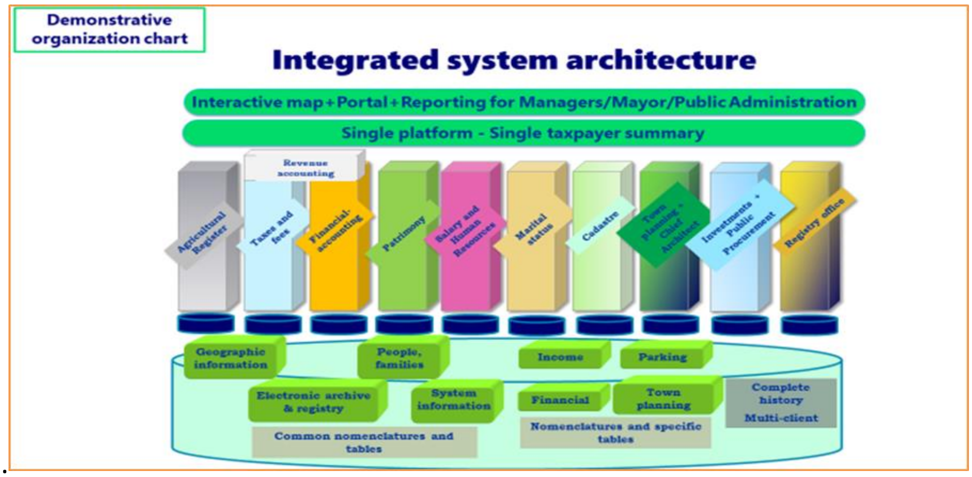

Figure 7. Demonstrative organization chart of the integrated system architecture

The architecture of the system, which is the basis of the solution, includes a set of basic components and subsystems, which can be configured and extended later with facilities specific to the activity of each local public administration (Figure 8):

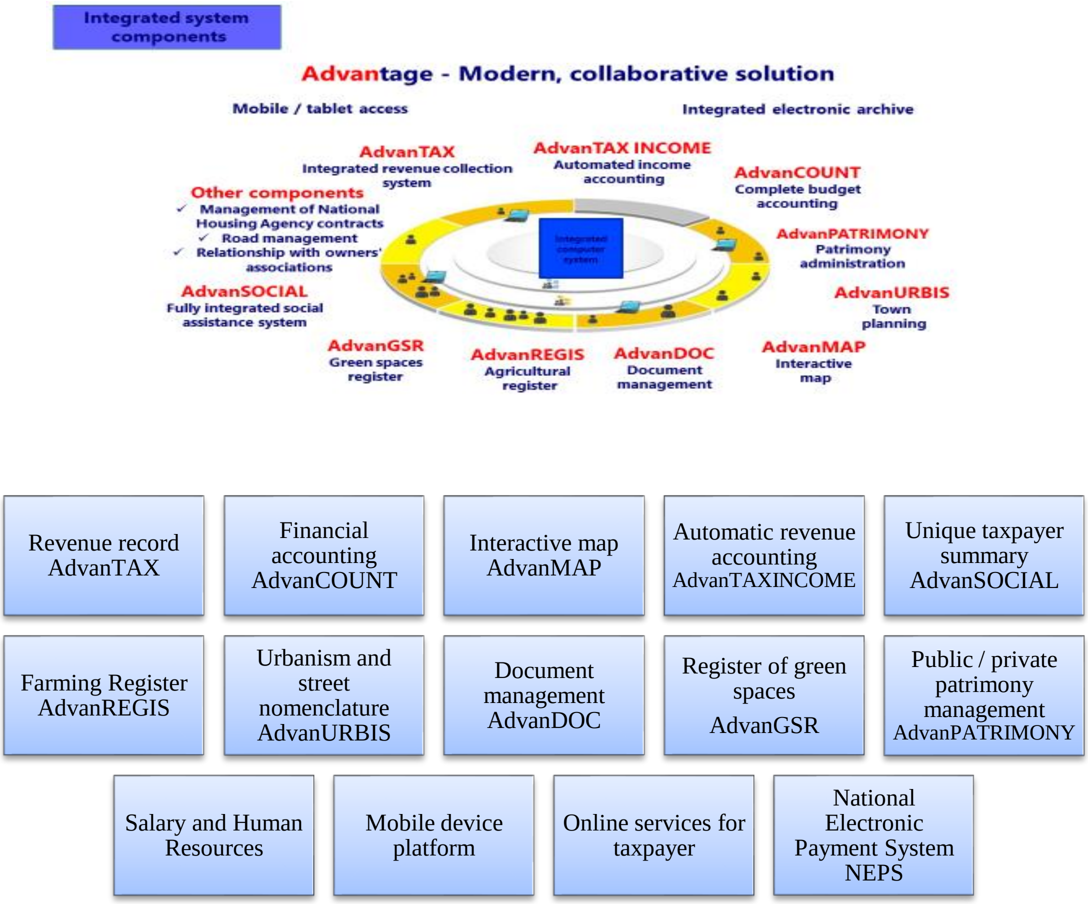

Figure 8. Components and Related Subsystems of the integrated information system

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RESULTS

The practical correlation of the objectives and needs of the local public administration (correctly and completely identified following the analysis) with the perspective vision leads to a solution with a strong starting point and a valuable know-how in the field. The benefits obtained by establishing a viable future web architecture, respectively, the approach in well-defined steps, are:

- Vision and superior control of the activity; tools for efficient financial management: minimizing losses or increasing revenue through good management of existing resources with the help of intelligent reporting;
- Implementation in several stages, in order of priority, produces a rapid impact on daily activities; increasing the adoption of users as they assimilate the new way of working and realizing the operational benefits, such as reducing unnecessary effort for manual activities;
- Reducing the immediate financial pressure and staggering the budget;
- Development / adaptation and incremental addition of functionalities specific to the activity of the local public administration, necessary to fulfil the objectives;
- Increasing the security of the successful implementation of the integrated information system and the viability of the investment and correlation of data between different departments;
- Instant access to information, from anywhere, anytime (mobile, tablet, laptop);
- Better image in front of taxpayers, modern working techniques, and superior data security.

CONCLUSION

We may conclude that our expectation about the Smart city market in Romania is growing rapidly, 860 projects compared to 594 in 2020, in a pandemic context. The initiatives and implementation steps for the digital transformation of Romanian cities and communities are aligned with the development strategy of the European Union, as presented in the European Green Deal objectives. The analysis performed by the Romanian consulting companies are significant in the terms of funding an increasing number of projects (50%), and under implementation or initiatives at the project stage. At the same time, we may conclude that our proposed framework is a viable solution in a smart city, regarding the implementation of an integrated management IT solution for any local public administration, in order to be visible and beneficial to citizens, to a better quality of life.

The potential of the human mind to create smart things knows no bounds.

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Gap Analysis of Cohave, Geolife and T-Drive Datasets

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Abstract

We compare several well-known GPS datasets (COhave, Geolife and T-Drive dataset) with respect to their basic properties such as number of recorded GPS coordinates, number of trajectories, length of trajectories in both distance (length in meters) and duration (time in hours), and number of users. Then we focus on gaps, which reflect time periods when GPS coordinates could not be computed due to signal propagation phenomena such as signal reflection, multi-path signal propagation etc., as well as satellite occlusion. Our ambition is to show how gap distances (their length in meters) are distributed, so that gaps can be added to other realistic or synthetic GPS datasets with respect to the estimated probability distribution. Our results show that the numbers of gaps decays exponentially with their length. We also argue that gap analysis needs to be done, whenever it is necessary to estimate the efficiency of various algorithms for trajectory acquisition, analysis or comparison as the performance of these algorithm can be thereby significantly influenced.

Keywords

Dataset evaluation and analysis, GPS datasets, user trajectory evaluation.

INTRODUCTION

The GPS (Global Positioning System) datasets that we investigate herein include discrete user trajectories based on GPS coordinates that represent user's measured position. Such a measured position can be different from user's actual position as GPS coordinates are known to be normally distributed around an actual position (Heng et al., 2011, Tiberius and Borre, 2000).

Due to various phenomena related to signal propagation such as reflection, multi-path propagation or occlusion it often happens that GPS signal cannot be received by user's wireless device and subsequently GPS service gets interrupted. This leads to what is called *gap*, a time period when user coordinates cannot be computed; see Fig. 1 for an example with two gaps.

When comparing user trajectories with respect to their similarity as defined by a suitable similarity measure, gaps pose a specific challenge as compared trajectories can have gaps at different overlapping or non-overlapping segments. User trajectories that get

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lost due to gaps need to be either interpolated, extended by user's synthetic positions or handled otherwise. This is especially important when applying algorithms such as the Needleman-Wunsch algorithm (Needleman and Wunsch, 1970) that attempts to compute optimal global alignment, i.e. an alignment alongside the complete input sequences, or sequences of GPS coordinates as in our case. When computing an alignment, this algorithm applies matches, mismatches and gaps, whereby the latter reflects the fact that, for example, sequences of nucleotides often suffer from various replication errors. To put it shortly, the gap mechanism within the Needleman-Wunsch algorithm can be mapped onto gaps that emerge due to various detrimental signal propagation conditions. For details on how this can be done we refer the interested reader to (Čavojský et al., 2021).

In order to estimate the efficiency of any algorithm that is based on sequence alignment computation, we must first understand how gaps are distributed in GPS datasets. This is our central motivation for analyzing the following GPS datasets:

- COhave, which is based on a campus-wide experiment that took about 3 years and where students received 455 mobile devices (Čavojský and Drozda, 2016, Čavojský et al., 2018),
- Geolife dataset, which is based on an experiment that took more than 5 years, most locations were recorded in Beijing, China (Zheng et al., 2008, Zheng et al., 2009, Zheng et al., 2010),
- T-drive dataset, which is based on an experiment that only took 7 days, the locations were only recorded by cabs in Beijing, China (Yuan et al., 2010, Yuan et al., 2011).

We thus consider three distinct datasets, two datasets are stemming from the same area (Beijing, China). The T-drive dataset only includes trajectories bound to streets where cabs can operate. The COhave dataset is tied to a specific social group, i.e. students that use all kinds of transportation means and may exhibit a distinct social behaviour compared cab users in Beijing.

The contribution of this paper can be succinctly summarized as follow. We provide an analysis of gaps in the three considered datasets. We focus on computing distribution of gap lengths in these datasets, so that synthetic datasets containing gaps can be constructed in the future. Unlike probability distribution of user GPS coordinates around user's actual position, which has already received attention from the research community, there is very limited knowledge about quantities and qualities of gaps in various types of urban environments, as well as in various types of social behaviour. Herein we provide a first step in the direction of presenting basic statistics related to gaps. To our best knowledge, such an analysis has not been yet presented in the literature.

The rest of the paper is organised as follow. In the following section we give an overview of the related work, then we present the basic properties of the three considered GPS datasets. Subsequently, we continue with presenting our preliminary results on how gap distance (length in meters) is distributed in these datasets. Then we conclude and give ideas on our future work.

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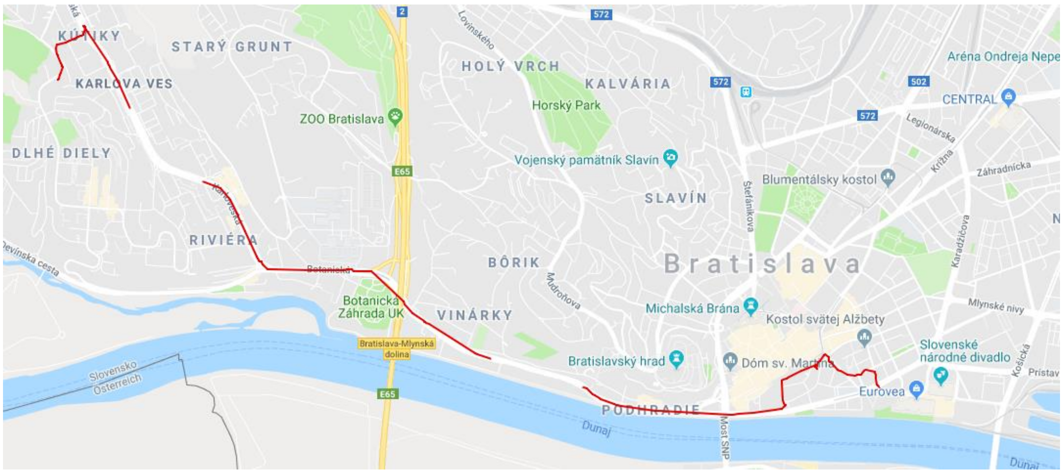

Figure 1: An example showing two gaps. (Čavojský et al., 2021)

RELATED WORK

In this section we review how the three considered datasets are used by other researchers. The topic of user trajectory analysis is however rather wide; we refer the interested reader to (Zheng et al., 2014, Barbosa et al., 2018) and the references therein.

The COhave dataset is described in (Čavojský and Drozda, 2016, Čavojský et al., 2018). It is applied in experiments that include user location management that is helped by locations of WiFi access points. It is also applied in a study on the suitability of the Needleman-Wunsch algorithm for pairwise comparison of user trajectories (Čavojský et al., 2021). The advantage of this dataset is that it includes the horizontal accuracy of GPS coordinates as estimated by Android OS. According to (Čavojský et al., 2021), this accuracy is 10.37 ± 8.02 meter.

(Ghosh and Ghosh, 2016) apply the Geolife dataset for semantic analysis of trajectories in order to explore human movement patterns. They propose a framework that allows for spatio-temporal clustering, categorisation of users, and finding associations between user-user and user-place.

(Zhen et al., 2009) apply the Geolife dataset for mining of interesting locations and travel itineraries in order to support automatic travel recommendation. They conclude that their approach dominates other known approaches that are mostly based on rank-by-count or rank-by-frequency statistics.

(Chen et al., 2021) propose a pick-up location recommendation scheme with location indistinguishability as well as semantic indistinguishability for Ride hailing services. They model the rider mobility as a time-dependent first-order Markov chain and generate a rider's mobility profile. They calculate the geographic similarity between riders, additionally, they apply Cosine similarity and unified hypergraph in order to compute the semantic similarities between locations. The validation of their approach is based on Geolife dataset.

(Yang et al., 2021) propose a trajectory clustering algorithm based on spatial-temporal density analysis. They focus on better trajectory analysis in the presence of noise points, which emerge due to signal reflection and similar signal propagation phenomena. These noise points are referred to as nests in (Čavojský et al., 2021). Noise points, or nests, are

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clusters of false GPS coordinates that are computed using reflected, or otherwise deteriorated, GPS signal. (Yang et al., 2021) apply Move ability (Luo aet al., 2017) in order to filter out such noise points.

(Ashfaq et al., 2017) propose Secondo, a geospatial big data analysis platform. They apply this platform to test the performance of simple and complex spatio-temporal queries, as well as to test the efficiency of parallel processing techniques. In their experiments they use the T-Drive dataset.

(Hu et al., 2014) explore the possibility of direct phone-to-phone communication between vehicles. They toggle between client and hotspot mode of mobiles, when transferring data. They claim to significantly reduce data transfer latency. The experimental part of their research is based on the T-Drive dataset.

The above reviewed results give a rough idea on how the three GPS datasets get used in other research settings. The reviewed results include basic information on applied datasets, however, herein our focus lies on analysis of gaps. To our best knowledge, gaps have not yet been considered in research literature. A reason for this may be that other researchers did not attempt to apply sequence alignment algorithms such as the Needleman-Wunsch algorithm to trajectory analysis.

BASIC PROPERTIES OF DATASETS

We evaluate the three datasets with respect to the following properties:

- number of users,
- number of GPS points (coordinates),
- number of trajectories,
- trajectory length by distance and time, and
- the number of gaps and distribution of gap lengths.

As we have already mentioned, we focus on the last property as it is of paramount importance for any future efforts related to constructing synthetic datasets with gap samples drawn from a probability distribution that reflects how gaps emerge in real world setups.

The basic properties of the considered datasets are summarized in Tables 1-3. As we can see the COhave dataset has 4,638,100 points (measured GPS coordinates), 21,050 trajectories and 222 users (peak number over one year). There were more than 455 mobiles distributed among students, this suggests that willingness to participate in the experiment was limited to less than one half of the students. The Geolife dataset has 23,517,803 points, 42,138 trajectories and 77 users. The T-Drive data set has 11,817,531 points, 682,846 trajectories and 9,638 users. The Geolife dataset is thus the largest one with respect to the number of points, the T-Drive is the largest one by the number of trajectories.

Tables 1 and 2 also provide information on the number of points and trajectories when gaps are excluded. For the sake of simplicity, we filter out trajectories that have gaps longer than 5 minutes or 10 kilometres.

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Table 1: COhave dataset

		With gaps		Without gaps	
Year	Users	Points	Trajectories	Points	Trajectories
2015	222	1,807,529	7,533	1,807,529	7,533
2016	222	2,798,134	13,126	2,798,134	13,126
2017	3	32,437	391	32,437	391

Table 2: Geolife dataset

		With gaps		Without gaps	
Year	Users	Points	Trajectories	Points	Trajectories
2007	58	290,313	1,016	279,902	2,131
2008	77	8,108,659	6,691	7,597,347	14,059
2009	70	11,534,237	7,244	10,937,582	19,585
2010	18	1,414,893	1,599	1,375,766	2,504
2011	25	2,844,731	1,478	2,685,183	2,676
2012	5	665,473	643	642,023	1,183

Table 3: T-Drive dataset

Year	Points	Users	Trajectories
2008	11,817,531	9,638	682,846

Tables 4-6 summarize the participation of users in the three considered datasets. As we can see in Table 4, the T-Drive dataset has the largest user participation, however, due to the nature of the dataset, the user participation is short-lived as the users in this case are cab drivers that get involved in the experiment. Both COhave and Geolife datasets include users that participated in the experiments longer than one year. Table 5 shows that certain cab drivers produced more than 100 trajectories during the experiment that led to the T-Drive dataset. Table 6 shows the T-Drive dataset recorded trajectories with the largest length. This is natural, as cabs are expected to transport customers over large distances. This is even more pronounced when compared to the COhave dataset that also includes pedestrian traffic. The Geolife dataset can be seen in this respect as mixed dataset, with both pedestrian and vehicular traffic. Table 7 shows that the T-Drive dataset includes trajectories that are short by the consumed time.

Table 4: Distribution of users by data involved period.

	COhave	Geolife	T-Drive
Data involved period	Users	Users	Users
< 1 week	90	27	9,638
1 week - 1 month	51	37	0
1 month - 1 year	166	100	0
more than 1 year	3	18	0
Total	310	182	9,638

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Table 5: Distribution of users by number of trajectories.

	COhave	Geolife	T-Drive
Number of trajectories	Users	Users	Users
< 10 tracks	122	55	1,289
10 - 50 tracks	97	59	2,536
50 - 100 tracks	39	27	3,681
more than 100 tracks	52	41	2,132
Total	310	182	9,638

Table 6: Distribution of users by distance.

	COhave	Geolife	T-Drive
Distance	Trajectories	Trajectories	Trajectories
< 5 km	16,519	6,913	297,477
5 - 20 km	2,801	6,717	286,309
20 - 100 km	1,258	4,182	93,868
more than 100km	469	843	5,192
Total	21,047	18,655	682,846

Table 7: Distribution of users by effective duration.

	COhave	Geolife	T-Drive
Effective duration	Trajectories	Trajectories	Trajectories
< 1 hour	13,173	10,923	547,007
1 hour ~ 6 hours	5,794	4,766	123,575
6 hours ~ 12 hours	653	2,047	8,437
more than 12 hours	1,427	919	3,827
Total	21,047	18,655	682,846

DISTRIBUTION OF GAPS

In this section we present our results on the distribution of gap lengths in the three considered datasets. As we have discussed above, gaps emerge when GPS coordinates cannot be computed due to various signal propagation phenomena such as satellite occlusion, signal reflection, multipath signal propagation etc. Our ambition is to provide an initial insight on how synthetic GPS datasets that include gaps could be generated, so that any studied algorithms for trajectory acquisition, analysis, and comparison can be efficiently evaluated.

Fig. 2 shows how the gaps are distributed with respect to distance (length in meters) in the three considered datasets; the range of gap distances on the x-axis is from 300 to 2,300 meters. We can see that the number of gaps decays exponentially with gap distance (notice that we apply log scale on the y-axis). The results is similar for all datasets, hence it

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can be hypothesized that this is an inherent property. In the future, we plan to analyse additional datasets in order to provide a more reliable insight.

Fig. 2 show the results after a number of gaps got filtered out. This is necessary since a certain number of users produced gaps that are related to air travel rather than the mentioned signal propagation phenomena. In Fig. 3 we can see that T-Drive dataset includes gaps that have more than 12,000 km in length, which either reflects trans-pacific air travel, or occasional failure to compute GPS coordinates. This has occasionally resulted in the GPS coordinate (0, 0), which is located in the Atlantic ocean, off the coast of Africa, in the Gulf of Guinea (also known as Null island).

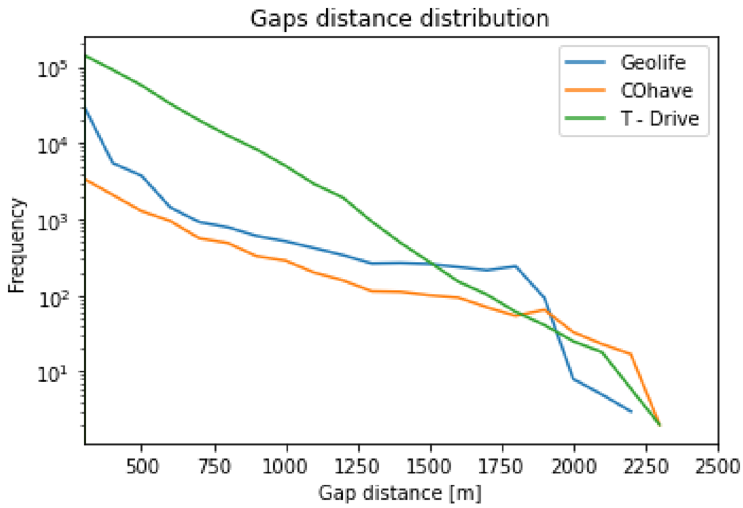

Figure 2: Gap distribution after filtering.

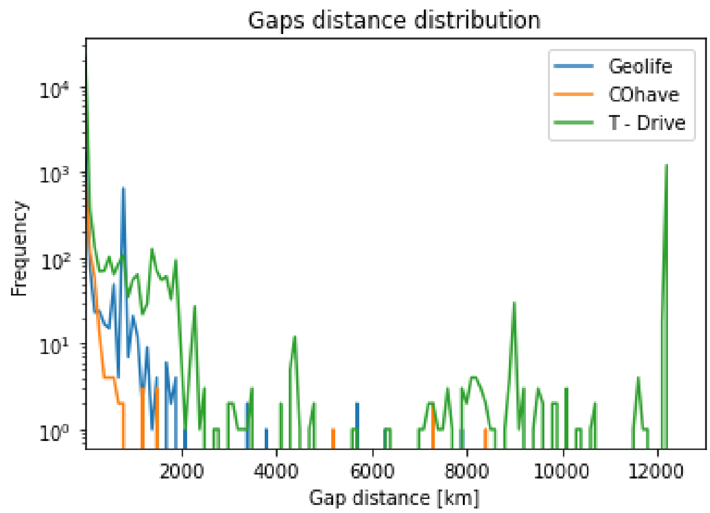

Figure 3: Gap distribution before filtering.

CONCLUSION

We provide our preliminary results on how gaps are distributed in several well-known GPS datasets. Our results indicate that the number of gaps seems to decay exponentially with their length, however, a more formal statistical analysis will be necessary in order to

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conclude that gap length can be drawn from exponential distribution. Such a statistical analysis can be based on standard test such as the Kolmogorov-Smirnov test (Massey, 1951), however, we first aim at analysing several other GPS datasets in order to get more robust results. Nevertheless, our results show that gap analysis needs to be included in any experimental work related to GPS dataset analysis, as performance of any algorithm, for example the above mentioned Needleman-Wunsch algorithm, can be influenced by this phenomenon.

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Text Extraction from PDF Documents from Student Theses

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Abstract

Digitized documents have now become an essential source of information. Most scientific literature and scientific articles are available in the Portable Document Format (PDF). Although this format is suitable for transmitting and displaying the information created by the original author, extracting information from it is a difficult task. In this work, we will try to describe the problems that may arise during extraction, present the currently available tools and techniques for extracting texts from PDFs and compare the results achieved. We will describe the advantages and disadvantages of our chosen approach to extract text from PDF, resulting in a structured output in JSON format, which contains the extracted text from the document, as well as semantic information about the text and font style. Based on this information, it is then possible to process and query only selected parts of the document that are useful in natural language processing applications.

Keywords

Text extraction, PDF, Automatic tools, Corpus.

INTRODUCTION

PDF is one of the most popular formats for electronic documents. The google browser itself currently indexes more than 3 billion PDF documents, which is more than for any other document format, with the exception of HTML. However, PDF is a "layout-based" format, which means that it specifies on each side the position and font of the individual characters the text consists of (Hannah Bast, 2017). Page description languages (PDLS) are used as communication between a formatted description of a page or document in a composition system and an output device such as a monitor or printer. The advantage of a document that is written in PDL format is full control over the appearance. The disadvantage of such documents is the size of the file and the lack of a logical structure compared to the HTML markup language (Lovegrove & Brailsford, 1995).

Currently, the processing of natural language is dominated by data-controlled technology. Great progress in a number of natural language processing (NLP) sectors can be seen thanks to advances in machine learning and increasing data sets. However, the availability of clean data sets is still a persistent problem for most languages in the world.

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Commonly, data is extracted by mining from the World Wide Web to expand data sets (Munk et al., 2021; Pilkova et al., 2021). As the demand for ever larger data sets increases, it is necessary to look for other sources of texts (Tiedemann, 2014).

The PDF format by its very nature represents paper in digital form, which is why it naturally contains a large number of texts. This format has been optimised for printing paper and therefore focuses mainly on the visual side of documents. The format is not structured and does not distinguish the semantic meaning of objects on the side. When extracting information, no distinction is made among headings, paragraphs, text in tables or captions. The PDF association, which defines the ISO standard for PDF format, is currently focused on making PDF documents available. The aim is that people with disabilities (e.g. visual) also have full access to the information contained in the document. It is based on the possibility to add a logical structure to the format, which refers to specific parts of the pages in the document and adds semantic meaning to them. As in HTML, in PDF documents the semantic meaning of content is represented by tags. The taged PDF document subsequently allows accurate extraction of paragraphs, annotations, headings, but also the correct order of reading for multi-column documents. The presentation of the logical structure in PDF format is not mandatory, therefore there are few documents with a given structure. Some programs, such as an Apple office program package, add tags when exported to PDF automatically.In this work we will address the issue of extracting texts from PDF format. The rest of the paper is structured as follows. The next section describes the research background and introduces the main issues when extracting information from PDF. The third section summarizes tools used for extracting data from PDF and describes our own approach. The last section provides the conclusion.

RESEARCH BACKGROUND

As PDF displays text based on font and position on a given page for individual characters, tools that extract text encounter several issues. We will specify some of them:

Word identification — is important when searching for words in a document. If the word fails to identify correctly, the word sought may not be found. The problem with identifying words is that the spaces between letters may vary not only between rows, but also within a single line. Long words can be separated by a dash at the end of a row, thus visually dividing one word and appearing in two places in the document (Tiedemann, 2014).

Word order — Determine the order of words is essential for applications such as e-book readers or if we want to get unformatted text. The order of words can be determined based on the position of words in PDF. However, for documents that have a multi-column layout, the order cannot be determined by the position.

Delimitation of paragraphs — to determine the beginning and end of the paragraph is again important for applications that read the document. This problem is caused, for example, by the fact that an image or a table is inserted in the paragraph. The application may incorrectly evaluate the end of the paragraph, even if it hits the end of the page. Although the paragraph continues on the next page, the application will evaluate this as two different paragraphs (Chao & Fajn, 2004).

Ligature — another problem is character recognition. For example, the character "fi" (Unicode U+FB01) represents only one character (Figure 1). When extracting the word

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“fiction”, the first two letters “f” and “i” can be misidentified and will not be present at all in the output.

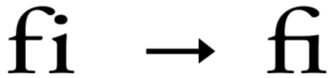

Figure 1: Ligature fi. Source: https://upload.wikimedia.org/wikipedia/commons/2/2f/Ligature_fi.svg

Word division — Differentiating words with a dash causes a problem in cases where we want to reuse the extracted text, for example, in the processing of natural language. Most of the tools use heuristic rules to distinguish a dash in terms of dividing the word.

Semantic meaning — since PDF is not structured format, it does not distinguish between text within the meaning of a section, title, note or page number. PDF eliminates this shortcoming by the possibility to complete the structure of the document and thus create tagged PDF documents.

Currently, all known tools such as pfttotext, PDFMiner, Apache Tika, pdf2xml, PDFExtract, as well as various libraries such as pyPDF2 (python), Apache PDFBox (JAVA) and other online tools for extracting text from PDF, extract the whole text from documents, without distinction on the type of text. They result in an unstructured text file, which is subsequently difficult to process. Some tools (pdf2xml) also allow structured output in the form of an XML file. However, this only contains information about the position and font used in the PDF document. According to this, we can assume what semantic role a given character or word had in the original file, but it is a difficult and not entirely precise process.

Changfeng Yu et al. (Yu, Zhang, & Wang, 2020) extract the text of academic PDF documents in their work to obtain 'body text', which represents only sentences and paragraphs. 'Non body text' of parts of the text such as headings, tables, pictures, graphs, authors’ names and mathematical equations are neglected. The result is a text file that contains the original sequence of sentences while at the same time preserving the division of paragraphs. The authors represent their own PDFBoT system for detecting multi-column page layout. The PDFBoT system is based on pdf2htmlEX, which creates a structured HTML file from the original PDF document. On this file, a pre-processing composed of several parts shall be carried out. A DOM tree is created for each side, each object in the tree occupies a certain quadrilateral area and the absolute starting position is calculated for it. In the next step, the frequency of font sizes is calculated and non-text objects such as pictures and tables are removed. The text properties shall be determined based on their starting point to form row sequences. Then the detection of a multi-column layout is triggered and the removal of other “non body text” of parts such as headings, footnotes or descriptions of images, graphs, and tables. Finally, only the resulting “text body” consisting of paragraphs and sentences that are written into a text file is aligned.

PDFBoT system achieved high accuracy values with an average F1 score for extracting sentences of 0.99, for extracting sections 0.96 and 0.98 for removing tables, pictures, and graphs on the corpus of academic PDF documents randomly selected from arXiv.org (Yu, Zhang, & Wang, 2020).

Hassan and Baumgartner (Hassan & Baumgartner, 2005) used a multi-algorithmic process that converts a PDF document into a structured XML output.

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The first step is ontology-based wrapping is a method that tries to create and use general relationships between different objects within a document. It allows you to express several types of relationships between objects and not just a simple hierarchy. The second step is to convert to a structured format. The logical structure of the document is created using the rules written in the logical or procedural language. This makes it possible to represent content in a hierarchical structured format such as XML. The last step is spatial reasoning. This is the process of extracting objects in a document based on location or relation to other objects on the page.

Jörg Tiedemann (Tiedemann, 2014) describes the process of extracting texts from any PDF documents for use in NLP applications. A set of documents made up of publications and parliamentary journals of the European Union serves as a reliable multilingual resource (e.g., training models for statistical machine translation). It used its own tool to convert a large multilingual database extracted from the book shop of the European Union to create a parallel corpus. It combines the benefits of several existing solutions for converting a PDF document into plain text and adds language-independent procedures for post-processing, which will clean the text for further linguistic processing. Specifically, the use of libraries to render PDF — pdfXtk, Apache Tika and poppler with multiple configurations. From the output of these tools, they restored the correct boundaries using language models and linguistically independent heurists for extraction. The main objective was to create a linguistic resource from PDF documents. The selected output format was XML, which contains linguistic information in a standardised and consistent format. The conversion takes place in several steps. The first step was to extract data using Apache Tika, poppler, pdfXtk and pdftotext. All these tools extract plain text output, so the next step was to identify words within a page. This was followed by a clean-up of text data and the identification of sections. The last step was to recognise the language. As they were multilingual documents which often contained a mix of several languages within a single document, it was necessary to correctly recognise the language for the paragraphs in question. They used the Google Compact Language Detector, whose functionality can be disabled as needed. The result of the work was a multilingual corpus that came from a collection of 135 849 PDF documents with the main use in machine translation applications.

METHODS

The aim of the work is to analyse the currently available tools for extracting texts from PDF documents and to design our own procedure, which will allow the processing of extracted data.

Data set

For extraction we will use 100 student theses in PDF format. The text of the works is aimed at translating selected text from a foreign language (English) into Slovak. We will focus precisely on the parties that contain text in both languages in order to use them in the creation of a parallel corpus.

Experiment

The aim of the experiment (measurement) will be to see if parts of the PDF document have been omitted when extracting. Since we focused on extracting paragraphs and parts

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of the text as headings, captions, graphs and tables or page numbers were considered non-body texts, the reference text did not contain this information. However, extraction tools in their outputs also contain the following parts of the text. This is a small part compared to the total content of the text and therefore small deviations in the cosine similarity (<0.0005) from the reference text can be attributed precisely to non-body texts.

Tools

We evaluated the following tools:

pdftotext — one of the most used tools to extract data from PDF. Converts PDF into plain text but does not identify paragraphs or semantic meaning of texts (Ramakrishnan, Patnia, Hovy, & Burns, 2012). Available at: https://www.xpdfreader.com/index.html

Pdfbox — library from Apache, written in Java. Like the previous tool, it converts PDF into text format, without distinguishing paragraphs or semantic meaning of texts. Available at: https://pdfbox.apache.org/

PdfMiner — a tool that can analyse the structure of a PDF file and convert it into text, XML or HTML output. The text is divided into paragraphs, lines, and characters. Available at: https://github.com/pdfminer/pdfminer.six

PDFix — SDK for reading, writing, rendering, and handling PDF files. Thanks to advanced algorithms, it can recognise a logical structure such as texts, headings, images, tables or header and footer of a document. All these data are then available in HTML, CSV, JSON or XML formats. Available at: https://pdfix.net/

pdfforge — a freely available online tool for extracting text from PDF documents whose output is a text file. Available at: https://www.pdfforge.org/

The tools used have been compared in different categories such as availability of the tool (freely available, online freely available, paid), output format (unstructured text, structured JSON/XML/HTML), configuration option and output quality. Cosine similarity rates were used to measure output quality or to evaluate extraction quality.

Cosine similarity is a metric used to measure the similarity of documents regardless of their size. It is actually an expression of the size of the angle that two vectors representing two documents make up. Cosine 0° is 1 and is less than 1 for any other angle. It's a view of orientation and not the size of the vectors. Two vectors of the same orientation have cosine similarity 1, the two vectors at 90° are similar to 0 and two diametrically opposite vectors have a similarity of -1, regardless of their size (Kapusta, 2020).

$$Cos\theta = \frac{\vec{a} \cdot \vec{b}}{||\vec{a}||\ ||\vec{b}||} = \frac{\sum_1^n a_i b_i}{\sqrt{\sum_1^n a_i^2}\ \sqrt{\sum_1^n b_i^2}} \quad (1)$$

We have compared the tools on a number of criteria. One of them was the output extraction format (txt, xml, json, html) (Table 1). This is the most important criterion when choosing a tool, since we want to extract the data in order to use it in NLP applications. In the case of plain text output, data cannot be further processed, so we focused mainly on structured outputs.

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Table 7: Comparison of tools based on output format. Source: author

Tool	Output format
pdf2text	txt
pdfix	json
pdftohtml	xml, html
pdftoxml	xml
PdfBox	txt
pdf2xml	xml, html
PdfMiner	txt, xml, html
PDFExtract	xml

Tools whose output is a structured format have the advantage that they can be subsequently processed and cleaned of non-body text. PDFExtract or PDFMiner, however, contains information about the position on the page, what style and font size have been used. This requires further processing and geometric representation of objects on a particular side, and only then it is possible to determine, based on heuristic rules, what semantic meaning a given object represented on a particular side.

Based on the analysis of the tools, we decided to use the tool pdfix. Its output is a JSON file (Figure 2) that contains extracted texts from a PDF document along with their semantic meaning.

Figure 2: Sample of JSON output from PDFix. Source: author

The tool was able to recognise parts of the text and assign semantic meaning to them based on heuristic rules. Each page of the document is evaluated individually and forms a page-map object. It contains elements with information about the type of text, the text itself and the style of the text. Based on this information, we then process the output and create text files that contain only body-text. We created a command-line utility to process the JSON output. It parses a given file and creates two text outputs containing only parts of a PDF document that have been recognised as body-text. Based on language information, the text is written into the relevant text file (English or Slovak). This information could be added to the PDFix configuration file. The other tools do not provide this option and the PDF format can contain language information only at the level of the whole document. The program code is freely available at: https://github.com/4gac/pdfix_json_processor

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The accuracy of the resulting files was evaluated by cosine similarity measure with an average result of 0.9986. We used manually extracted texts from documents as a reference.

RESULTS

Finally, we used tools for extraction, the output of which is a text file and compared the cosine similarity with our extraction results (Table 2).

Table 8: Cosine similarity of documents. Source: author

	pdfix	pdf2text	pdfbox
pdfix	1	0.99979	0.99985
pdf2text	0.99979	1	0.99932
pdfbox	0.99985	0.99932	1

The differences in results are very small and are due to the fact that the pdf2text and pdfbox tools contain non-body text elements.

Another metric to compare extraction results was Levenshtein distance. We compared automatically extracted texts from PDF documents with reference texts (Table 3).

Table 9: Levenshtein distance between extracted texts and reference. Source: author

Tool	**Levenshtein distance**
pdfix	4926
pdf2text	92415
pdfbox	93233

In the results we can see a big difference between the pdfix tool and the others. This is because our reference Slovak and English text were in separate text files. Pdfix is the only tool that allowed us to add language information about the text (English or Slovak) and thus the resulting text files contained text only for that language. Tools that do not allow this functionality combine different languages in their output, which requires further processing such as using language identification techniques for each paragraph or page.

CONCLUSION AND FUTURE WORK

The aim of our research was to analyse current tools for extracting texts from a PDF document in order to use these texts in NLP applications like machine translation. We found that if the output from the tool is only an ordinary text document, the text cannot be further processed and cleaned of non-body texts. Such a text is then difficult to segment into sentences, which is necessary in order to align texts. The works were used as a structured output of HTML or XML formats. This confirms that for extracted text from documents to be subsequently processed, additional information on the text must also be included in the output.

Our results correspond to the results of studies (Tiedemann, 2014) (Yu, Zhang, & Wang, 2020) (Hassan & Baumgartner, 2005) (Stastny & Skropil, 2008), that the result of the

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extraction process is never 100 % and none of the tools can accurately determine the logical structure of the document as intended by the original author. Therefore, our further direction of research will look at the possibilities of adding this information directly to PDF format. The ISO 32000-2:2020 standard for PDF format defines the structure and techniques by which parts of a document can be marked and therefore add semantic meanings to the document or to add language identifier to determine the language in which the text is written.

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The Use of Cloud for Generated Statistics Data File Storage in Statistics Tasks

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Abstract

The paper builds on previous work that dealt with the automatic generator of parameterized tasks and tests. In these works, the author focused mainly on the issue of automatic generation of parameterized tasks in the field of data science. A key problem in creating tasks of this type is the generation of source data and especially their storage and subsequent access in various systems and formats. This contribution is an innovation of previously used procedures and an extension of the possibilities of working with synthetic data files. The innovative data storage system uses cloud storage for its work and thus simplifies the work of the generator user when generating tasks that also contain the statistics data stored in the data file. No knowledge of cloud technologies is required to generate these tasks. In this solution we can work with the statistics tasks containing data files not only in format of selected LMS (for example LMS Moodle), but we can work with these tasks published in PDF format, where the data is represented by a link to the cloud storage. The contribution is more technical and contains the procedures and codes needed to work with cloud storage in both directions – data storage and data retrieval. These procedures also include instructions that allow you to create and use cloud storage. An integral part of the solution is also the design of the administration system of stored data and their periodic cleaning.

Keywords

Generator of parameterized tasks, Generation of random data collection, Statistical data file, Cloud,. Matlab.

INTRODUCTION

Automatic generation of parameterized task can generate a unique problem for each student. Students can practise one task with different input parameters. It helps them to understand the problem from different points of view. In the article (Automatic generation of cloze questions, 2011) the basic principles of an automatic generator of questions and answers are described. The generator of algorithms generates random input parameters of a question according to problem constraints. At the same time, the generator solver calculates and generates responding answers based on the input parameters according to the problem solution. The outputs of the procedure consist in creating questions meant to be imported to a question bank and/or in creating a set of randomly selected and automatically created questions for the whole test. Both outputs can be generated within

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the demanded structure suitable for the applied system. The output of the generating process is a description of tasks in universal XML format. From this format, tasks can be converted to the desired target format using the XSLT process. One of the generator target output formats can be for example Moodle XML which is used to import data into LMS Moodle Question bank.

A specific approach is applied when generating tasks from the field of statistics and statistical processing as well as an analysis of the data. In this case just the statistical data are the key object. Creating the data according to the required parameters, storing the data in the file and inserting the information about the file must be an integrated part of the generation process, as well as the information about the data themselves and then storing them in the output description of the generated task. In (Gangur, 2018) automatically generated data files are attached as a part of a statistical task. This feature of the tasks followed previously developed generator feature, i.e. automatic generation of parameterized images (Gangur, 2016), (Plevný, & Gangur, 2016).

In (Gangur, 2018) the problem of statistical data files storage on cloud was introduced together with an explanation of the advantages of generating synthetic statistical data as an integral part of a given task. Two types of statistical data were used. In the first group there are data files that are closely linked with the given generated task. In case of generating a task into the tasks bank in LMS these files are part of a file with the description of the entire task. For example, in statistical tasks these are relatively smaller selective files with the data selections which are unique for each task.

In the second group there are data files that can be joint for more tasks. Such files often contain a vast volume of data and it is not desirable to store them in repository together with the definition of each task. Basic files with a vast volume of the whole population may be an example of that. This type of statistical data storage has gradually become universal and links to this online data on the network is also part of statistical tasks in question bank.

This new approach and the large increase in cloud storage files has required more flexible administration in storing and cleaning these data files in the cloud. This paper shows the solution to this problem as it is currently used by the automatic task generator.

The reminder is structured as following. Next section provides an overview of the literature on the problem of automatic generation of synthetic statistical data. Following section describes the process of data files storage on cloud and administration of files on cloud. Finally, the advantages and limitations of proposed solution are discussed, and the conclusion is stated. In the following parts, the methods are presented on an example of Matlab functions (MathWorks, 2013). Unlike other development environments, the presented relatively simple solutions developed and tested by the author, are not at the very least, directly available and easily searchable.

RELATED WORKS

Many resources offer statically created datasets that are used in teaching statistics. For all can be mentioned for example (Freeman, 2021) or (State, 2021). Such data can be used as static or it is possible to generate various selections with the required properties from these datasets.

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The generated data, also called synthetic data, is offered on some websites created using built-in generators. They are used by teachers to teach their stats class. They know data for a statistical test, and they know the result. As example two websites exist that do just that. One tried, and trustworthy resource was created by I/O psychologist Richard Landers (Landers, 2021). Second one social psychologist Andrew Luttrell offers (Luttrell, 2021). Both allow interactive user-friendly generation of statistical data files for further use in teaching statistics. However, none of such web sites or other similar sources offer APIs for flexibly obtaining generated datasets according to specified parameters and using them further to automatically generate statistical tasks. Another example of the use of prepared non-interactive synthetic data in teaching can be found in (Mobahi & Min, & Wojtusiak, 2019).

Another approach is used by the author in (Arifin, 2011). The process of creating a dataset is made with the utilization of PASW Statistics to generate random values. The objective of the contribution is to demonstrate the creation of data which are measured on continuous scale, using PASW Statistics menus and syntax. Even in this case of using the SW tools, the generated data are used for teaching, but dynamic connection to other systems creating corresponding statistical tasks over the generated data is not applied.

Compared to the above examples of the use of generated data sets, the automatic generator system (Gangur, 2018) generates synthetic data as part of a statistical task, and the structure of the generated data interacts with the assignment of the generated task. The problem with the original version of the generator was in the administration of the generated data files, i.e. their storage. This process was inflexible and "manual" rather than automatic. This contribution seeks to overcome this shortcoming by utilizing the cloud and the Google Service Drive API. In the following the article explains the design of automatic upload process of generated data files to the cloud using Google Service Drive API.

The described solution thus enables the generator user (teacher, task author) to conveniently create statistical tasks and especially statistical data for the given tasks at the same time and to create a dynamic connection between them. Automatically generated statistical data are thus an integral part of a given statistical task. This approach allows the use of statistical tasks with data not only in the repository of the task used by the LMS but is especially suitable in cases of generating tests in PDF format, in which dynamic links to data files are created.

METHODOLOGY

Our system uses the Google Service Drive API for automatic storage of files. The whole process we can describe in four main steps.

1. Generation of access token in Google drive.
2. Save data to temporary file on local disk. This step is for data controlling.
3. Upload the content of local temporary file to Google disk drive under demanded file name.
    a. Refreshing of access token to Google drive.

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   b. Uploading data from local temporary file to Google drive disk under demanded name (see Listing 1).
4. Downloading the data file from cloud under demanded file name (see Listing 4).
5. Cleaning files on drive.

Procedure for generating an access token

First, the access token to your account on cloud must be generated. This token is required for any access to cloud via Google Service Drive API. The token can be received as result of project registration in Google Service Drive API (Google, 2021a) and (Google, 2021b). The created token is saved in file in working directory. In Matlab system the token is in system mat file, for using by PHP the token and client secrets are saved in json files.

The process of saving data to local temporary file

In this step generated statistical data in *dataTask* variable are saved to local temporary file under name *dataFileName*. The data are saved with help of different Matlab functions with respect to format of input data.

The process of uploading file data to Google drive

In process of uploading data file the main function *UploadExcelToGoogleDrive()* called from task generator uploads data in local file *dataTmpFile* to cloud under name *nameFile* and sets the file life on cloud. The function *UploadExcel ToGoogleDrive()* (see Listing 1) refreshes access token to Google Service Drive for next using and then it retrieves access token for current uploading (see Listing 2). Then the function *uploadFileToGoogle() is* called as the key part of file uploading.

Listing 1: Refreshing access token and uploading file to cloud (Source: own)

```
% Upload coded xlsx file in base64 as media, i.e. upload of one % file
under demanded name on cloud.
function output = UploadExcelToGoogleDrive(dataTmpName, ...
                                           nameFile, ...
                                           lifTime)
% Refresh and retrieve access token
 aDrive = refreshAccessToken();
...
% Uploading file to Google drive
 output = uploadFileToGoogle(aDrive, dataTmpFile, ...
                             nameFile, lifeTime);
end
```

The refreshing token process load the *client_id* and *client_secret* from mat file. In second step the process connects to Google Service Drive API accounts and the token is refreshed with help of authentication information. New access token is returned, and all new information are saved again to mat file.

Listing 2: Refreshing and retrieving access token (Source: own)

```
function aDrive = refreshAccessToken()
```


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```
...
 load google_tokens.mat
 options = weboptions('RequestMethod','POST');
newAccessTokenString=webread('https://accounts.google.com/o/oauth2/tok
en','client_id', client_id, 'client_secret',client_secret,
'refresh_token', rDrive, 'grant_type', 'refresh_token',options);
 aDrive=newAccessTokenString.access_token;
 save('google_tokens.mat', 'aDrive', '-append');
end
```

Function *uploadFileToGoogle()* play the key role in process of uploading statistical data to cloud (see Listing 3). The uploading process consists of two steps. In first one the file is uploaded to Google drive and in the second one the permissions are set.

The function uses the classes http.io.MultipartFormProvider, http.io.JSONProvider, http.HeaderField and http.RequestMessage. This method creates object for request creation and its sending to Google Service Drive API access point. The request consists of two parts – message header and message body. The object http.HeaderField represents the message header and following parameters are included in header. The method of authorization is set via AccessToken and Content-Type is marked as multipart data.

- 'Authorization', 'Bearer '= AccessToken
- 'Content-Type'='multipart/form-data'

More parts in message body are made up of metadata and own data. Metadata described the characteristics of data using the following parameters:

- metadata.name = nameFile;
- metadata.mimeType = 'application/vnd.openxmlformats-officedocument.spreadsheetml.sheet';
- metadata.properties.lifeTime = lifeTime;
- metadata.parents = idFolder;

The parameters define the name of data file on cloud, the id of parent directory, where the data files are stored and very important information about type of statistical data. This parameter limits the format of transferred data only to spreadsheet data. This type is enough to solve the problem of statistical data transfer. Important property is lifeTime in added properties. This property together with built-in file property cretatedTime allow later administration of files on cloud according their expiration. The metadata are transformed to JSON format using the object JSONProvider.

The statistical data are second part of message body. The data are red in corresponding character set with respect to DefaultCharacterSet value. Different character sets can be selected (UTF-8, windows-1250 ect.).

Finally, the object MultipartFormProvider creates the message body from metadata and statistical data and the object RequestMessages finishes the message creation from message header and message body. The process of file uploading ends with setup of Google Service Drive API access point url and with sending request using send method of RequestMessage object. The url also includes parameters uploadType=multipart and supportsAllDrives=True that enable to send multipart message body and upload the file to all type of drives, including shared drives.

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In the second step the permissions to file are set. The request is sent with different service access point according to id of file received from previous upload request and with different parameters. The header includes following parameters, because the request consists in body only one part in JSON format:

- 'Authorization', 'Bearer '= AccessToken
- 'Content-Type'='application/json'; charset = UTF-8
- 'Accept' = 'application/json'

The permission setting is the most important part of this process. The permission role must be set to *reader* and permission type to *anyone*. Then the permission is transferred to JSON format as only one part of message body. The construction of request from header and body is realized by the same way as in first step of uploading with the help of RequestMessage object. The Google Service Drive API access point unlike the uploading request must contain file id on cloud that is received from response of uploading request in first step. The name of service is also different. In the first step the upload and in the second one the permission is used.

Listing 3: The key part of statistical data uploading (Source: own)

```
function output=uploadFileToGoogle(AccessToken, dataTmpFile, ...
                                   nameFile, lifeTime)

import matlab.net.http.io.MultipartFormProvider;
import matlab.net.http.io.JSONProvider;
import matlab.net.http.HeaderField;
import matlab.net.http.RequestMessage;

% The header of message
HeaderField = HeaderField(
        'Authorization',['Bearer ', AccessToken], ...
        'Content-Type','multipart/form-data' ...
                                            );
% Set id directory on cloud for uploading of files.
idFolder{1} = '0AJCqk3je7B8AUk9PVA';

% Metadata describe the properties of file on cloud in JSON.
metadata.name = nameFile;
metadata.mimeType = 'application/vnd.openxmlformats-
officedocument.spreadsheetml.sheet';
metadata.properties.lifeTime = lifeTime;
metadata.parents = idFolder;
metadata = JSONProvider(metadata);

code = feature('DefaultCharacterSet');
feature('DefaultCharacterSet','windows-1250');

% Read the file content
 data = fileread(dataFile);

formProvider = MultipartFormProvider('metadata',metadata, ...
                                     'data',data);
% The whole message creation
req = RequestMessage('POST',HeaderField,formProvider);
```


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```
% The creation URL of Google Service Drive API access point
url = 'https://www.googleapis.com/upload/drive/v3/files?
uploadType=multipart&supportsAllDrives=True';

% Send message to Google drive service
response = req.send(url);

feature('DefaultCharacterSet',code);
...
% ==========================================================
% Setting of authorization for file sharing in JSON
 Permission.role='reader';
 Permission.type='anyone';
 bodyPerm = JSONProvider(Permission);

% The creation of message header
HeaderFieldPerm = matlab.net.http.HeaderField
       ('Authorization',['Bearer ', AccessToken], ...
        'Content-Type','application/json; charset=UTF-8', ...
        'Accept','application/json' ...
        );

reqPermission = RequestMessage('POST',HeaderFieldPerm,bodyPerm);

% The creation URL of Google Service Drive API access point. The % id
from response of previous request is included
url = sprintf('https://www.googleapis.com/drive/v3/files/%s/
permissions?&supportsAllDrives=True',response.Body.Data.id);

% Send message to Google drive service
reqPermission.send(url);
...
end
```

The process of downloading file data from cloud

The data file was stored under demanded name, but the used url can't work with this demanded name, because the file is stored on cloud under unique id. The script must be applied for download the data file from cloud to local user's disk. The automatically generated link to statistical data file in created statistical tasks can have following format for PHP script language:

```
https://<public directory>/FindFile.php?nameFile=<demanded name>
```

This link is generated as part of statistical tasks and it is included in final PDF file as a working http link.

The script for file downloading can be developed in any suitable language. The important part of working with script is management of access tokens. The files with access token and client_secret, that we received during the Google Service Drive project registration, must be prepared in JSON format in directory of PHP script before downloading script using. In scripts we use classes Google_Service_Drive and Google_Client from GitHub (GitHub, 2021). Only one input parameter of script is demanded name of data file nameFile as one of metadata items of file data on cloud (see Listing 4). The functions GetToken() and ReturnFileID() are the key parts of downloading script. The accessToken allows us to get the ID of data file on cloud according to nameFile and idFolder. Retrieving a file and its ID uses

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a query like retrieving a list of files to clean (see Listing 5). Received ID allows us to construct request url of Google Service Drive access point for downloading data file with this ID. Finally, we start downloading process with help of header function. Similarly, as ID, we get specified properties of files in later administration of files on cloud.

Listing 4: Main part of downloading process in PHP (Source: own)

```
...
 $nameFile = strip_tags(htmlspecialchars($_GET["nameFile"]));
 $accessToken = GetToken();
 $idFolder = '0AJCqk3je7B8AUk9PVA';
 $idFile =ReturnFileID($idFolder,$nameFile,$accessToken);
...
 $url ='https://drive.google.com/file/d/'.$idFile.'/view?
        usp=sharing';
...
 header("Location: ".$url);
```

The function GetToken() performs two main tasks similar to access in uploading process – to get token from file token.json and to refresh the token with help of information client_id and client_secret in client_secret.json file. The refresh token is moved to access token and the refresh token is updated. The information is saved again back to file token.json for next using. All mentioned operations are performed with the help of Google_Client object and its methods.

In ReturnFileID() the object Google_Client is set with information from client_secret.json file and with access_token from token.json file. The object Google_Service_Drive accept the information from Google_Client object and then its method files-> listFiles finds all files on cloud according to demanded name nameFile and idFolder as parent directory. The parameter trashed is set to false to exclude trashed files. The field ID is extracted from the result as demanded output of the ReturnFileID function.

Cleaning files on drive

Accumulating files on drive requires their administration with respect to free drive space. Expired files must be deleted automatically. The two previously mentioned properties of the createdTime file and the added lifeTIme property are used to identify such files. Their values can be used to identify expired files and then delete them. This process can be started periodically using the cron service or called in one of the described routines - file upload or download. From this point of view, it seems more convenient to clean the disk with the Matlab CleanGoogleDrive () function before uploading files to free up disk space.

Cleaning process consists of two steps (see Listing 5). In first one the all non-trashed files in drive idFolder are received. In this case, the GET request without message body is used unlike file upload and mainly the parameters q and fields are included to request URL. Question q specifies parent folder and non-trashed files. Parameter fields determines the structure of the information of each file in the output list. The final url is constructed with the help of object matlab.net.Query Parameter, then it is encoded and sent to Google Service Drive API. The expired files are selected with respect to values of createdTime, lifeTime and current time. In second step the function CleanFile accept access token and file id and it deletes the file (see Listing 6). Unlike previous requests the DELETE request is applied without message body. The id of deleted file is inserted as part of basic URL.

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Listing 5: Cleaning expired files from drive (Source: own)

```
function output = Clean(AccessToken)
...
 q = sprintf("'%s' in parents and trashed=false",idFolder{1});
 fields = 'files(id,name,createdTime,properties)';
 url = 'https://www.googleapis.com/drive/v3/files';
 U = matlab.net.URI(url);
 U.Query = matlab.net.QueryParameter('q',q, ...
                          'fields',fields, ...
                          'supportsAllDrives','True', ...
                             'includeItemsFromAllDrives','True');
 url = U.EncodedURI;
...
```

Listing 6: Cleaning file from drive (Source: own)

```
function out = CleanFile(AccessToken,id)
...
 reqFile = matlab.net.http.RequestMessage('DELETE',
                                         HeaderFieldFiles);
 url=sprintf('https://www.googleapis.com/drive/v3/files/%s',id);
 U = matlab.net.URI(url);
 U.Query = matlab.net.QueryParameter('supportsAllDrives','True',
                              'includeItemsFromAllDrives','True');
 url = U.EncodedURI;
 response = reqFile.send(url);
...
```

The cleaning process can be time consuming and therefore it is not advisable to trigger it when uploading each file in the Matlab function UploadExcelToGoogleDrive(). The periodic activation of cleaning process is therefore controlled by the time of the last activation and the set period at begin of function CleanGoogleDrive() (see Listning 7). Both values are stored in a mat file and the time of cleaning is updated each time it is run successfully. Therefore, setting the frequency of the cleaning is important step of administration process.

Listing 7: Main function for cleaning drive (Source: own)

```
function output = CleanGoogleDrive()
 load('FrequencyCleaning','Period','LastUpdate')
 if ((LastUpdate+Period) < now())
  aDrive = refreshAccessToken();
  ...
  ok = Clean(aDrive);
  if (ok)
   LastUpdate = now();
   save('FrequencyCleaning','Period','LastUpdate')
  end
 end
end
```

CONCLUSION

The presented functional solution offers not only automatic upload of data files to the cloud as a usable function in its own program, but also subsequent connection to these files

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via a flexible generated link. The generated file names in the cloud are readable, memorable and allow manual entry when downloading these data files from cloud. The described functionalities can be used to integrate the generated synthetic data and the task in the automatic generation of statistical problems, where the data are directly connected to the task via the created link. Another advantage of the system is the ability to set the lifetime of the data file, which is used when cleaning up expired data in the cloud. With a properly set lifetime, temporary data can be distinguished from long-term data files. Finally, the advantage of this solution is also the simple implementation using the built-in libraries of the Matlab system without the need for the sometimes-demanding installation of external 3rd party products packages. Implementation in the Matlab system is also a restriction of system use only for users of the system. However, the described principles can be easily applied when implemented in other development systems using the appropriate libraries.

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Analysis of the Popularity Rate of Extracted Keywords From True and Fake News Related to Covid-19

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Abstract

At the end of 2019, the whole world began to perceive information about the new infectious virus SARS-CoV-2, which in a short time triggered the COVID-19 pandemic with a global impact on human lives. In the following years, the pandemic had a significant impact on the information on the Internet. News sites have published several new articles about COVID-19 that may not always be true. The paper deals with the extraction of keywords. A supervised technique called KeyBERT was used to extract keywords from the dataset, which contains true and fake news related to COVID-19. We used Google Trends as a tool to obtain the most popular search queries related to our extracted keywords. This paper proves that the level of popularity of related searches contributes to the identification of fake news and we examined that our supposed approach may be included in the models to identify fake news to increase their accuracy.

Keywords

Keyword Extraction, Natural Language Processing, Google Trends.

INTRODUCTION

During the pandemic, COVID-19 people spent a lot of time on the Internet searching for information about the actual situation, new positive cases, guidance, restrictions, prevention etc. On the other hand, in connection with COVID-19 lot of fake news was published (Nagy and Kapusta, 2021). According to (Carrion-Alvarez et al., 2020) misinformation and conspiracy theories have been exposed worldwide by June 2020 there were more than 590 hoaxes collected in Spain. Another recent study claims that 82% of Italians can't recognize hoaxes. Pandemic has grown worldwide which means, we must deal with the wave of misinformation that has a negative impact on human lives (Villa Gracia et al., 2020, Moscadelli et al., 2020).

Google Trends is an online analytic tool that analyses searches made on Google. By entering a single word into a Google Trends, the tool can return related searches and measure the interest in them anywhere in the world. This survey will research which phrases were entered in Google's search engine in connection with true and fake news during the

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COVID-19 pandemic. Another goal of our paper is to analyse whether it makes sense to include data from trending searches in fake news detection models.

RELATED WORK

Several studies have analysed search queries through Google Trends during pandemic COVID-19. (Rovetta et al., 2022) get related searches from Google Trends by entering synonyms of generic terms like a virus from the dictionary. Interesting points of their survey are a comparison of related search volumes of the trend before and after the Wuhan official outbreak and finding anomalies between the public interest in the word “influenza” (flue) before and during a pandemic. (Villa Gracia et al., 2019) analysed terms “bulo” (hoax) and “fake” on Google during a historical period and compares them with the pandemic in Spain through regression analysis. They found that "bulo" has the historical top number of searches one month before the worst data on deaths in Spain were reached. The survey (McCarthy et al., 2021) aimed to present public interest in search terms associated with metabolic health during a pandemic by manually choosing 13 terms connected to metabolic health. As the result, they found out that public interest measured by relative search volume in their selected queries related to health and exercise increased from pre- to post-COVID-19 pandemic while the “diet” and “fitness” significantly decreased.

Google Trends has been successfully used in several studies connected to COVID-19 but to the best of our knowledge, neither of them had concentrated on the way how to get the relevant set of words to enter to Google Trends and whether the Google Trends data can be used as variables in fake news detection models. For achieving a set of relevant words from both fake and true news we suggest using a method of Natural Language Processing (NLP) called Keyword Extraction (KE) over the dataset of true, fake and partially fake news related to COVID-19 composed of 3119 articles (Koirala et al., 2021). We will extract keywords for each category separately.

Keyword Extraction

Keyword Extraction (KE) is the process of automatic identification of a set of terms that best describe the document. With this technique, it is possible to extract a small set of units composed of one or more terms. Keyword extraction approaches can be divided into Statistical Approaches and Machine Learning Approaches. A more detailed division was presented (Sharma et al., 2019) who divided keyword extraction approaches into five categories:

- **Simple Statistical Approaches** can be characterized as methods that do not require training data. They use statistical information about the text, such as word frequency, to identify key phrases from the document. The advantage of statistical approaches can be considered speed and independence of language. The downside is that the extracted phrases may not make sense (Sharma et al., 2019; Beliga, 2014).
- **Linguistic Approaches** are based on lexical, syntactic, semantic analysis etc. Algorithms falling into this category using POS (Part of Speech) patterns, n-grams or NP-chunks. Using linguistic approaches, there is a possibility to extract keywords that fall. into the POS patterns such as adjective + noun. A significant benefit of

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linguistic approaches is the ability to extract meaningful phrases. On the other hand, linguistic approaches depend on the language (Sharma et al., 2019).

- **Graph-Based Approaches** can usually represent words as nodes that are connected by a link marked as the relationship between words. These nodes can be measured in two common ways. First is the sum of the number of edges that land in the vertex and the number of edges emanating from the node. This sum is divided by the number of nodes minus one. Another way is to measure the size neighbourhood to a given vertex. The representative of the models based on the graph is Textrank, which uses PageRank algorithm. The advantage of keyword extraction using Graph-Based Approaches are visual representation, but these approaches might depend on the language (Sharma et al., 2019; Ying et al., 2017; Beliga, 2015; Litvak et al., 2008).
- **Machine Learning Approaches** use supervised learning and transform the task of extracting key phrases into a classification or regression problem. The model trained on the marked set is used to determine whether the candidate word in the text is a key phrase or not. As an example, KEA (Keyphrase Extraction Algorithm) determines whether a candidate word is a key phrase by calculating the TF-IDF of each candidate word and inserting these two values into Naive Bayes. Other approaches use labelled corpus keywords as labels. These approaches depend on language, and they are more time consuming on massive datasets (Sun et al., 2020; Sharma, Li, 2019; Beliga, 2014).
- **Hybrid Approaches** combine the previous methods. They use heuristic knowledge, such as position, length of words, HTML tags around words and other methods. (Sharma et al., 2019).

METHODS

We used the Python programming language to manipulate the data, which contains several useful libraries for NLP.

Dataset

For keyword extraction purposes we used a collection of 3119 articles related to COVID-19. The dataset consists of news between the period of December 2019 and July 2020 and each article is labelled with “true news”, “false news” or “partially true news”.

Pre-processing

Data pre-processing plays a crucial role in keyword extraction. For the pre-processing purpose, we created a class TextProcessing which contains all of the methods needed to clean up the data.

The first step was splitting the original database (Koirala et al., 2021) into the three separate text documents containing the articles for true, false, and partially false news. For the extraction process, we have chosen a machine learning algorithm KeyBERT, which in most common cases doesn’t need pre-processing. On the other hand, we needed to exclude some phrases for our purpose, so we had to apply some pre-processing techniques to the dataset (Koirala et al., 2021; Benkova and Benko, 2020; Benko and Munkova, 2016).

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The fundamentals of text pre-processing for keyword extraction include removing empty lines, and punctuation except for apostrophes and lowercasing the text. As we work with a dataset of articles related to the COVID-19 pandemic, the most common occurrences included words such as "coronavirus", "covid-19" and others. There was no reason to include them in the research, because they are too general, and they will obviously appear in every single article. To get words that we did not want to include we needed to clear the text. Stop-words are words like “do”, “or”, “me” and so on. These words will appear frequently in the document, but we did not want to extract them. For this purpose, we used a set of Python libraries for NLP called NLTK (Natural Language), which contains a list of stop-words for the English language and can return them in the form of a Python list. After this step, we obtained other frequent words using a function from NLTK called FreqDist. This function returned us words like “virus”, “covid”, “2019ncov” that we marked as a blacklist.

KeyBERT

As we mentioned above, we have used KeyBERT for extracting process. KeyBERT is a technique using the pre-trained Bidirectional Encoder Representations from Transformes (BERT) model, which can extract keywords with high semantic relevance. Unlike the other approaches that read text from left to right, BERT uses an attention mechanism that learns the contextual relationships between words in the text. It contains two separate mechanisms, which are an encoder that reads text input and a decoder that generates a prediction for a given task. Since the aim of BERT is to generate a language model, only the coding mechanism is needed (Devlin et al., 2019).

The input is a sequence of tokens that are inserted into vectors and then processed in a neural network. The output is a sequence of H-size vectors, in which each vector corresponds to an input token with the same index. Many models predict the next word, which is a directional approach that essentially limits contextual learning. To overcome this challenge, BERT uses two training strategies, Masked LM and NSP (Next Sentence Prediction) (Devlin et al., 2019).

For the extraction process, we defined a class called Extractor with keybert_extraction function, which uses functions from the Python KeyBERT package. As parameters we defined the text file, from which we want to extract keywords, stop-words, n-gram range, which were for our purpose (1,1), a number of keywords, we want to return and a blacklist of words mentioned previously.

KeyBERT offers many pretrained embedding models. Generally, the “all.-mpnet-base-v2” model provides the best performance, but we decided to use “all.-MiniLM-L6-v2” which is 5 times faster and still has comparable quality. It is a sentence-transformer model which maps sentences and paragraphs into a 384-dimensional dense vector space.

For each category, we obtained the keywords separately and limited the algorithm to one-word keywords, from which we obtained nouns using the Wordnet lexical database. Table 1 presents occurrences of extracted keywords in each category. Some words, like pandemic, epidemic and pathogen were selected by the algorithm as keywords for category true and also for partially.

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Table 1: Occurrences of extracted keywords in categories.

	TRUE	FALSE	PARTIALLY
pandemic	1	0	1
outbreak	1	0	0
epidemic	1	0	1
plague	1	0	0
mortality	1	0	0
pathogen	1	0	1
protest	0	1	0
quarantine	0	1	0
lockdown	0	1	0
michigan	0	1	0
gridlock	0	1	0
risk	0	0	1
virulence	0	0	1
danger	0	0	1
hiv	0	0	1
threat	0	0	1

Google Trends data

We further processed the data in a Jupyter notebook for easy visualization of results. We used the PyTrends library, which provides an unofficial API for Google Trends, to get related search queries. The first step in connecting to Google Trends is to call. the TrendReq class, which accepts the host language as a parameter to access the service.

To get relevant queries, we created a function that accepts a keyword list as a parameter. To retrieve any data from Google Trends, the build_payload method is used. It accepts a list of keywords, the period for which we want to retrieve the data, and the geographic location in which we want to search for the data. For the period we used an identical date range as in the dataset. Google Trends can only analyse 5 keywords at a time, so we had to split our keywords into multiple Python lists. After that, we found related queries for each word and exported them to xlsx format. Related queries can be obtained using the related_queries function, which returns queries with two metrics (Table 2).

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Table 2: An example of related queries for word mortality

mortality			
top query	**top query value**	**rising query**	**rising query value**
mortality rate	100	covid mortality	2256400
covid mortality	27	covid mortality rate	1796650
coronavirus mortality	24	covid 19 mortality	1001750
covid mortality rate	22	covid 19 mortality rate	832800
coronavirus mortality rate	20	mortality rate of covid	471350
flu mortality	17	coronavirus mortality rate	415400
flu mortality rate	15	covid-19 mortality	364500
infant mortality	13	coronavirus mortality	355000
covid 19 mortality	12	mortality rate of covid 19	308500
covid 19 mortality rate	10	covid mortality by age	304700
death rate	10	covid death rate	260600
us mortality rate	8	covid mortality rate by age	247700
mortality rates	8	covid-19 mortality rate	225150
morbidity	7	covid mortality rate us	210900
corona mortality	7	covid deaths	198050
mortality rate of covid	6	coronavirus mortality by age	175150
mortality of coronavirus	6	mortality rate of coronavirus	162900
mortality rate corona	5	coronavirus mortality rate by age	152050
mortality rate of coronavirus	5	corona virus mortality	136200
		coronavirus deaths	131350
		coronavirus mortality rate us	128600
		covid 19 mortality by age	121950
		mortality of coronavirus	115000
		corona mortality	114900
		covid mortality rate cdc	113900

Data processing

For evaluating our data, we used Microsoft Excel. The first step of post-processing was to count occurrences of each keyword, that we got from KeyBERT in each article. We labelled this variable as sum_count in our sheet. After that, we manually filtered out queries, that were not related to COVID-19. For some of our extracted keywords, like “danger” or “gridlock” Google Trends has not provided any terms related to pandemic, which means that users did not search for them.

In the next step, we calculated the mean top queries (mean TQ), and we created two other variables. The first one is total mean TQ, which uses sum_count as weight and the last one is a binary variable false news, which adds value 1 to false news and 0 to both true and partially false news.

RESULTS

Gamma presents the probability of whether two variables are in the same or opposite order. It represents the degree of association between them. Table 3 shows that false news are well identified by top query values related to keywords “michigan” and “pandemic”. For these queries were found a statistically significant high measure of positive association was achieved (Gamma > 0.5, $p < 0.001$). In the case of keywords “hiv”, “plague”, “protest” and “lockdown” was achieved a statistically significant moderate measure of positive association (Gamma > 0.3, $p < 0.001$). And in the case of the keyword “mortality” and its related queries, a statistically significant low positive association was achieved (Gamma > 0.1, $p < 0.01$).

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Table 3: Goodman and Kruskal's gamma

	Valid N	Gamma	Z	p-value
false news & michigan total mean TQ	3119	0.77***	5,6545	**0,0000**
false news & pandemic total mean TQ	3119	0.53***	17,7466	**0,0000**
false news & hiv total mean TQ	3119	0.46***	8,9213	**0,0000**
false news & plague total mean TQ	3119	0.45***	6,5179	**0,0000**
false news & protest total mean TQ	3119	0.45***	4,7874	**0,0000**
false news & lockdown total mean TQ	3119	0.34***	7,5957	**0,0000**
false news & mortality total mean TQ	3119	0.16**	2,6915	**0,0071**
false news & threat total mean TQ	3119	0,04	1,0428	0,2970
false news & risk total mean TQ	3119	-0,01	-0,4070	0,6840
false news & virulence total mean TQ	3119	-0,01	-0,0736	0,9414
false news & epidemic total mean TQ	3119	-0,06	-1,8872	0,0591
false news & quarantine total mean TQ	3119	-0.09**	-2,9773	**0,0029**

Note: *** p < 0.001, ** p < 0.01, * p < 0.05

Otherwise, the remaining keywords and their related queries do not identify false news. In the case of the keyword "quarantine" a statistically significant ($p < 0.01$) but only a trivial negative association (Gamma < 0.1) was identified, which means that it rather contributes to the identification of true news.

Matrix graphs visualize the associations (Figure1, Figure 2). In the first image (Figure 1) there are visualized associations between false reports and the top query values related to keywords that can potentially contribute to the identification of false news. In the second, cl. words (Figure 2), where only the trivial degree of association was reached.

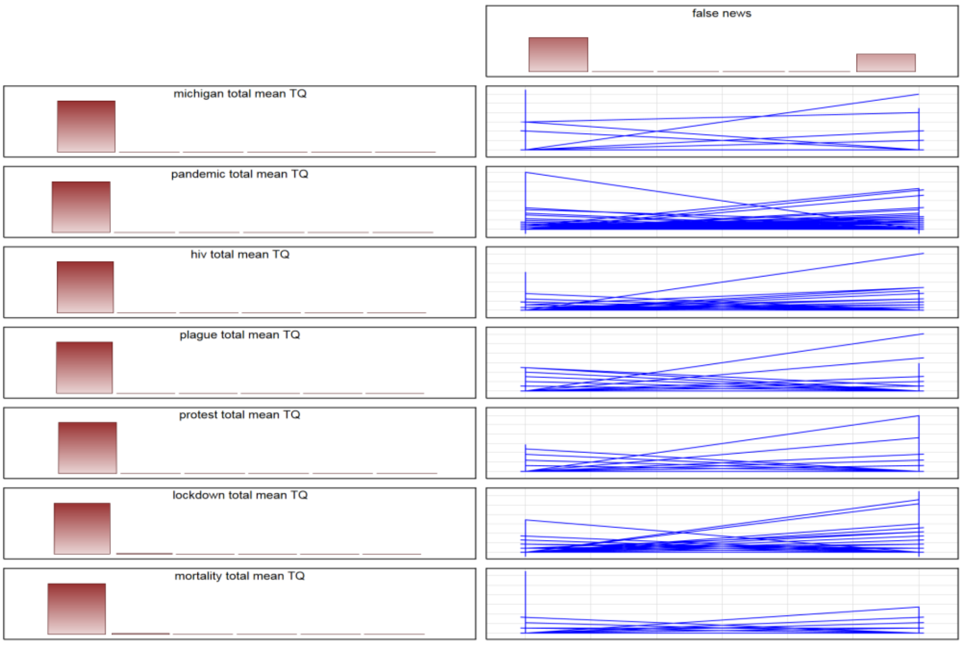

Figure 1: Association matrix between total mean TQ of related queries and false news which can possibly contribute to false news detection

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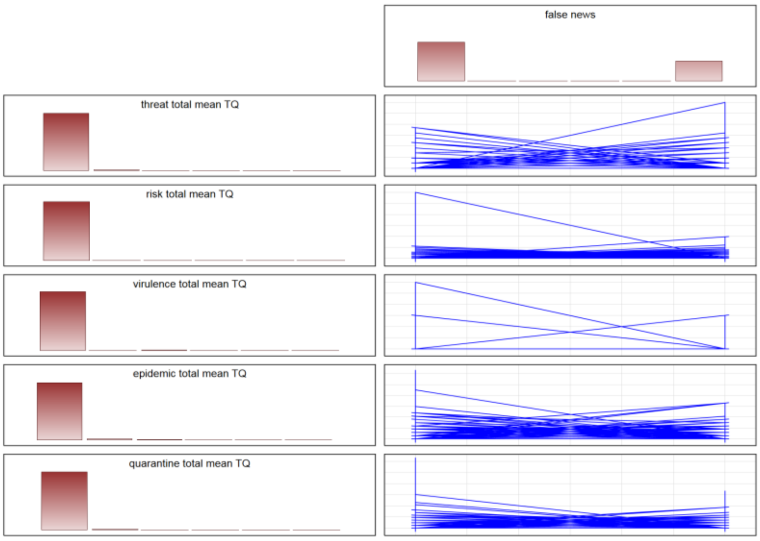

Figure 2: Association matrix between total mean TQ of related queries and false news with a trivial degree of association

CONCLUSION AND FUTURE WORK

Our paper proposes a new approach to automated keyword extraction, which can be used to obtain the related search queries. We introduced the keyword extraction process and its approaches.

This paper confirms that keyword extraction is useful for obtaining relevant search queries. In our future work, we would like to try different approaches to extracting keywords, for example extracting them for each article separately and giving a weight to each keyword depending on the HTML tag.

We also found that the data from Google Trends for related queries can identify false news. In our future work, we would like to get a closer look at the differences between false and true news in the popularity rate of extracted keywords by testing if there is a statistically significant difference between them. We would also like to try a similar approach using a rising query variable.

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Artificial Intelligence in Education: A Study on Using Bibliometric Systems

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Abstract

Artificial Intelligence (AI) is currently one of the fastest-growing areas, which shows a growing demand for experts with advanced knowledge and the ability to learn and discover new approaches. Commercial scientific databases Web of Science and Scopus, as well as the Dimensions platform, a product of Digital Science, were analysed as bibliometric systems supporting the monitoring of scientific trends and updating of research in various fields. An example is given of the use of Web of Science, Scopus and Dimensions tools to monitor the usefulness of research on the use of artificial intelligence in education as one of the tasks of the European Project "Future It Professionals Education In Artificial Intelligence" (FITPED-AI). In this secondary research, we limited ourselves to thematic publication activity and did not consider the contribution of individual scientists or publishers. The results of our work confirm the steady scientific interest in the problem of AI in a broad context, with a lack of research on the use of AI in the process of implementing personalized formal education, and actualize the need for additional research in the field of technical sciences and mathematics to provide technological support for the use of AI in education.

Keywords

Artificial Intelligence, Education, Scientometric Databases, Bibliometric Analysis, Scientific Research.

INTRODUCTION

Information technology has transformed virtually all significant spheres of people's daily lives, including education. In many fields, including education, artificial intelligence (AI) and machine learning (ML), mechanisms originally used for data management and process development, have made a special mark.

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Starting from 2017 enabling technologies of artificial Intelligence in educational practice has been considered by experts as important developments in educational technology for Higher Education (NMC Horizon Report: Higher Education Edition, 2017, 2018, 2019). It has fundamentally changed the way educational platforms and applications operate, henceforth tailored to the needs and knowledge of students, noticeably improving teaching effectiveness (Kuleto, Ilic´, Dumangiu, Rankovic´, Martins, Paˇun, and Mihoreanu, 2021), in particular, to develop skills among students, a collaborative learning environment, and an accessible research environment (Ilic´ et al., 2021).

Because artificial intelligence is the focus of numerous studies and research by experts from different countries, its corresponding research community and scientific paper production are expanding considerably. As a result, there is a growing demand for secondary studies that address this huge number of publications, synthesising knowledge in the field by systematically processing and organising research. Secondary studies offer mutual benefit - they help researchers guide future work on research gap and enable practitioners to understand the effectiveness of, for example, a particular method or technology.

To our knowledge, there are not enough studies comparing the use of artificial intelligence in general and its application in education, especially for the implementation of personalised learning. However, there are other secondary studies (analysis of the results of primary research, thanks to work in scientific publications), which are partly related to the following studies.

Artificial Intelligence Methods and Algorithms for Human-Computer Intelligent Interaction is the subject of a secondary study by researchers from Slovenia (Šumak, Brdnik, Pušnik, 2022); Visual tools for teaching machine learning - from Brazil (Gresse von Wangenheim et al., 2021); Artificial Intelligence Techniques for Distance Education - from Cyprus (Aljarrah, Ababneh, Karagozlu, & Ozdamli, 2021). Other studies, such as Boundaries Between Research Ethics and Ethical Research Use in Artificial Intelligence Health Research (Samuel1, Chubb, & Derrick, 2021) or Exploring Opportunities and Challenges of Artificial Intelligence and Machine Learning in Higher Education Institutions (Kuleto, Ilic´, Dumangiu, Rankovic´, Martins, Paˇun, and Mihoreanu, 2021), based on secondary research and document analysis (literature review), content analysis, and primary research (survey). To analyze the organization of personalized learning (Shemshack, Spector, 2020), researchers drew on several academic, scientific and commercial sources for insights into the research subject.

The aim of this paper - based on an analysis of scientific publications from the last decade - is to assess research activity in the use of artificial intelligence in general and its application to education, in particular, to implement personalized learning, and to use bibliometric methods to identify the main trends in this direction.

Objectives of the study:

1. Analyzing scientific databases and identifying bibliometric analysis tools for monitoring and supporting research in a specific subject area. The results obtained can be used by researchers to make decisions on the choice of source databases for bibliometric analysis.

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2. The use of tools embedded in various bibliometric systems to identify general trends and patterns of publication activity of researchers from different countries in the use of artificial intelligence in general and its application in education, including the implementation of personalized learning. The quantitative data obtained can be used by researchers to determine the state of development of a particular subject area in general, according to different research areas, countries of publication and qualitative analysis of research to determine its quality of effectiveness.

MONITORING PROGRESS IN RESEARCH ON THE USE OF ARTIFICIAL INTELLIGENCE IN EDUCATION USING BIBLIOMETRIC SYSTEMS

Research design

In the study, we relied on the methodological foundations of the literature review process as a research method (Creswell, 2014); research on a systematic literature review of terms related to personalized learning (Shemshack, Spector, 2020), comparison of bibliographic data sources (Visser, van Eck, & Waltman, 2021), (Martín-Martín, Thelwall, Orduna-Malea, et al., 2021), (Thelwall, (2018), and experience in applying bibliometric methods to assess subject areas (El Mohadab, Bouikhalene, Safi, 2020) or international research networks (Smyrnova-Trybulska, Morse, Kuzminska, & Kommers, 2018).

The *research methodology* recommended by the systematic literature review was chosen for this study. It consists of four main phases: planning (obviously, research questions and search strategy), selection (obtaining the source base and creating datasets), extraction (stopping the development of bibliometric systems) and data analysis (providing interpretability).

Research Questions

RQ1. What are the publication evolution and main publication venues on AI in education?

Rationale: One of the goals of this study is to guide the increasingly vast literature available on AI in education. The study will identify (i) the dynamics of growth in the number of publications by certain categories, following the objectives of the European Project "Future IT Professionals Education In Artificial Intelligence" (FITPED-AI), (ii) the state of development of the subject area and availability of research results the percentage of scientific articles compared to other types of scientific products, in particular conference proceedings, and support for the open access initiative in their publication, and (ii) the countries that have contributed most to the research area.

RQ2. In which research areas is AI applied, and are there any gaps that demand future research?

Rationale: The main goal of this study is to understand the pedagogical potential of AI use, e.g. on determinants of AI in the effectiveness of personalized learning and identify areas needed for its successful implementation in both pedagogy and engineering. To do so, it will identify (i) Research Areas where AI is being utilized, and (ii) the existing thematic focus of research based on the analysis of keywords of scientific publications (primary research).

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Source base. Methods of comparative analysis of the functionality of scientometric databases and analysis of literature sources on this issue were used to select data sources for bibliometric analysis of a specific subject area. As a result, Scopus, Web of Science and Dimensions scientometric databases were used as sources to identify trends and patterns of publication activity in the use of artificial intelligence in general and in education in particular for the effective introduction of personalized learning.

Search strategy. The search for published articles was conducted over the last ten years (from 2012 to 2021); all data were received on February 5, 2022. We used various search queries to explore the development of artificial intelligence in general ("artificial intelligence", query 1), narrowing the search to education ("artificial intelligence in education" or "(artificial intelligence) and education", query 2), considering ways to use artificial intelligence in the context of implementing personalized learning in general "(artificial intelligence) and (personalized learning)", query 3) and training in educational institutions in particular ("(artificial intelligence in education) and (personalized learning)").

As we were interested in research on the application of artificial intelligence rather than research on terminology, we searched for these keywords in the three selected databases Scopus, Web of Science and, respectively, "Topic" (Web of Science), "TITLE-ABS-KEY" Scopus) and “Title and Abstract” (Dimensions). Each query was subject to publication year restrictions: PUBYEAR> 2011 AND PUBYEAR <2022, i.e. we extracted publications from 2012 to 2021. This resulted in 12 datasets: Web of Science (W1-W4), Scopus (S1-S4) and Dimensions (D1-D4).

Bibliometric analysis. This analysis used mainly descriptive statistics. We used tools embedded in some scientific databases to classify and analyse trends in the thematic area of research by analysing publications. This included country distribution, research areas, publication types, support for the open access initiative and thematic focus.

RESULTS

1. Comparison of bibliographic data sources

Currently, there are several bibliographic platforms with scientometric tools (scientometric databases) that allow, in particular, quantitative research to identify long-term trends related to strategic monitoring of science. The value of a bibliographic data source also depends on many different elements.

Studying the statistics of bibliographic materials in different areas, such as countries, items, authors, etc., researchers in various fields of knowledge have tried to conclude the importance of research objects – the productivity of scientists, the scientific efficiency of publications, the scientific potential of the country and others. Since in bibliometric research the choice of tools depends on the object of analysis (the examined set of documents), it should be the basis for the classification of methods and selection of the source base.

By comparing source databases, in particular, Scopus, Web of Science, Dimensions, Crossref and Microsoft Academic, M. Visser and co-authors identified (Visser, van Eck, & Waltman, (2021)) strengths and weaknesses from different data sources and highlighted the need to combine different databases to achieve comprehensive coverage of the scientific literature. The results of a comparison of Digital Science’s new Dimensions

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database (launched in 2018), including its free version, with the commercial databases Scopus and Web of Science, conducted by M. Thelwall in Thelwall, M. (2018), show a high correlation between the indicators of all three sources.

As researchers consider the component of the Dimensions scientific database as an alternative to Scopus and Web of Science, we will consider the tools of these databases to determine the activity and scope of research in the field of AI in education, including personalized learning (our analysis). It should be noted that we have limited ourselves to the study of publishing activity, so the impact of individual authors, organizations, publishers or countries (through citation analysis) was not assessed in this study.

Another limitation is the ability to use the Scopus, Web of Science and Dimensions embedded tools for bibliometric analysis. For statistical analysis, visualization and mapping (e.g. co-author network maps, citations, keywords) you can use both the Dimensions embedded editor - VOSviewer online and export data (available in all databases) for further analysis in the desktop version of VOSviewer (Smyrnova-Trybulska, Morze, Kuzminska, & Kommers, (2018) or other similar programs (Smyrnova-Trybulska, Morze, Kuzminska, & Kommers, (2017)).

As can be seen from Table 1, the presence of common features of classification and, respectively, data filtering in the proposed databases, as well as some differences, confirms the proposal of M. Visser to use several databases for complex bibliometric analysis.

Table 1. Comparison of Scopus, Web of Science, Dimensions tools

Characteristics / Filters	Web of Science	Scopus	Dimensions
Publication Year	+	+	+
Document Types	+	+	+
Authors/ Researcher	+	+	+
Affiliations	+	+	-
Countries	+	+	-
Source Title / Publication Titles	+	+	+
Open Access	+	+	+
Fields of Research / Research Areas	+	+	+
KeyWords		+	
Sustainable Development Goals			+

2. Results of bibliometric analysis

What are the publication evolution and main publication venues on AI in education

The search strategy (execution of queries W1-W4, S1-S4, D1-D4) yielded a different number of publications from 2012 to 2021 in the different scientometric databases (Table 2). It should be noted that in the case of the analysis of the use of artificial intelligence, the Dimensions database has a larger coverage compared to Scopus and Web of Science databases, which confirms the feasibility (or at least the possibility) of using this base as an alternative to a commercial one. In other cases, the results of the analysis of the W, S and D sets have a sufficient correlation. In particular, it is possible to make assumptions about the smallest development of the topic of using artificial intelligence for the implementation of formal and non-formal learning: the number of publications in sets 3 and 4 on all scientometric databases is many times smaller than in the others.

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By type of publications, on average 50% are articles that support the assumption that the topic of artificial intelligence is sufficiently studied (results of W1, D1 analysis), but the use of artificial intelligence to implement personalized learning requires additional scientific research. The publications of sets W4, S4, and D4 are the lowest: 49.9%, 26.2% and 23% respectively). It should also be noted a slightly lower percentage of articles among the publications of sets S and D compared to W, which indicates different policies of different scientific databases and publishers, which, in turn, confirms the validity of using different sources (in this case Scopus, Web of Science and Dimensions) to analyze the research topic area.

As far as the support for the Open Access initiative is concerned, as many as 50% of the articles (regardless of data set) are in open access (All OA filter was applied). The situation is slightly worse with other types of publications, which may indicate the specificity of the presentation of research results in social sciences and educational sciences (among the publications of the D4 set only 19.5% are in the public domain, W4 - 39.8%).

The growth track over the last 10 years has gone through two stages: the first (2011-2018), which had a very slow period of development, and the second (2018-2021). In the period 2018-2019, there was a sharp increase in the number of publications on all datasets compared to previous years, which may indicate the relevance of the subject area (NMC Horizon Report: Higher Education Edition, 2017, 2018, 2019) and its prospects for its further study by researchers.

Table 2. Number of publications from 2012 to 2021

Query No.	Dataset	Publications	Open Access	Articles	Public Access
1	W1	68464	27395 (40%)	39808 (61.8%)	19171 (48.2%)
	S1	248783	65229 (26.2%)	73832 (29.7%)	30624 (41.5%)
	D1	1336032	457406 (34.2%)	679806 (50.9%)	345419 (50.8%)
2	W2	2695	1083 (40.2%)	1451 (53.8%)	745 (51.3%)
	S2	10733	2956 (27.5%)	2979 (27.6%)	1482 (49.7%)
	D2	492261	139399 (28.3%)	206756 (42%)	105909 (51.2%)
3	W3	866	456 (52.7%)	451 (52.1%)	275 (61%)
	S3	2364	979 (41.4%)	770 (32.6%)	438 (56.9%)
	D3	156054	40168 (25.7%)	50855 (32.6%)	28312 (55.7%)
4	W4	405	161 (39.8%)	202 (49.9%)	110 (54.5%)
	S4	386	112 (29%)	101 (26.2%)	57 (56.4%)
	D	110191	21514 (19.5%)	25286 (23%)	14067 (55.6%)

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Analysis of the research in terms of the countries from which their publications originate (Table 3) has identified several countries from which the authors' publications need particular attention when examining qualitative experiences in the application and development of artificial intelligence. Summarising the authors' contributions (the Top 3 prolific countries for each query were identified) over the period (2012-2021), the leaders are the United States and China - on average, researchers from each of these countries authored around 20% of all publications in each our sets. The contribution of researchers from England (the third country in the Top 3) is less than 10%. The publication activity of scientists from India (dataset analysis) S1 needs further research

Table 3. Distribution of authors by countries

Selection	USA	CHINA	ENGLAND (UK)	India
W1 (68464)	14292 (21%)	13038 (19%)	4967 (7.3%)	
S1 (248783)	45951 (18.3%)	50527 (20.3%)		21153 (8.5%)
W2 (2695)	590 (22%)	449 (16.7%)	204 (7.6%)	
S2 (10733)	2571 (24%)	1822 (17%)	670 (6.2%)	
W3 (866)	260 (30%)	120 (14%)	100 (11.5%)	
S3 (2364)	725 (30.7%)	393 (16.2%)	220 (9.3%)	
W4 (405)	85 (21%)	102 (25.2%)	35 (8.6%)	
S4 (386)	75 (19.4%)	97 (25.1%)	20 (5.2%)	

It should be noted that the Dimensions toolkit does not identify the most productive countries by the number of publications. However, our additional mapping with VOSviewer for the D4 set (Fig. 1) as the one most in need of additional research, confirmed the results of the analysis of sets from groups W and S (Table 3).

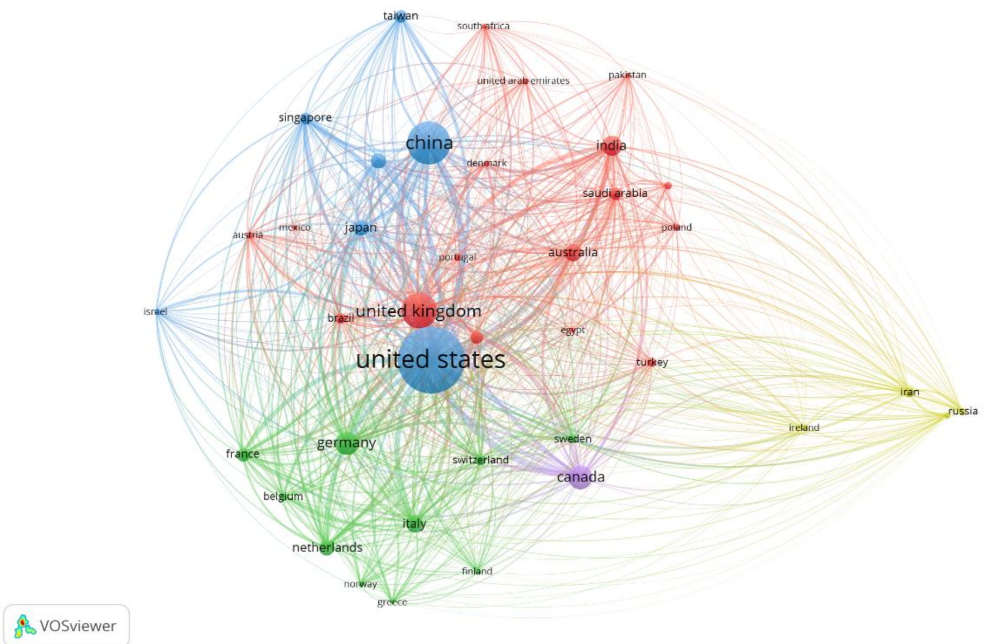

Figure 1. Mapping with VOSviewer for the D4 set

In which research areas is AI applied, and are there any gaps that demand future research?

Regarding Research Areas (Fields of Research in Dimensions), we have identified the most relevant Areas - those that cover more than 15% of the total number of publications

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(Table 4). We have set this percentage threshold because several publications (on average no more than 0.05%) do not contain data (metadata description) in this field.

Table 4. Distribution of authors' Research Areas

	Computer Science	Engineering	Education	Medical and Health Sciences	Mathematics
W1 (68464)	24 735(36.1%)	20 573 (30%)			
S1 (248783)	136351 (54.8%)	68399 (27.5%)			66036 (26.5%)
D1 (1336032)	561590 (42%)	199055 (15%)			
W2 (2695)	876 (32.5%)	509 (19%)	782 (29%)		
S2 (10733)	6976 (65%)	3050 (28.4%)	2259 (21%)		
D2 (492261)	139359 (28.3%)		75164 (15.3%)		
W3 (866)	225 (26%)	159 (18.4%)			
S3(2364)	1196 (50.6%)	465 (19.7%)		811 (34.3%)	
D3 (156054)	51285 (32.9%)			23795 (15.2%)	
W4 (405)	214 (52.8%)	84 (20.7%)	110 (27.2%)		
S4 (386)	270 (69.9%)	111 (28.8%)	96 (24.9%)		76 (19.7%)
D4 (110191)	26902 (24.4%)		16598 (15.1%)		

As can be seen, the main subject areas are Computer Science (Information and Computing Sciences in Dimensions), Engineering, Education Educational Research (Education in Dimensions, Social Sciences in Scopus), which indicates a comprehensive study of the application and development of artificial intelligence. Moreover, the category of educational sciences does not appear in any scientometric database in the general overview of this issue (analysis of W1, S1, D1 datasets), as well as when considering the use of artificial intelligence for personalized learning (W3, S3, D3 datasets). The appearance in the analysis of S3, D3 sets belonging to the category of Medical and Health Sciences (medicine in Scopus) may indicate the use of artificial intelligence in personalized medicine and prevention and appropriate training (mostly informal) medical staff, as evidenced by qualitative analysis of individual publications this dataset. Thus, based on the results obtained, it is possible to make assumptions about the use of artificial intelligence for the implementation of formal personalized learning as a promising area of research. It should also be noted that, considering various aspects of the use of artificial intelligence, about 20% of the publications in mathematics were found in the S1 and S4 datasets. This may indicate the high producibility of a particular subject area and the actualization of the strengthening of the mathematical apparatus to ensure it.

In order to identify frequent topics (frequency of specific keywords in each dataset), we used the corresponding Scopus toolbox (Table 1), i.e. we analysed keywords from sets S1-S4 (Table 5). As a result, not taking into account the highest frequency of "artificial intelligence" as a key term in all queries, the areas of development of artificial intelligence in education (sets S2, S4) include the application and development of Learning Systems, and the relevance of students' interest in using AI motivational component. Also of note is the development of algorithms and the use of machine learning in personalized medicine (set S3), which is in line with current trends in the digitalization of medical education.

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Table 5. Frequency of keywords according to the description of publications in Scopus

Selection	Learning Systems	Machine Learning	Human	Education	Students	Personalized Medicine
S1 (248783)	39655 (15.9%)	29575 (11.9%)	22620 (9.1%)			
S2 (10733)	2382 (22.2%)			3367 (31.4%)	2594 (24.2%)	
S3 (2364)		1058 (44.8%)	964 (40.8%)			763 (32.3%)
S4 (386)	134 (34.7%)			104 (26.9%)	126 (32.6%)	

CONCLUSIONS

The number of published studies on the development and application of AI technologies is constantly growing. Nevertheless, there is a need for additional research on the use of AI in social sciences and educational sciences and multidisciplinary research to develop algorithms, and technological and methodological solutions for the effective use of AI in education. A qualitative study of the experience of application and development of artificial intelligence (defined as a prospect for further research) should pay attention to the initial research of scientists from the United States and China. The high probability of the conclusions is confirmed by a strong source base of bibliometric analysis (total number of primary publications - 334696) and independence from the specific scientometric base or publisher policy: the same general trends are observed in the analysis of different sets of groups W, S and D. "Non-critical" differences, their detection in the process of this study may be accidental.

The identified need for additional research on the use of artificial intelligence in the implementation of personalized learning can be partially met in the teacher training system (Morze, Liakh, & Kuzminska, 2017) or in the implementation of projects – in particular, European Project „Future IT Professionals Education In Artificial Intelligence" (FITPED-AI) (2021-1-SK01-KA220-HED-000032095). For example, the main outcome of the project is an educational model for building highly specialized skills in AI-oriented university study programmes.

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Case Study Comparing the Accuracy Classification of Emotion and Analysis of Sentiment Using IBM Natural Language Understanding and Emotnizer Applications

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Abstract

In this paper, we present a case study aimed at comparing the accuracy of classification in sentiment analysis using the IBM Natural Language Understanding tool and the Emotnizer application developed by us. The Emotnizer application was tested, and its classification accuracy reached 82.31% in a research sample of 50 participants. In this paper, we compare the results of text sentiment analysis, which was analyzed using a professional tool from IBM and an application developed by us. The comparison was made on a text prepared on the psychologist's instructions so that it could be considered as a reference for both instruments.

Keywords

Sentiment, Emotion, Text Analysis, Classification.

INTRODUCTION

A large amount of data is generated daily on social networks, which can be analyzed and useful information can be extracted from them. Such an emotional analysis of a text represents sentiment, which is a thought, opinion, or feeling about a given topic. Individual thoughts, opinions and feelings, whether in the short or long term, are part of all human activities and significantly influence people's behavior (El-Kassas *et al.*, 2021), (Birjali, Kasri and Beni-Hssane, 2021).

From the perspective of the Covid-19 pandemic, there has been an increase in extremist groups as well as individuals who publicly promote their views on various portals (Thaqi *et al.*, 2020), (Abrams, Lalot and Hogg, 2021).

Sentiment analysis seeks to identify the opinion / sentiment that is assigned to a given word, phrase, sentence, and comprehensively throughout the text. Sentiment analysis classifies texts containing emotions into three categories: positive, negative, and neutral. Neutral in this sense falls into the objective category of subjective analysis, although some

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authors (Zhang and Wallace, 2015), (Wang *et al.*, 2018) define neutrality as an opinion that does not have a clear tendency toward positive or negative user feelings.

Emotions are a complex and very good indicator of a person's feelings. Rosenberg states that emotions are a biological condition associated with the nervous system (Rosenberg and Ekman, 2004). Therefore, a lot of useful information such as mood, temperament or personality can be read from them (Trnka, Zahradnik and Kuška, 2016). The original division of sentiment analysis into 3 basic categories can thus be extended by others with the correct analysis, using different models of emotional representation: discrete, dimensional and component. The discrete model distinguishes basic emotions (called labeled) and describes each emotional attitude as a combination of basic emotions. The emotional characterization group of the recognition algorithm uses emotions based on its own characteristics, and the given type of representation causes an interpretation problem such as the inaccuracy of the whole concept of words and the problem of inaccurate semantic (semantic) discrimination. A typical representation of such a discrete model is the classification of 6 basic emotions of anger, disgust, fear, happiness, sadness and surprise (Ekman and Friesen, 1971), (Li and Deng, 2020).

The dimensional model represents an emotional attitude as point 10 in a two- or three-dimensional place. The most widely used dimensional model was proposed by Russell, who stated that every emotion can be characterized by two other parameters, excitement and satisfaction (Russell, 1994), (Posner, Russell and Peterson, 2005), (Shams, Wahab and Fakhri, 2013).

The component model uses several factors that shape or affect the resulting emotional state. It works on the principle of combining two or more elementary emotions to create a new one (Donaldson, Dollwet and Rao, 2014). A typical example is Plutchik's model divided into eight sectors which indicate eight basic emotions given into four pairs of oppositions. Color determines the intensity of emotion. The farther the neighboring words are from the center of the diagram, the weaker the relationship formed by them. A neutral state would arise if we projected a two-dimensional representation on a three-dimensional state and the highest midpoint indicated a neutral state. For example, if we combine trust and fear, inferiority is created (Plutchik, 2001), (Castillo-Huitrón *et al.*, 2020).

The paper is divided into several parts. In the Related work section, we present an overview of the works that have most significantly influenced research in the field of text analysis, specifically sentiment and classification of emotional state. In the experiment section, we present the basic research methodology and the course of the experiment. The Discussion section focuses on summarizing the results of the experiment, and the Conclusion section presents our vision for the future.

RELATED WORK

The analysis of the text and the determination of the sentiment (or emotions) resulting from it is currently a very challenging task not only from the point of view of psychology, but also of artificial intelligence. Sentiment analysis classifies texts according to the polarity of the emotions that are expressed. The biggest obstacle to improving is that we are not in direct contact with the person, only using the text that has been created. As part of the analysis, it is important to identify how the person works with it. We know three basic

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techniques for determining sentiment and emotions in text analysis. The first method is to recognize emotions from the text using keywords. This method can be described as a problem in finding the occurrence of keywords from given parts of sentences, the so-called lexical source (Chun-chieh, 2013). A lexical resource can be defined as a list of words that are evaluated on the basis of strong emotions or on the basis of their positivity and negativity (Grljević and Bošnjak, 2018). Words are most often classified according to Ekman's classification into categories such as happiness, anger or surprise. This method consists of several steps. The text is first divided into so-called tokens, keywords are then extracted from these tokens. An intensity analysis follows, and before determining the emotion itself, the negative is being verified, such as the phrase "I'm not happy" (Yang and Eisenstein, 2017). Emotion analysis therefore requires different approaches depending on the needs of the recipients of the text being analyzed. The idea of sentiment classification is designed so that one part of the text has added value (positive, negative or neutral).

The second method is to determine emotions through machine learning (Amodei *et al.*, 2016), (Cambria *et al.*, 2020). In this case, we're not looking for keywords, but we're taking the text as a whole. This method tries to find out the emotional state using trained classifiers. These classifiers apply various machine learning theories such as SVM (Support Vector Machines) to determine which category the input text should belong to (Akhtar, Ekbal and Cambria, 2020). The third method is a hybrid method that uses keyword search along with machine learning to improve the accuracy of emotion determination. A typical example is the approach described in the work (Minaee, Minaei and Abdolrashidi, 2021). When analyzing text to determine sentiment and specific emotions, it uses a rules-based approach to extract semantics related to specific emotions. These semantics and attributes are associated with emotions in the form of emotion association rules. As a result, these emotion association rules replace the original keywords.

The problem with machine learning at present is the correct understanding of context in text analysis. For example, the syntax for "*I am being laughed at*" has a different meaning from "*laughed at*". If we only followed the search for a keyword, then these two phrases would give the impression of the same emotion, although it is clear from the context that these are completely different emotional states. Another example is the phrase "The government has made great fights against the financial crisis, which has bankrupted many companies." This sentence must be considered negative because it discusses the consequences of the financial crisis and the bankruptcy of many companies, but it must also be considered positive in the analysis of government sentiment, as the government ended the financial crisis (Dobrescu, 2011). Thus, machine learning methods must be able to distinguish between probabilities and emotions.

MATERIAL AND METHODS

In an experiment to compare the accuracy of the classification in the analysis of sentiment and emotions from the text, we used a cloud service from IBM and the Emotnizer application programmed by us (Magdin *et al.*, 2020). This application has already been tested (sample size 100 students), where we achieved a classification accuracy of 82.31%. The application allows you to classify 4 basic emotional states (happiness, anger, sadness and the state of relaxation, or neutral state), which are found in both Ekman's classification and Russell's model.

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At present, it is possible to analyze the text and determine the sentiment (or emotions) by various available software tools. One of the possibilities is to use a cloud service called IBM Natural Language Understanding (hereinafter referred to as IBM NLU) (https://www.ibm.com/cloud/watson-natural-language-understanding). This service has undergone several changes since 2017 and its original name being Tone Analyzer. However, as its functionalities were expanded, its name was also changed so that it would better represent its current aim of activity.

IBM NLU is a service based on the theory of psycholinguistics, an area of research that clarifies the relationship between linguistic behavior and psychological theories. It uses linguistic analysis and the correlation between the linguistic properties of the written text and emotional and speech tones to evaluate all dimensions of the text. This service can analyze input text as individual words, sentences, or an entire text document. It can be used for a deeper understanding of the written text and subsequent adjustment according to the detected undertone of the text. As input, the service supports JSON and HTML files, as well as plain text, which cannot exceed the size of 128 KB of text, which, however, corresponds to more than a thousand sentences in the case of plain text. Subsequently, a response will be returned to us in the form of a JSON file, which contains an evaluation of our input. This allows us to adjust the text to evoke a certain emotion.

Research in text analysis has shown a strong and statistically significant correlation between word choice and personality, emotions, attitudes, needs, values and thought processes. Researchers have found that people are different in how often they use certain categories of words, whether they are writing a blog or essays. Therefore, they argued that communication media can help predict various aspects of a person's personality (Fast and Funder, 2008), (Adamopoulos, Ghose and Todri, 2018) (Dukan and Kovari, 2013) (Kovari, 2015).

Research by (Fast and Funder, 2008) is based on finding psychologically meaningful word categories from the words used in the text, and serves as the basis for the IBM NLU. The service seeks to identify a person's personality traits, thinking, writing style, emotions, needs and values from the words he uses. IBM uses its own machine learning models to evaluate these characteristics by assessing various text parameters. The results show that the average performance of the models is statistically better than the best accuracy of other state-of-the-art models by about five percent (IBM, 2020). Comparing the expected emotions and sentiment with the IBM NLU and those assigned by people, the service scored 75% for the analytical undertone, 53% for the preliminary undertone, and 73% for the faithful undertone. Overall, the differences between the predicted and the people assigned to the undertones were not significant and indicate that this service is very accurate (IBM, 2022).

Individual features the IBM NLU supports (IBM, 2022):

1. Domain customization,
2. Text analytics,
3. Deploy anywhere,
4. Entities,
5. Categories (Beta),

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6. Classifications,
7. Concepts,
8. Emotions,
9. Sentiment (Beta),
10. Relations,
11. Metadata,
12. Semantic roles.

To implement the IBM NLU API, an environment that allows you to send requests and receive responses to our inputs needs to be used. IBM NLU provides an APIKey and URL for its services. It is possible to use various programming environments, such as NetBeans, or use the platform from IBM to send requests - Postman. It allows you to create commands that represent inputs for evaluating emotional states. These can be collected in collections depending on whether the input is a word, a sentence, or an entire document. The POST method is used to send input, which sends the input for evaluation. If data is sent in JSON format, the response is returned in the same format. The answer has a simple and understandable structure (Figure 1):


```
{
  "usage": {
    "text_units": 1,
    "text_characters": 37,
    "features": 1
  },
  "language": "en",
  "emotion": {
    "targets": [
      {
        "text": "apples",
        "emotion": {
          "sadness": 0.028574,
          "joy": 0.859042,
          "fear": 0.02752,
          "disgust": 0.017519,
          "anger": 0.012855
        }
      },
      {
```


Figure 1. Sample dump

EXPERIMENT

The goal of the experiment was to verify the difference in the accuracy percentage of the classification in the final evaluation between the IBM NLU service, the Emotnizer application and the subjective evaluation obtained from the statements of the participants in the experiment.

The experiment proceeded with the following steps:

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1. Choice of text based on the recommendation of a psychologist. The aim was, based on the content of the text, to evoke emotional states in its reading, which could be classified as fear or anxiety.
2. Participants (total number 50) read the text, their task was to rewrite it correctly and then evaluated it using SAM (Self Assessment Manikin). Emotnizer evaluated the emotions that participants experienced when transcribing the text based on the number of errors, length of writing, and other relevant factors. These values were compared with the subjective evaluation of SAM and the accuracy of the classification was determined. A complete procedure can be found in the paper of (Magdin *et al.*, 2020).
3. The text was inputed into the IBM NLU service via PostMan.
4. Acquired results were compared with each other.

The IBM NLU service divided the text into individual sentences, which it evaluated according to sentiment and emotions. Although the service allows you to parse the sentence and evaluate each word from the point of view of sentiment and emotions separately, in the final evaluation only the whole sentence or a pair of sentences is important, which clarify the mutual meaning and subsequently the content of the analyzed text. Therefore, in the output, the IBM NLU lists the overall score and sentiment along with the emotional state (with the highest value) that the text subconsciously evokes in the reader (Table 1). In some cases, more than one emotion was reported in the results (text content can evoke multiple emotional states), with each service always assigned a score.

Table 1. IBM NLU text analysis results

Sentence	Emotion	Score
Parents wanted to make a romantic weekend without their son. He was already 15 years old so he could take care of himself.	Sadness / Tentative	0.575961 / 0.716301
In order not to feel alone, he always had his dog with him.	Sadness / Confident	0.528336 / 0.509368
The pet was so trained that he slept under the boy's bed every night.	Joy / Confident	0.579775 / 0.751512
The first night, when he was home alone, the sink in the bathr oom began to drip.	Fear	0.573738
The boy was not in his skin, so he put his hand down from the bed so that the dog would lick it. After the while the boy finally ventured, he went to pull the tap so that the water finally stopped dripping.	Joy / Analytical	0.678419 / 0.892152
During the second night, the scenario was repeated. Something began to drip into the bathroom again.	Tentative	0.88939
The boy put his hand out of the bed again to be licked by the dog. After a while, he got out of bed and went to the bathroom. There was no dripping from the sink. This time there was sliced boy’s dog and with his blood was written on the mirror: Not only dogs can lick hands!.	Analytical	0.801827

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Overall, however, the content of the text in terms of evoked emotions was classified as Joy with a score of 0.551533, while it does not evoke any other emotion. From the point of view of sentiment, the analyzed text was included in the category of positive.

A detailed procedure as well as the results of the experiment, which was carried out using the application Emotnizer, can be found in the article The Possibilities of Classification of Emotional States Based on User Behavioral Characteristics. The paper points out the fact that participants, when reading the same text (which was inserted into the IBM NLU service) and its subsequent transcription, subjectively assessed their emotional state, which they were just experiencing. Based on 15 different parameters determining the participant's behavioral characteristics and regression analysis, Emotnizer classified the percentage of each emotional state: Happiness, Anger, Sadness and Relax (Figure 2).

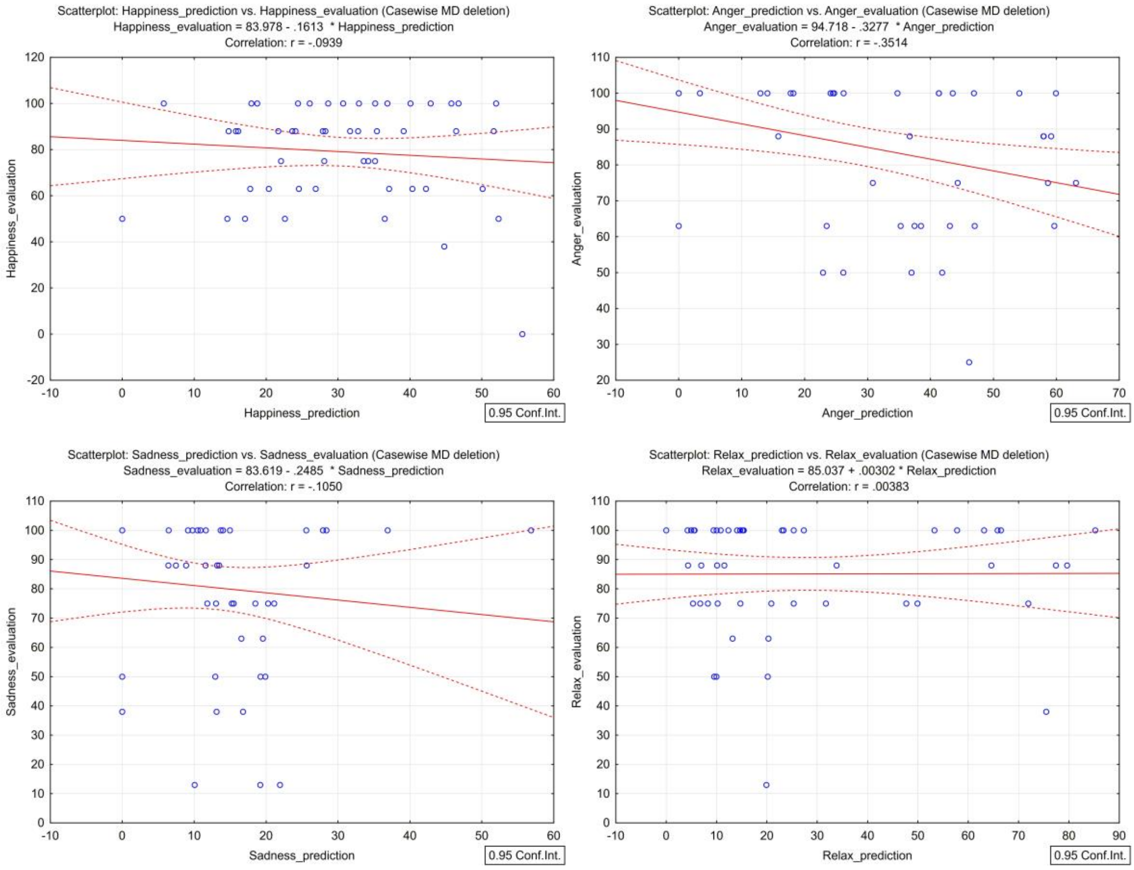

Figure 2. Results of the Emotional State Classification using application Emotnizer

According to the Figure 2, we can see that based on the classified emotional state and the subsequent subjective evaluation of the participants, the application works with an overall classification accuracy of more than 80%, which we can consider a sufficiently good classifier.

The average score of values of individual emotional states, which the Emotnizer application classified for a total of 50 participants, is Happiness 0.309022, Anger 0.282105, Sadness 0.108709 and Relax 0.253832.

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Even though the aim of the prepared and analyzed text was to evoke negative emotions, the highest value in the IBM NLU was achieved by the emotional state of Joy. IBM NLU does not report other emotional score scores in complex text analysis. The value of Joy 0.551533 thus represents a 55% probability that one can perceive the analyzed text as amusing. In the analysis of the results obtained from the Emotnizer application, it is necessary to consider that the individual values were divided between 4 classified emotional states. From the point of view of sentiment, the analyzed text is also perceived as positive (higher values of Happiness and Relax than Anger and Sadness) rather than negative.

CONCLUSION

The analysis of the text and the resulting determination of sentiment, classification of emotions, or the search for other entities and social contexts is today an area of scientific research, in which, in addition to psychology, informatics also participates. Artificial intelligence in the form of neural networks or machine learning can help us not only in the very classification of sentiment and emotional state, but also in understanding how the reader worked with the text. In this paper, we focused on a service from IBM called Natural Language Understanding. This service allows a wide range of text analysis, without the need to be a programmer or an artificial intelligence expert. The aim of the paper was to compare the results obtained by text analysis using this service with the results we obtained during the experiment from the Emotizer application programmed by us. If we consider IBM NLU as a reference tool, the results show that the Emotnizer programmed by us is working properly. The results in Table 2 show that 50 participants perceived the text positively in terms of sentiment.

In the future, we will focus on comparing the results obtained using the Emotnizer application, the IBM NLU service and the Affdex SDK. Based on a mutual comparison of the results, we could determine the individual differences that arise in the analysis of the text in more detail when classifying sentiment together with emotional states.

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Essays’ Automatic Evaluation

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Abstract

Automated essay scoring is a complex problem whose research leads to different approaches built in the real world. Such approaches can help teachers with the evaluation of students’ works and therefore they need less effort which they can use on different tasks. In our paper, we focus on using natural language processing techniques for creating a suitable classification vector and using a neural network we are trying to predict the final grade of an essay. Standard used natural language processing techniques are TfIdf, POS tags and pre-trained doc2vec. The paper aims to find out whether it is possible to improve the classification for predicting the evaluation of students’ essays using syntactic and morphological analysis. We compared three knowledge extraction techniques and the results show that we can predict the final grade of an essay with an accuracy of approximately 80 %.

Keywords

automatic essays scoring, knowledge extraction, machine learning, automatic evaluation, natural language processing

INTRODUCTION

Today, state departments of education are developing new forms of testing and grading methods. The need for more sophisticated and affordable options is vital in this field. The critical thinking and analytical skills of the students can be measured by essays. Essays are one of the most important expressions of knowledge, but they are expensive and time-consuming to grade by hand. The number of student-written essays is huge, and a relevant social problem is their faster evaluation. Currently, there is no fast, effective, and affordable solutions for automated grading of student-written essays (The Hewlett Foundation, 2012).

Essays are a type of unstructured text which can be analysed using natural language processing (NLP) methods (Rajagede, 2021). Unstructured texts are not organized in a pre-defined scheme and do not have a pre-defined data model (Kapusta et. al, 2021; Munkova et al., 2021). These properties make them difficult to understand for computers because they cannot be stored in fielded form, cannot be indexed, or mapped into standard database fields. Unstructured texts play a key role in predictive analytics and sentiment analysis. Mining unstructured text delivers new insights by uncovering previously unknown information, detecting patterns and trends, and identifying connections between seemingly

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unrelated pieces of data. Using NLP we can extract information from unstructured texts, create a vector for machine learning predictive models and perform training, testing and evaluation of the models (Zhao et al., 2021; Kapusta, Drlik, Munk, 2021).

According to current research work, we know that we can applicably analyse text, create vectors from texts and use them in classification tasks that can classify with high accuracy. Syntactic and morphological analysis can be widely used in different unstructured texts for knowledge extraction (Kapusta and Obonya, 2020). Text's syntactic analysis is defined as analysis that tells us the logical meaning of certainly given sentences or parts of those sentences. The morphological analysis is a process of classifying the words into grammatical-semantic classes and assigning grammatical categories to these words (Nagy and Kapusta, 2021). The results of the morphological analysis are part of speech tags (POS tags). Research in the education area is aimed to verify students' essays and their evaluation using NLP methods, thus helping teachers to consequentially evaluate their students' essays.

The main question of this research is to verify whether it is possible to improve the classification for predicting the evaluation of students' essays using syntactic and morphological analysis. The research aims to find out with which accuracy we can automatically classify essays from students using machine learning methods and NLP techniques.

The workflow is as follows:

1. Calculation of the TfIdf weights of the words in the essays.
2. Identification of POS tags.
3. Combination of TfIdf weights and POS tags.
4. Knowledge extraction using the Doc2Vec model.
5. Creation of input vectors for the classifiers.
6. Design and creation of classification models.
7. Identification of the results and their analysis and evaluation

RELATED WORK

Automated essay scoring (AES) has to reduce costs associated with human rating, especially at universities. The growth in e-learning systems in higher education started research interest in improving the accuracy of the automated essay scoring systems.

The paper of Beseiso et al. (Beseiso et al., 2021) presents a neural network-based model for improving automated essay scoring performance. They are using Bi-LSTM and RoBERTa language model for Kaggle's ASAP dataset. The comparative analysis of results demonstrates the applicability of the proposed model in automated essay scoring at the higher education level.

In the research of Chang and Cutumisu (Lu and Cutumisu, 2021) three AES algorithms with word-embedding and deep learning models (CNN, LSTM, and Bi-LSTM) were implemented and compared. They also proposed a novel automated feedback generation algorithm based on the Constrained Metropolis-Hastings Sampling (CGMH). Their results

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show that the scoring accuracy of the AES algorithm performs with high accuracy and the CGMH method generates semantically related feedback sentences.

Another neural network based paper was introduced by Liang et al. (Liang et al., 2018). They proposed a symmetrical neural network AES model that can accept the input pair. The model Siamese Bidirectional Long Short-Term Memory Architecture (SBLSTMA) can capture not only the semantic features in the essay but also the rating criteria information behind the essays. The SBLSTMA model was used for the task of AES. Experimental results show that their approach is better than other neural network methods.

Neural networks are widely used in the field of automated essay scoring. Single-layer unidirectional LSTM network, multi-layer unidirectional LSTM network, word-level recurrent highway network and word-to-sentence-level recurrent highway networks were implemented by Hurtado and Saladi (Hurtado and Saladi, 2018). After training the models they found that the multi-layer unidirectional LSTM network performs the best with an accuracy of 63 %.

Ramnarain-Seetohul et al. (Ramnarain-Seetohul et al., 2022) analysed multiple existing AES systems to provide insights into the different similarity techniques and methods used to generate a score for students' answers. The analysis results say that there are two main types of similarity techniques used by AES systems. The first one is similarity-based where similarity is computed with a reference answer. The second one is instance-based which uses models to learn features of essays and then predicts a corresponding score. Both similarity techniques have used several methods to generate a score for students' answers.

As knowledge extraction and creation a vector from documents multiple natural language methods can be used (Rokade et al., 2018). The BERT model was used by Ormerod et al. (Ormerod et al., 2021) for essays classification. Their transfer learning and language models improved the performance of document classification texts in the NLP domain. Similarly, BERT model was used for sentence embedding by Rajagede (Rajagede, 2021). Their best model produces an f1-score of 82.1 % using pre-trained fastText sentence embedding and the stacking model between the neural network and XGBoost. Marcinczuk et al. (Marcinczuk et al., 2021) compared multiple approaches – doc2vec, BERT, TfIdf and wordnet for knowledge extraction from learning outcome documents. According to analysed research papers, we can say that knowledge extraction from essays can be performed using NLP techniques and the neural network can be used for the classification part of the problem.

DATA

For training our model and verification of our proposed methods we are using students' essays provided by The Hewlett Foundation (The Hewlett Foundation, 2012). The dataset consists of 12 976 different essays to the same topic graded on a scale of 0 to 10. The dataset consists of multiple feature values, but just 2 of them is relevant for us. The first one is the column *essay*, which is the unstructured text of the essay and the second one is the column *final_grade*, which holds the final manual evaluation of the student-written essay. There is no need to clean these data, there are no empty values. The grades were encoded binary zeros and ones, each grade below or equal to 5 is rated as 0 and it refers to a bad essay and each grade above 5 is rated as a good essay.

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METHODS

For the knowledge extraction from texts, we are using three techniques – TfIdf, TfIdf combined with POS tags and doc2vec. The first method is TfIdf (Term frequency – inverse document frequency) which is a traditional technique that is leveraged to assess the importance of tokens to one of the documents in a corpus. The TfIdf weight is composed of two terms: the first computes the normalized Term Frequency (Tf), the second term is the Inverse Document Frequency (Idf) and it is calculated as follows (Khan et al., 2019; Nagy and Kapusta, 2021):

$$tf(t,d) = \frac{f(t,d)}{f(w,d)}\,, \tag{1}$$

$$idf(t,D) = \ln \frac{N}{\sum(d \in D : t \in d) + 1}\,, \tag{2}$$

$$tfidf(t,d,D) = tf(t,d) \times idf(t,D). \tag{3}$$

Where *t* is a term, *d* is a document, *w* is any term in a document, *f(t, d)* is the number of terms in the document *d* and *f(w, d)* is the number of all terms in the document, *D* is the corpus of all used documents and *N* is the number of documents in the corpus.

The second technique for knowledge extraction is the combination of TfIdf and POS tags and using n-grams presented by Kapusta et al. (Kapusta et al., 2021). In this approach, the TfIdf vector is merged with vector from POS tags which expresses the relative frequency of each tag in the frame of the analysed list of POS tags identified in the document. This vector is calculated as follows:

$$\overrightarrow{PosF(d)} = (p_1, p_2, \dots, p_n). \tag{4}$$

Each value *p* is calculated as follows:

$$PosF(pos,d) = \frac{f(pos,d)}{f(w,d)}\,. \tag{5}$$

PosF(pos, d) is the number of occurrences of POS tag in document *d* and *f(w, d)* is the number of all identified POS tags in the document.

Doc2vec was introduced by Le and Mikolov (Le and Mikolov, 2014) and the main idea is to compute a feature vector for every document in the corpus which means a creation of a numeric representation of a document, regardless of its length. The main idea is the same as for word2vec, but doc2vec is extended by another vector, so-called Paragraph ID.

There are two models for implementing doc2vec:

- Distributed Memory version of Paragraph Vector (PV-DM)
- Distributed Bag of Words version of Paragraph Vector (PV-DBOW)

The main applications of the vector are in the problems of finding similarities between the documents, classification tasks and other NLP problems (Le and Mikolov, 2014). The result is a fixed-length vector for each document. We have chosen vector length 500 which

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means each document is mapped to 500-dimensional vector. In python, there is a doc2vec implementation in the gensim library which was used in this research to compute the doc2vec vector values for the dataset.

MODEL

The recent development of computation resources and accumulation of data, and new algorithmic techniques, has enabled this branch of machine learning to dominate many areas of artificial intelligence, first for perception tasks like speech recognition and computer vision, and gradually for NLP since around 2013 (Liu and Zhang, 2018). For this reason, we decided to evaluate our solution using the neural network model. Neural networks are simple models of the way the nervous system operates. The basic units are neurons, which are typically organized into layers. In a feed-forward neural network, each neuron from one layer is connected by each neuron on the following layer. The training uses the backpropagation algorithm (Skorpil and Stastny, 2008).

A simple small feed-forward neural network was designed to limit the memory and runtime of the model. The neural network had 3 layers with 8, 4 and 1 neuron. There was a dropout between layers of size 0.25. Sigmoid activation function was used; binary cross-entropy was chosen as loss function and the Adam was chosen as optimizer.

We used k-fold validation for evaluating our models. This technique is popular and easy to understand. It ensures that every observation from the original dataset has the chance of appearing in the training and test set. We first shuffle our dataset in k-fold cross-validation, so the order of the inputs and outputs are completely random. We do this step to make sure that our inputs are not biased in any way. The original sample is randomly partitioned into k equal sized subsamples. A single subsample from the k subsamples is retained as the validation data for testing the model, and the remaining *k - 1* subsamples are used as training data. The cross-validation process is then repeated k times, with each of the *k* subsamples used exactly once as the validation data. We set *k = 10* in our evaluation, so the dataset was randomly split into 10 subsamples.

We measured the results using accuracy (6), precision (7), recall (8) and f1-score (9), where TP is the number of true positives, TN is the number of true negatives, FP is the number of false positives and FN is the number of false negatives. Precision gives the percentage of correctly determined positive values and all values; it is also translated as correctness. The recall is the ratio of correctly determined positive values and all positive values also referred to as completeness. F1-score is the harmonic average of precision and recall.

$$acc = \frac{TP + TN}{TP + TN + FP + FN} \tag{6}$$

$$precision = \frac{TP}{TP + FP} \tag{7}$$

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$$recall = \frac{TP}{TP + FN} \tag{8}$$

$$F1 - score = 2 * \frac{precision * recall}{precision + recall} \tag{9}$$

RESULTS

The results show that we can predict the final level of the essay with approximately 80 % accuracy (Table 1). On the following boxplots, we visualised the quartiles. The mean values of the results are very similar to the median values. TfIdf together with POS tags performs the best (Figure 1). Using TfIdf together with POS tags performs the best with an accuracy of 80.61 % and precision of 80.96 %. The lowest accuracy 79.62 % have the doc2vec technique and the lowest precision have the 79.18 %.

Table 1: Final accuracy and precision of classifications using different knowledge extraction techniques.

Technique	Accuracy	Precision
TfIdf	79.76 %	79.18 %
TfIdf and POS tags	80.61 %	80.96 %
Doc2vec	79.62 %	80.66 %

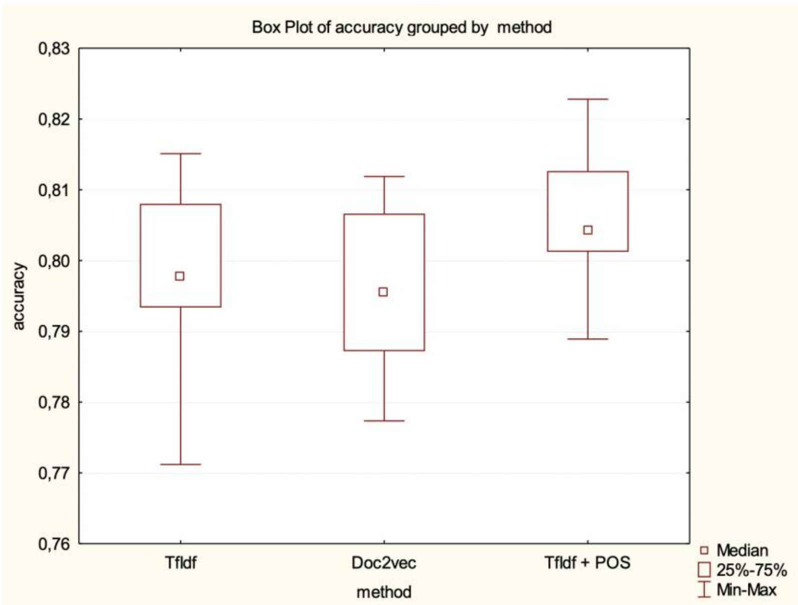

Figure 1: Boxplot for the model performance measurement – accuracy.

Boxplot of the precision of the true values (Figure 2) shows that doc2vec and TfIdf with POS tags perform better than simple TfIdf. TfIdf has value 79.18 % while doc2vec has value 80.66 % and TfIdf with POS tags 80.96 %. The results show that the precision of the bad essays (Figure 3) cannot predict doc2vec. In this case, the simple TfIdf performs the best with an average precision of 80.97 % and TfIdf together with POS tags with an average precision of 80.19 %.

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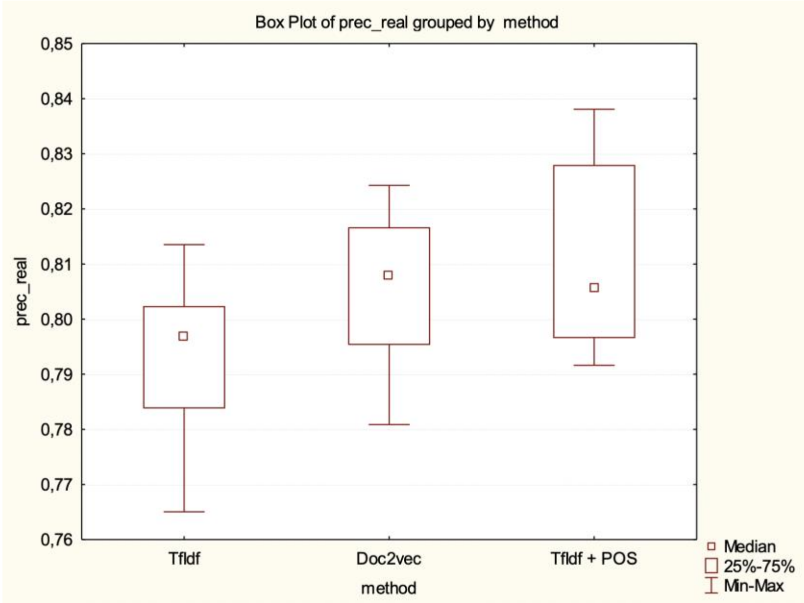

Figure 2: Boxplot for the model performance measurement – precision real.

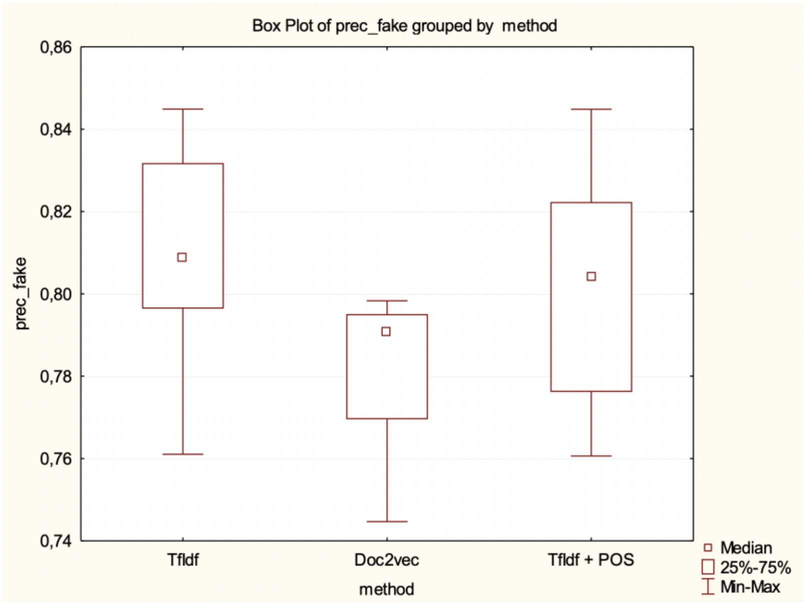

Figure 3: Boxplot for the model performance measurement – precision fake.

The recall measurement (Figure 4) is the highest for the TfIdf with POS tags with a value of 79.28 %. Doc2vec has a recall of 78.44 % and the simple TfIdf has a recall value of 77.99 %.

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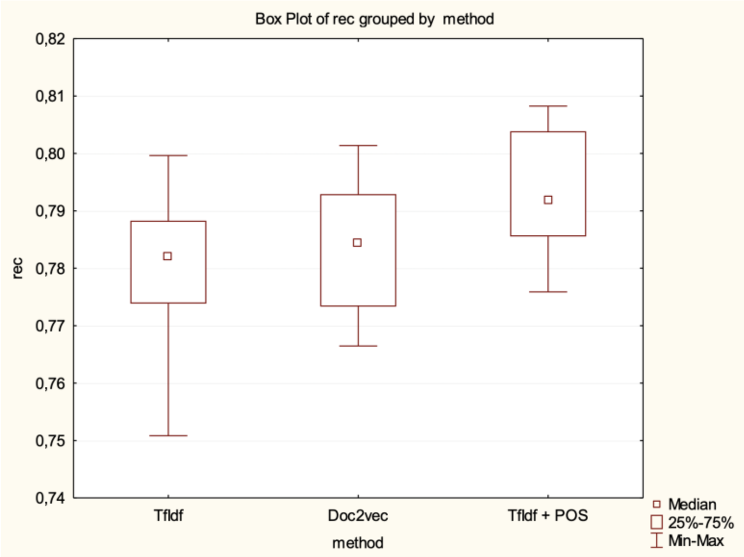

Figure 4: Boxplot for the model performance measurement – recall.

Finally, we calculated the f1-score (Figure 5). This score takes both false positives and false negatives into account. F1-score is usually more useful than accuracy, especially in the case of uneven class distribution. This performance measurement confirms the best results of the TfIdf with POS tags.

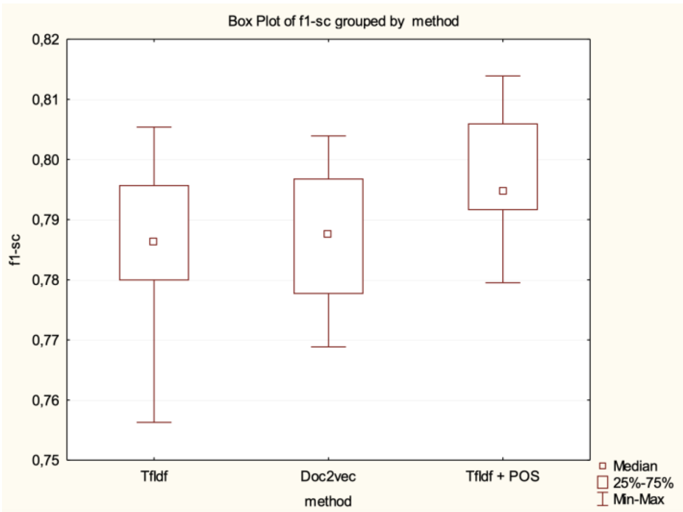

Figure 5: Boxplot for the model performance measurement – f1-score.

DISCUSSION

In this paper, we focused on automatic students' essays evaluation. We created a suitable vector from the dataset for training the classification model which is based on a neural network. Three knowledge extraction methods were evaluated – TfIdf, TfIdf with POS tags and doc2vec. We regard accuracy as the most important performance measurement in the NLP problem of classification. We achieved the best results for TfIdf with POS tags with the value of accuracy is 80.61 %, for simple TfIdf it is 79.76 % and for doc2vec it is 79.62 %.

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In our research, we tried to find out whether it is possible to predict final students' essays evaluation and their accuracy. An important result is the finding that we can predict the final student's evaluation with an accuracy of approximately 80 %.

Similar research was made by Beseiso and Alzahrani (Beseiso and Alzahrani, 2020) who used the BERT model for feature creation and they achieved an accuracy of 75.2 % for Quantized Classification.

CONCLUSION

The automatic essays classification is a real research problem and when significant results will be achieved it will facilitate the work of many teachers and evaluators. It will be an efficient way that will fasten and lower the time effort when it comes to essay evaluation. In our research, we focused on only a smart part of this huge issue. The chosen classification methods go out from the last publications in this area.

Our goal was to evaluate if traditional NLP knowledge extraction techniques with a combination of neural network classification can be used to predict students' final evaluation. Statistically notable differences between the three used knowledge extraction methods were not observed, all three methods in combination with a neural network can achieve approximately 80 % accuracy. Precision shows that we can a little bit better predict the worse essays using TfIdf techniques.

In our future work, we would like to focus on verifying other techniques for knowledge extraction and even higher accuracy prediction.

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The Issues Related to Preprocessing Educational Datasets for Improving Student's Performance

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Abstract

Educational data mining has received considerable attention in the last few years. Many data mining techniques are proposed to extract hidden knowledge from educational data. The extracted knowledge helps the institutions to improve their teaching methods and learning process. All these improvements lead to enhancing the performance of the students and the overall educational outputs. The quality of data mining techniques depends on the collected data and features. Therefore, the representation and quality of the instance data is first and foremost. If there is much irrelevant and redundant information present or noisy and unreliable data, then knowledge discovery during the training phase is more difficult. It is well known that data preparation and filtering steps take a considerable amount of processing time. It should be underlined that it is also feasible to gather an appropriate dataset along with features during the data collecting process, which can afterwards be expanded. Thus, we choose to model the available Moodle dataset and illustrate the necessity of pre-processing techniques before predicting the final outcome of the students. The study's primary objective was to identify and implement data pre-processing techniques such as data cleaning, normalization, transformation, feature extraction and selection, etc., on Moodle datasets, which are often omitted. The product of data pre-processing is the final training set. It would be nice if a single sequence of data pre-processing steps would lead to the best performance for each dataset, but this does not happen. As a result, we have prepared a balanced dataset in this study consisting of 24 academic features through data pre-processing techniques. These types of features are strongly related to the frequency of students' interaction with the e-learning management system. The resulting pre-processed dataset can be used in future research to predict students' final performance through ML algorithms.

Keywords

Educational data mining, data pre-processing, data cleaning, feature selection, academic performance.

INTRODUCTION

The educational landscape has shifted considerably in recent years. The use of web-based education systems has increased enormously, owing to the proliferation of Learning Management Systems (LMS) built and installed in universities, schools, and educational businesses. A learning management system (LMS) is used to manage, document, track, and

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provide electronic educational technology, courses, and training programs (Skalka, Drlik and Kapusta, 2012). LMS strive to use online technology in their courses in order to enhance the effectiveness of traditional face-to-face education (Amrieh *et al.*, 2015). These learning systems amass a massive quantity of data on various subjects, ranging from personal information about users to information about students' activities, academic performance, and user interactions. There is already a considerable amount of data available about students' academic records and habits in many academic institutions (Hussain *et al.*, 2018). The visualization and analysis of these datasets are carried out using a variety of methodologies in order to identify interesting and useful hidden patterns for forecasting students' performance (Chouldechova, 2017; Kusner *et al.*, 2017). The study of this data may yield significant information that is beneficial to both teachers and students. In order to analyse the efficacy of the courses and the progress of the learners, it is possible to generate reports for different users and courses. Insights can assist in gathering to different learning styles, which can assist in determining the complexity of courses, identifying specific areas of the content that cause difficulties in understanding the concepts, and receiving insights about the future performance of students. One of the most widely used approaches to examine vast amounts of data is to use machine learning (ML) to discover hidden patterns and employ the knowledge discovery process, which is centred on the application of data mining (DM) techniques for better decision-making models. These patterns are then used to predict students' performance using an academic dataset. As a result, the main goal of using data mining techniques is to predict students' final performance for enhancing learning institutes' outcomes in education systems (Choudechova, 2017; Chawla *et al.*, 2002; Kabathova, Drlik, 2021).

Although it is well known that data pre-processing influences the final output of ML tasks, the majority of research focuses on user and session identification, with only a few studies discussing data pre-processing and its effect (Munk, Drlik, 2011; Munk, Kapusta and Svec, 2010). We concur that many of the decisions that affect a model's predictive behaviour are made during data preparation and are executed as part of the pipeline prior to using the data to train the model. We believe that the way data is pre-processed for machine learning model has observable effects that can be quantified and analyzed further on to:

- understand the sensitivity of specific data point results to various pre-processing approaches,
- improve the transparency of the entire machine learning process by examining any of its individual steps, which will enable the development of more accurate and fair models.

Collecting suitable datasets is also considered as one of the most important factors in improving the performance of the prediction model. However, having a large volume of data in a variety of formats may contain redundant, inconsistent, noisy, missing data and unrelated qualities that could have an impact on the prediction of final and worsened results (Hussain *et al.*, 2018). Students' performance can be predicted more accurately by using educational datasets (Amrieh *et al.*, 2016). Therefore, we concentrate on modelling the available data and highlighting the critical nature of pre-processing approaches for subsequent usage in predicting the students' outcomes. The resulting coherent dataset may improve the accuracy of predicting students' performance, thereby assisting educators in making decisions. The purpose of this study is to show steps which lead to creating a dataset optimized for use in future research through data pre-processing.

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DATA DESCRIPTION

With a rapid effort of educational science to improve the students' performance, several datasets are being used for such purposes. The necessity for constructing an efficient dataset has emerged due to small datasets in the field (Fernandes *et al.*, 2019). Additionally, there are only a few freely available datasets from LMS Moodle, which are anonymised and can be analysed with the aim to generalise findings and make them useful for the whole community of researchers.

One such a dataset is called "Teaching with Moodle", made accessible for research purposes where the students' data were transferred into tables. A dataset of this type enables to develop of procedures that may be applied to other Moodle data files in the future. The data used within the research comes from the August 2016 session of the course "Teaching with Moodle". This course is taught twice a year by Moodle Pty Ltd employees in the form of online sessions. The course description says that it is free and meant for anyone who wishes to use the Moodle learning platform for teaching, whether it is at a school, a university, a company, or just for personal pleasure (Dalton, 2017).

The session was offered entirely online through a learning management system from August 7 to September 4, 2016. 6119 students were enrolled in this course, of which 2167 agreed to use their data which created a total of 32 000 records. Out of this number, 1566 students received a badge within the course, and a total of 735 students successfully completed the course, which consisted of completing all activities within the course. The presented data set consists of six selected tables from the Moodle database pages that were extracted using SQL to CSV (comma-separated by values) files. A pseudonymous username has been included in each data file in order to enable the reconstruction of relationships between users and their completion of activities, log entries, badges, and grades, among other things. Certain other columns of data were omitted either for privacy concerns or because they did not contain valuable data in this data collection. Table 1 shows descriptions of six csv. files. Each file includes a set of attributes.

Table 1: Description of .csv files used to create a preprocessed dataset.

Filename	Description	Records
mdl_badge_issued.csv	There are records of all badges granted to users during the "Teaching using Moodle" session on August 16.	1844
mdl_course_modules.csv	This file contains records for each activity in the "Teaching using Moodle" course.	60
mdl_course_modules_completion.csv	This file contains records of each user's completion of each activity in the course.	30986
mdl_grade_grades_history.csv	This table maintains a historical record of individual grades for each user and each item, in the same format as they were imported or submitted by the modules themselves.	70037
mdl_logstore_standard_log.csv	This table contains entries for each "event" logged by Moodle, and it serves as the source for all of the Moodle "log" reports generated by the logging system.	52684
mdl_user.csv	This is the table that contains information about users.	2167

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Each of the following files consists of a large number of attributes, which support ML learning techniques to sufficiently build an effective predictive model for student performance prediction.

METHODOLOGIES

Data pre-processing is considered an important step in the knowledge discovery process, which includes data cleaning, feature selection, data reduction and data transformation (Hussain *et al.*, 2018) (Figure 1). After the data collection task, it is important to apply some pre-processing mechanisms to improve the quality of the data set. Therefore, several operations were performed in order to properly prepare pre-processed .csv file out of all previously specified data.

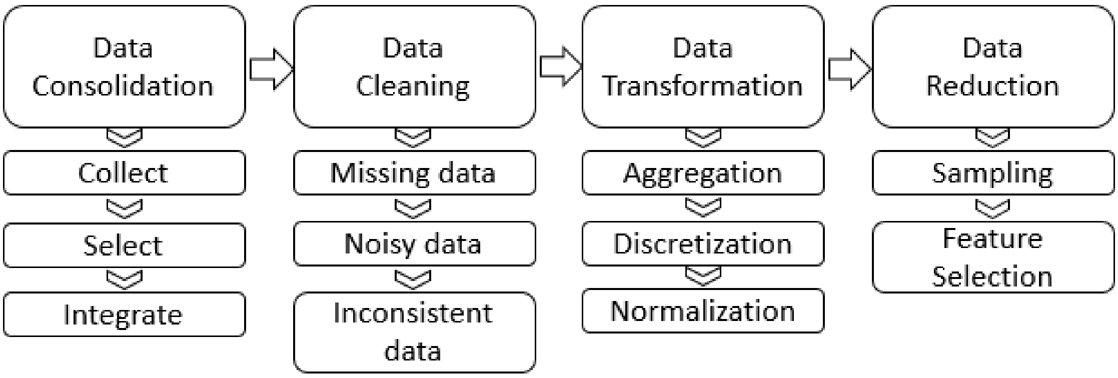

Figure 1: Data pre-processing steps (Amrieh *et al.*, 2016).

The dataset consists of 2167 student records. Following 24 attributes shown in Table 2 were selected for this research: "*CourseID*", "*StudentNo*", "*BadgesNo*", "*AttemptCount*", "*Ah1*", "*Ah2*", "*Ah3*", "*ActivityHistory*", "*OtherModules*", "*AtRisk*", "*M1*", "*M2*", "*M3*", "*M4*", "*M5*", "*M6*", "*M7*", "*M8*", "*M9*", "*M10*", "*M11*", "*M12*", "*ModuleSummary*" and "*Result*".

Attribute "Result" was mapped with the outcome of the student either having passed or failed the course based on the completion of each module. At first, the records from "*mdl_course_modules.csv*" were extracted about each activity within the course module. Second, the results of those specific students in the particular activities were extracted from "*mdl_course_modules_completion.csv*".

Data cleaning is usually applied to a particular dataset to reduce the noise and missing values. There were no records that did not provide comprehensive information, but 213 records were removed during the data cleansing step due to the fact that files contained academic information only about 1954 students out of 2167.

The files were subsequently merged, and pre-processing was completed with a result of a single consolidated .csv file with 1954 records.

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Table 2: Description of selected features.

Feature	Description
CourseID	The code for the course in which the student has enrolled.
StudentNo	The anonymized student's name.
BadgesNo	The number of achieved badges by a registered student.
AttemptCount	The number of attempts in the course.
At1 – At3	Historical achieved points of each student completion of selected 3 activities.
ActivityHistory	Total number of completed historical activities.
OtherModules	The number of any other completed activities by a registered student.
AtRisk	Previously failed two or more historical activities.
M1 – M12	The number of completed modules within the course.
ModuleSummary	Summary of all completed modules within the course.
Result	The final outcome of the registered student based on the completion of each module.

After that, we used the discretization mechanism to transform several properties of the students' performance from numerical values into nominal values, which represent the class labels of the classification problem.

To accomplish this step, we divided the dataset into three nominal intervals (High, Medium and Low), as shown in Table 3. The criteria used to convert numeric values into nominal intervals are thirds. This convesrions was done in order to better map the result of the target variable "*Result*". Generally, the dataset had two common issues that frequently occur with this type of educational data. On the one hand, the data set was multidimensional; the number of attributes or features grows huge. Given large number of attributes, some were not meaningful for classification as well as some attributes were not correlated. On the other hand, the data was skewed, with the majority of students passing while a minority failed.

Table 3: Numeric to nominal value conversion.

Nominal Value	Attempt Count	Activity History	Other Modules
High	3	3	6≤
Medium	2	2	3,4
Low	≤1	≤1	≤2

The imbalanced data problem emerges because learning algorithms frequently disregard less common classes in favour of the most frequent ones. As a result, the resulting classifier will be incapable of appropriately classifying data examples that belong to poorly represented classes.

Algorithms for feature selection can be used to determine which feature has the most impact on the output variable (academic status). Feature selection is the process that focuses on reducing the number of attributes that are appearing in patterns, in which it reduces the dimensionality of feature space, removes redundant, irrelevant, or noisy data, and increase the comprehensibility of the mining results (Fernandes *et al.*, 2019).

In this research, we applied a filter-based approach using an information gain-based selection algorithm to evaluate the features correlation to check which features were most important, as shown in figure 1. The main goal was to alleviate the challenge of high-dimensional data by lowering the number of attributes without sacrificing classification

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reliability. In this case, the feature selection showed that the output variable was strongly related to completing each activity within the course.

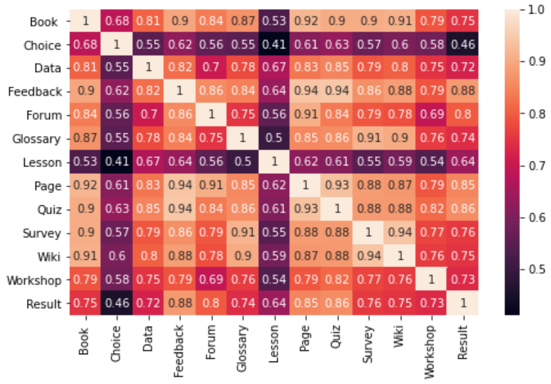

Figure 2: Correlation matrix for selected features.

The next step was to map the historical record of individual grades for each student and In the next step, we took into account the historical records from the table ”*mdl_grade_grades_history.csv*”, which provided information about each student's points earned through various historical activities. As part of this step, 6 of the 16 activies had to be removed as they contained missing values and replacing them with zero/null values could distort the analysis results. Simultaneosly, in order to work with historical data, it was necessary to remove 752 records because no information about these students was available.

On the contrary, there were three activities in the file that were assigned achieved points for the majority of students had in common, so we took them into account. Also, one of the selected features referred to records merged from file "*mdl_badge_issued.csv*", which contains all badges issued to students who were enrolled in the Aug 16 session as well as badges awarded outside that course. Ensuring confidentiality and privacy, the identity of the students was coded and mapped accordingly. The character marking and generalization method was used to anonymize the data where necessary and applicable. Figure 3 represents the final dataset created from the processed data.

CourseID	StudentNo	BadgesNo	AttCount	AttCount	At1...At3	ActivityH	ActivityH	OtherMod	OtherMod	AtRisk	M3...M22	ModSum	Result
10464	Student 1	0	1	Low	0	1	High	0	High	Yes	1	5	Fail
10464	Student 2	1	1	Low	6	3	Low	0	High	No	3	20	Fail
10464	Student 3	0	1	Low	0	0	High	0	High	Yes	0	1	Fail
10464	Student 4	3	1	Low	6	3	Low	3	Medium	No	4	33	Pass
10464	Student 5	2	1	Low	6	3	Low	4	Low	No	4	33	Pass
10464	Student 6	1	2	Medium	0	2	Medium	0	High	Yes	3	19	Fail
10464	Student 7	2	1	Low	6	3	Low	3	Medium	No	4	33	Pass
10464	Student 8	0	1	Low	0	0	High	0	High	Yes	0	1	Fail
10464	Student 9	2	1	Low	6	3	Low	3	Medium	No	4	33	Pass

Figure 3: Final pre-processed dataset.

CONCLUSION

Academic achievement is being a big concern for academic institutions all over the world. The wide use of LMS generates large amounts of data about teaching and learning interactions. This data contains hidden knowledge that could be used to enhance the academic achievement of students. Student engagement is usually referred to as spending

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time by students in educational activities. Student engagement includes not only the spending time on tasks but also their desire to participate in some activities.

There are many definitions and research that were focused on students' behaviour and engagement. All of these approaches confirm the strong relationship between students' behaviour and students' academic achievement.

The main aim of this study was to create a dataset consisting of multiple academic features through data pre-processing. These types of features are strongly related to the learner's engagement with the e-learning management system. The resulting pre-processed dataset can be used in future research to predict final student performance through machine learning algorithms, as well as to solve other knowledge discovery tasks. ML algorithms automatically extract knowledge from machine-readable information. Unfortunately, their success is usually dependent on the quality of the data that they operate on. If the data is inadequate or contains extraneous and irrelevant information, machine learning algorithms may produce less accurate and less understandable results or may fail to discover anything of use at all.

Thus, the pre-processing step is necessary to resolve several types of problems, including noisy data, redundant data, missing data values, etc. All the inductive learning algorithms rely heavily on the product of this stage, which is the final dataset. Selecting relevant instances usually helps to remove irrelevant ones as well as noise and/or redundant data. The high-quality data will lead to high-quality results and reduced costs for data mining projects. In addition, when a data set is too huge, it may not be possible to analyse it through conventional means and ML algorithms. In this case, instance selection could reduce data and enable a ML algorithm to function and work effectively with massive data. In most cases, missing data should also be pre-processed to allow the whole dataset to be processed.

Moreover, most of the existing ML algorithms are able to extract knowledge from data set that store discrete features. If the features are continuous, the algorithms can be integrated with a discretization algorithm that transforms them into discrete attributes. Feature subset selection is the process of identifying and removing as much of the irrelevant and redundant information as possible. Feature wrappers often achieve better results than filters due to the fact that they are tuned to the specific interaction between an induction algorithm and its training data.

However, they are much slower than feature filters. Moreover, the problem of feature interaction can be addressed by constructing new features from the basic feature set (feature construction). Generally, transformed features generated by feature construction may provide a better discriminative ability than the best subset of given features, but these new features may not have a clear physical meaning.

This study provides the pre-processed dataset consisting of 1202 records along with the following 24 selected academic features: "*CourseID*", "*StudentNo*", "*BadgesNo*", "*AttemptCount*", "*Ah1*", "*Ah2*", "*Ah3*", "*ActivityHistory*", "*OtherModules*", "*AtRisk*", "*M1*", "*M2*", "*M3*", "*M4*", "*M5*", "*M6*", "*M7*", "*M8*", "*M9*", "*M10*", "*M11*", "*M12*", "*ModuleSummary*" and "*Result*". A filter-based approach was used for identifying the most important features. Each step of data pre-processing used within the study was considered to achieve the best performance for a dataset.

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The pre-processed dataset can be useful for further research to explore students' academic performance in online learning environments through ML algorithms.

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The Impact of Distance Learning During the Covid-19 Pandemic on the Statistical and Data Literacy

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Abstract

The advent of the COVID-19 pandemic has generated a huge demand for scientific knowledge. Science is based on evidence that has a statistical and data basis. However, many people do not understand this issue and therefore do not have enough confidence in it. Distrust in science is a major issue for any progress. The aim of the article was to analyze the impact of a large amount of statistical and data-based information from the media during a pandemic on statistical and data literacy of computer science students at the university. We also examined how it is affected by a large proportion of distance learning compared to traditional face-to-face teaching. We analyzed the impact of statistical information on students, especially in the form of graphs. Students tested during the pandemic completed a large part of their studies in the form of distance learning. The assumption was that a high rate of the daily influx of statistical information would force students to try to understand this information, as it is often very important. On test results from 2013 to 2021, we examined a specific area of statistical and data literacy. It is primarily reading and understanding graphs. The results of the experiment, which we conducted, showed that the statistical literacy of students rather decreased during the pandemic. However, the reduction in statistical literacy was significant in terms of reading and understanding the graph. The results of the research therefore showed that in other areas, such as the understanding of statistical terminology, there was no statistically significant decline.

Keywords

Statistical literacy, covid-19, distance learning.

INTRODUCTION

The COVID-19 pandemic has hit the world, setting an unprecedented situation for the entire planet, but each individual has to deal with it in some way. However, this is a problem that needs to be addressed not from an individual perspective, but from a societal perspective. The pandemic engaged people in consuming scientific information (Engledowl and Weiland, 2021), which is primarily numerical. All "pandemic numbers" have a pandemic context and often remain misunderstood and misinterpreted by the media themselves.

All numbers, tables, and graphs generated by the COVID-19 pandemic have a certain context that is mathematically and statistically linked to real experience. However, this context remains misunderstood, if we do not understand the basic connections between

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the variables in the graph shown to us by the media, for example in clarifying the need for the curve to flatten with exponential growth and limited hospital capacity (Heyd-Metzuyanim, Sharon and Baram-Tsabari, 2021). Understanding or not understanding the context results in individual decisions by individuals. These are largely based on their quantitative and statistical literacy. The ability to interpret statistics critically and to refute claims is not innate. These skills need to be taught adequately if students are to become informed individuals (Sharma, 2017; Johannssen *et al.*, 2021). Statistical literacy is therefore a key competence that characterizes active and critical citizens in information-intensive societies (Gal, 2002).

The course of the pandemic has shown the importance of statistical literacy in a very wide range (Grawe, 2021). The bombardment of society with data, statistics, predictions and incredible claims with COVID-19 has provided the starkest evidence supporting this statement since it was written (Watson and Callingham, 2020). The necessity to increase statistical literacy of the average person has come to light in this pandemic. It means statistical literacy, that can be the key to a deeper understanding of all global issues, such as the COVID-19 pandemic. The basic problem is trust.

Well, the year 2022 is a time when an important part of society does not trust authorities, whether political or scientific. One can only feel trust in the people and things he understands. At the time of the pandemic, part of society is questioning scientific facts with its unprofessional views. Science and its results will be part of everyday life more and more. Failure to build enough trust in society can have catastrophic consequences. This is noticeable, for example, in the field of vaccination. Vaccine hesitancy is also associated with a structural crisis of confidence in science and technology (Verger and Dubé, 2020).

Today, science is increasingly based on large amounts of data. These data are statistically processed into a form based on which useful information and conclusions can be drawn. In a large part of society, the problem is that they do not understand the issues of data acquisition, processing, and statistical evaluation. This is a relatively measurable factor. We call it statistical literacy (focused mainly on reading graphs, etc.), or data literacy (Dekker, 2010). It focuses on the ability to recognize the need for data (Jarolímková, 2017), interpretation (and thus identification of misleading interpretation) of quantitative data, critical thinking, and understanding of numerical information and its representation. These two types of literacy suggest whether a person can read correctly, e.g. a graph that the politician shows and describes; interpretation of data on the current situation published in the media; or whether any statistical survey was conducted on a relevant sample of citizens. If a person cannot evaluate whether the media is telling him the truth and based on which they came to the given conclusion, he trusts or does not trust based on other factors such as simplicity of information, intensity (media noise), frequency of encountering information and so on.

This ‘data deluge' provides both opportunities and challenges. Good use of these data requires statistical literacy (Carter *et al.*, 2011). The question is whether this constant influx of statistical information on people, who usually cannot know them perfectly without much effort, will increase their ability to read graphs or statistical thinking.

The aim of this article is to verify through an experiment whether a pandemic with a continuous supply of statistical information has helped to enable university students to better evaluate statistical information and thus increase their statistical literacy. In the

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article, we also examine the impact of distance education on this form of literacy, as this form of teaching became a priority during a pandemic. The research was carried out on university students of computer science.

RELATED WORK

Several authors point out the problem of the need to increase statistical literacy. This fact is not mentioned only in the context of pandemic, but also for example, an awareness of the issue of global warming. Not only right and wrong solutions, 100% and 0%, effective and ineffective anti-pandemic measures, significant and negligible global warming. People should realize how a measure will or wouldn't help, which is largely related to the understanding of percentages, dependencies, and many other elements that we can put into statistical or data literacy (Murtugudde, 2019).

In 2020, Metzger et al. studied the role of statistical literacy in the interpretation COVID-19 related information, assessments of infection risk, and compliance with mobility restrictions. They hypothesized that more statistically literate people are more likely to understand the threats posed by COVID-19 and to adjust their behavior according to the actual risk of infection, based on the available information (Metzger, Paaso and Pursiainen, 2020). They used the Statistical Reasoning Assessment test (Garfield, 1998) on 4000 Dutch households. The results showed that respondents with higher statistical literacy generally considered influenza vaccination to be more important, potentially suggesting a more positive attitude towards COVID-19 vaccines as well.

The impact of data-oriented specialized teaching was also examined by Reichel and Munk (Reichel and Munk, 2016). Based on their analysis, it was proved that students focused on data analysis did not statistically significantly increase the ability to read graphs or overall statistical thinking.

If we look at the issue of statistical literacy analysis at universities, in order to produce statistically literate students with minimal misconceptions, the statistics module should be 'carefully' designed at the university level is not mentioned earlier classes. (Nikiforidou, Lekka and Pange, 2010).

Hahns-Vaughn et al. investigated by quasi-experiment and using a validated assessment tool (the Comprehensive Assessment of Outcomes in Statistics; CAOS) throughout the semester if statistical course length was related to statistical literacy. From their point of view, if other factors are constant, the format of provision is not related to statistical literacy for postgraduate students (Hahs-Vaughn *et al.*, 2017). This contradicts some existing research which show us that hybrid teaching is better than online (Means *et al.*, 2009).

MATERIALS AND METHODS

The task of the research was to find out whether there is a significant difference in statistical literacy between students in the period before the pandemic and the period after the pandemic began. From this research problem we developed the hypothesis:

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H: There is a significant difference between students' statistical literacy before a pandemic and after the start of a pandemic.

To verify this hypothesis, we used a dataset of student test results from 2013 to 2021. They are students of applied informatics at the University of Constantine the Philosopher in Nitra. The number of tested students was a total of 451. They were tested in classes Computer data analysis in the second year of bachelor's study when the impact of this course on students' statistical literacy was also analyzed (Reichel and Munk, 2016). Students were tested in the Virtual learning environment LMS Moodle.

The tests have been modified and supplemented over the years based on various factors such as test reliability (Reichel and Munk, 2014). Therefore, since each student did not answer every question from our question dataset, it was necessary to select the relevant subset from all the answers (student/question combination).

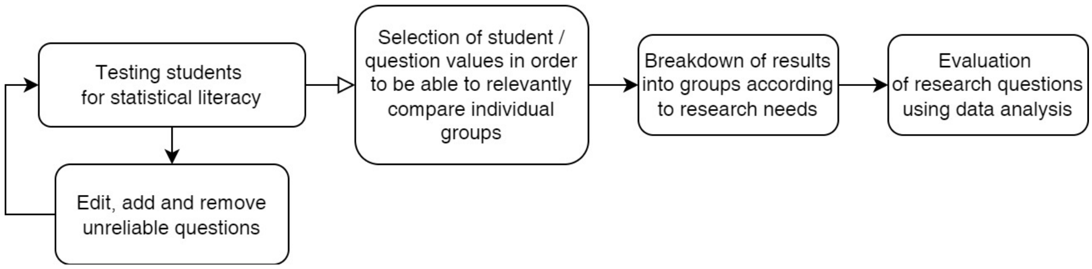

Figure 1: Scheme with methodical research procedure

Figure 1 describes the scheme of the use of tests in our research. Table 1 shows the base file before further processing, which contains 7351 records. The matrix contains a combination of variables:

- *Question* – the question identifier in our test question dataset;
- *Id_student* – the student id that was used as his unique identifier;
- *Value* – percentage evaluation of the correctness of the given answer to the given question;
- *Year* – the year in which the student passed the test, ie. in which year he answered the question.

Table 1: Preview of a basic set of questions and correctness of answers

Question	Id_student	Value	Year
q24	430	0	2021
q25	430	50	2021
q26	430	100	2021
q27	430	25	2021
q28	430	0	2021
q29	430	100	2021
q30	430	100	2021
q31	430	100	2021
q32	430	100	2021
q33	430	100	2021
q34	430	100	2021

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A total of 35 questions were used in the tests, but in comparison we only used the results of the answers to the questions answered by all the students studied. Therefore, we also had to reduce the total number of records from students (the total number of students tested was 451). We penetrated the questions and students that were answered from the entire testing period from 2013 to 2021 by the students. As a result, the answers from 2013 were dropped from the analysis, because after this year, the content of the tests changed significantly, and these data would not be relevant in the analysis.

There is a dataset in Table 2 that we further processed. Since the base dataset contained all the questions and all the students, in the matrix of Table 2 we filtered only the selected questions and the students who answered all the selected questions. Based on this selection, we calculated a Statistical Literacy Score (*Statistical_literacy*) for each student.

Each test question can be categorized into a specific area. In the context of perceiving the data associated with the pandemic, we consider the most necessary ability to interpret graphs that are presented to people by the media or politicians, or other authorities. We want to verify the status of this part of the statistical capabilities separately. Therefore, we divided the questions into 2 categories:

1. Understanding and interpretation of graphs - 8 questions (the score for this group of questions is represented by the variable *Graph_SL*);
2. Other areas of understanding statistical data (statistical thinking, critical thinking in the context of data, basic statistical concepts, probability, and calculation of percentages) - 7 questions (the score for this group of questions is represented by the variable *Other_SL*).

Based on this distribution, in addition to the total score (*Statistical_literacy*), we also calculated scores for questions focused on reading and interpreting graphs (*Graph_SL*) and other statistically focused questions (*Other_SL*).

Table 2 also contains information about the year the student answered the question (*Year*). From this data, we also generated the variables Period (*Before* - pandemic testing, *After* - testing after the start of a pandemic) and *Year_period* (for a clearer comparison, we combined the results of 2 consecutive years in Figure 5). Table 2 also shows how 15 questions were evaluated, from which the other variables expressing the scores were calculated.

Table 2: Preview of the dataset, which we further processed.

Id_student	q10g	…	q30	Statistical _literacy	Graph _SL	Other _SL	Year	Period	Year_ period
179	100	…	100	87.74	77.07	99.94	2016	Before	16/17
181	66.66	…	0	84.37	83.25	85.66	2016	Before	16/17
27	66.66	…	0	79.92	74.89	85.66	2014	Before	14/15
432	66.66	…	0	66.59	74.89	57.10	2021	After	After
207	0	…	100	65.52	60.39	71.39	2016	Before	16/17
65	66.66	…	0	65.50	72.85	57.10	2014	Before	14/15
441	66.66	…	50	65.50	60.34	71.38	2021	After	After

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RESULTS

To compare the levels of statistical literacy of these two groups (*Before*, *After*), it is necessary to test whether there is a statistically significant difference between these values. For the mathematical formulation H0, we will formulate it at this point as follows.

H0: There is no statistically significant difference in the Statistical_literacy variable between the Before and After groups of the Period variable.

For further analysis, it is useful to verify that the variables *Statistical_literacy*, *Graph_SL,* and *Other_SL* have a normal distribution. Based on this, it is possible to determine whether to use parametric or non-parametric methods in the analysis. We will use Kolmogorov-Smirnov, Lilliefors test, and histogram plotting.

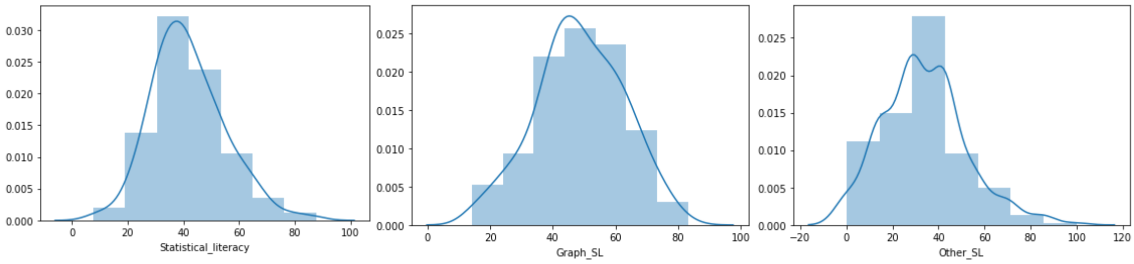

Figure 2: Histograms visualizing the distributions of the variables *Statistical_literacy*, *Graph_SL* and *Other_SL*

Based on the histograms in Figure 2, all three variables appear to have a normal distribution. The results of the normality tests were as follows:

- Statistical_literacy – K-S $D(271) = 0.07$, $p < .15$; Lilliefors $p < .01$
- Graph_SL – K-S $D(271) = 0.04$, $p > .20$; Lilliefors $p > .20$
- Other_SL – K-S $D(271) = 0.12$, $p < .01$; Lilliefors $p < .01$

Normality tests show that the variable *Graph_SL* has a normal distribution and *Other_SL* does not follow a normal distribution. However, as this is a larger sample (more than 30 records) (Hogg, Tanis and Zimmerman, 1977), we can work with the data as if it had a normal distribution.

To verify whether these groups can be analyzed together, we used correlation analysis to determine whether these groups of questions (or the skills they verify) are interdependent. We used Pearson's correlation coefficient, which is a parametric method. The result is $r(271) = .37$, $p < .001$ (Figure 3). It means that there is a statistically significant dependence between the groups and therefore it is possible to analyze the *Statistical_literacy* variable separately.

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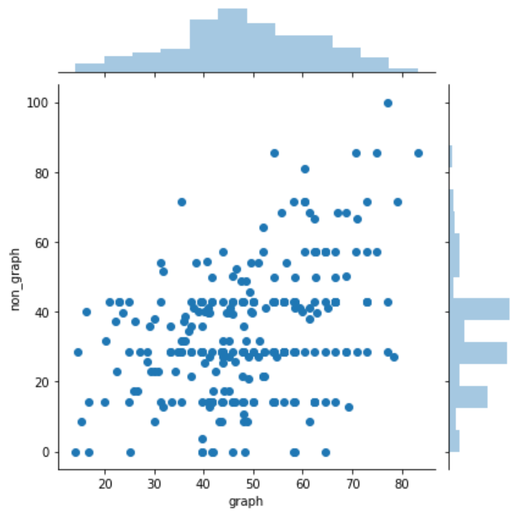

Figure 3: Visualization of dependence of variables *Graph_SL* and *Other_SL*

Using the above results, we can proceed to verify hypothesis H0. Since we have more than 30 records, we can use the parametric method. We will use a t-test for independent variables. We used TIBCO Statistica statistical software for evaluation. We also compared the groups *Before* and *After* for the variables *Graph_SL* and *Other_SL*.

Table 3: T-test results for two independent variables (*Statistical_literacy*, *Graph_SL*, *Other_SL*)

	Mean Before	Mean After	t-value	df	p	Valid N Before	Valid N After	Std.Dev. Before	Std.Dev. After
Graph _SL	51.16	43.04	-4.588	269	0.000	185	86	13.329	14.089
Other _SL	34.98	31.14	-1.615	269	0.107	185	86	18.921	16.431
Statistical _literacy	43.61	37.49	-3.604	269	0.000	185	86	13.161	12.695

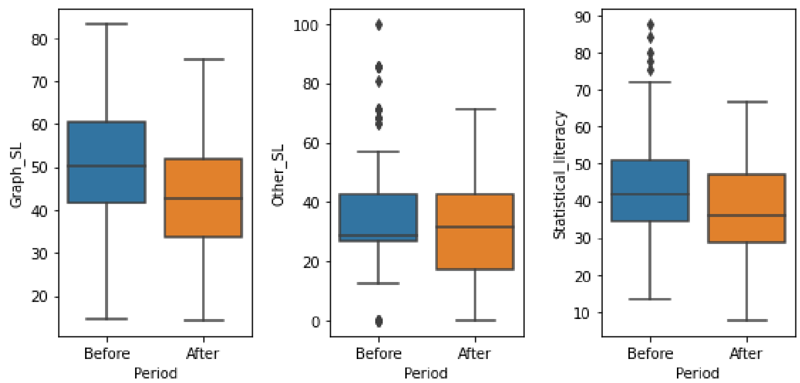

Figure 4: Visualization of differences between *Before* and *After* groups in variables *Graph_SL*, *Other_SL* a *Statistical_literacy*

From the above results (Table 3) a statistically significant difference between the *Before* and *After* groups in the variables *Statistical_literacy* and *Graph_SL* is evident (Figure 4). In contrast, there is no difference in students' performance in questions focused on statistical areas other than graph comprehension. Based on the results, we reject H0, which

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means that there is a statistically significant difference between the *Before* and *After* groups in the *Statistical_literacy* variable. Based on the results, we can also say that the *Statistical_literacy* variable acquired higher values in the period before the pandemic (*Before*). Questions from the *Other_SL* area also included questions focused on terminology. It can be assumed that this area has not worsened for students due to statistical information from the media. Many terms that people do not commonly encounter have become a common part of life. Despite the lack of a clear understanding of the context, a better understanding of terminology is a relatively expected outcome (Watson, 1998).

For a better overview, we have divided the variable *Before* into smaller periods (2 years) in the variable *Year_period*. Based on this, we can see the development of statistical literacy of computer science students over the years (*After* contains the years 2020 and 2021) (Figure 5).

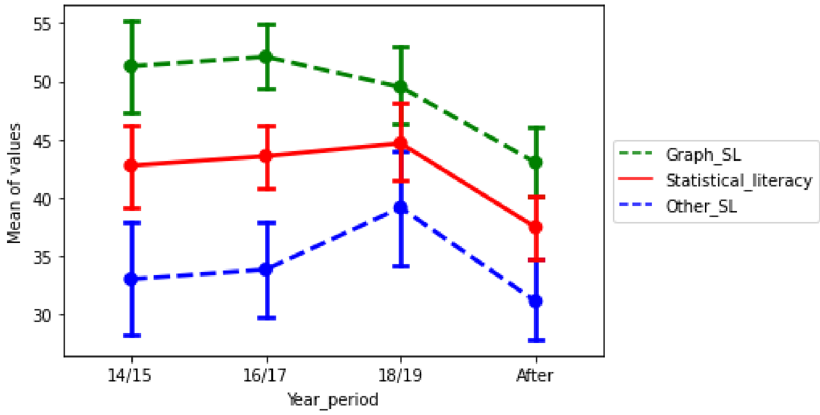

Figure 5: Visualization of statistical literacy over the years.

CONCLUSIONS

The pandemic highlighted the necessity to understand the amount of data and the statistical conclusions drawn from them. The beginning of the pandemic also started a huge supply of statistical information, especially graphs, which are interpreted by professional or non-professional authorities. The low statistical literacy of the addressees of these interpretations can lead to incorrect conclusions and incorrect decisions. It is very necessary to think about how society is prepared for the daily chart reading. Their correct understanding significantly affects their lives, but also their community.

A simple assumption is that if people (such as college students) often come across statistical information, they will begin to understand it better, because they are forced. In this article, we tested the hypothesis which means a significant difference between the statistical literacy of university students before and after the beginning of the pandemic. We have used tests since 2014 (tests from 2013 have been removed from the analysis). Therefore, we had to reduce the number of questions used in the analysis and also the number of students who had the opportunity to answer each question with one of the selected subset of questions. Using the analysis, we compared the results and concluded that there is a statistically significant difference between students' statistical literacy before and after the beginning of the pandemic. Surprisingly, according to the results, statistical literacy tended to fall from an average of 51.16 to 43.04, evaluating the same subset of

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questions. If we looked at the areas of "understanding graphs" and "other areas of statistical literacy", a statistically significant difference was not confirmed for "others" and the decrease in statistical literacy was mainly reflected in the ability to read and interpret graphs (Figure 4).

The results show us that the pandemic has reduced the students' statistical literacy. During the pandemic, university teaching was mainly in the distance form. We assume that this fact has negatively affected the ability to read and understand the graph correctly. In contrast, students' statistical literacy in other areas did not decrease significantly. We attribute this to the fact that, even though a large amount of statistical information did not help to better understand the graphs, the daily encounter with this type of information in students promoted terminological knowledge in the field of statistics.

Understanding the statistical information on which all scientific progress is based is an important factor in promoting general confidence in science. This need became very clear in society during the pandemic. It is the huge influx of this type of information that people seem to be reluctant to understand, which may be another cause of our research. Further research and popularization in this area are therefore necessary.

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Analysis of Problem Parts in Educational Tutorials for Blender

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Abstract

During the past two years we were facing COVID-19 pandemic which changed our lives a lot. It also forced educational system to online format. It brought us more demanding explanation of the curriculum and many unexpected technical problems. Online explanation of the individual functions of Blender, software for making 3D graphics, is very challenging for students, who were not using this software before. We found out that this could be fixed by making video tutorials, which are uploaded as unlisted on YouTube platform. All participants who attended online classes were watching these educational videos during lessons under the supervision of the teacher on their own devices separately. Students often use these video materials multiple times during the semester to review the curriculum. The aim of this paper is to focus on problematic parts of these video tutorials, when students had to pause, rewind or slow them down to understand 3D modelling as good as possible to complete the assignment. YouTube allows their creators to see statistics of their uploaded videos. We will use these data for to improve next educational tutorials for Blender software. In this article, we are introducing a simple analysis of the variable Absolute audience retention. With this variable we are able to know how many time our viewers spent on certain part of the video by pausing it, rewinding or slowing it down. In this article, we will try to find out which parts of the prepared videos are most often viewed by students. From the results, we can find out which functions of the Blender software caused the students problems, or which part was often replayed.

Keywords

Blender, 3D graphics, Video tutorials, YouTube Analytics.

INTRODUCTION

The Covid-19 pandemic has brought a dynamic changes in the global education system. The imposition of lockdowns resulted in the closure of physical classrooms, and online education became the new normal. While it is not a new phenomenon, its importance came to light after the pandemic. It has managed to keep education alive during these times, but it cannot completely replace the peer-to-peer education (Aslan, 2021).

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One of the best advantages of online classes is their accessibility from anywhere around the world. Students can simply log in to their online courses from anywhere. Here, they have access to learning materials from the convenience of their home (Craig and Friehs, 2013).

Synchronous online courses are constantly challenged by technical issues. Access to appropriate electronic devices, such as webcams, microphones, headphones, computers and a proper internet connection are mandatory requirements for online courses (Blummer and Kritskaya, 2009). Additionally, technical issues such as slow internet connections or lack of suitable technical infrastructure can also affect seamless learning (Yuda Handaya *et al.*, 2021). That is the main reason why we focused on asynchronous online class. Those are rarely threatened by technical issues. Students attended online lecture with a teacher, but they continued their lessons individually on their own devices, watching pre-recorded tutorial video. In case of any problem, teacher was able to help, explain and discuss it with the students.

We have decided to completely change the available online course focused on 3D graphics, where we have been working with students in the open-source software called Blender. We have only changed the original assignments in detail for the actual version for this software. At the time of writing this article, the Blender software version is 3.1 (Blender, 2022). The course is aimed at beginners and is divided into 10 lessons. In each lesson there is an accessible tutorial video and an assignment.

In this article, we will see which parts of the prepared videos are viewed by students the most.We can determine which functions of the Blender software caused problems for them or which part was often replayed based on the results.

METHODOLOGY

Video contents

Each video focuses on different parts of Blender, the first was an introduction, where we described the UI of the program and learn how to use its basic functions. In the second we described adding different shaders to an object. In the following lessons, we have been working more with the objects, adding the environment and learned how to create animations or import objects.

Each video has been edited, added with graphic shapes, text and spoken word via Camtasia Studio. The reason of using this software was that nor only it allows us to edit videos easily, but also record our screen with commentary.

Sections

Every video was divided to 12 sections for the sake of clarity. For every video, there was always a section at the beginning called *Introduction*, when the teacher was welcoming the students and approached next content in the video.

Most common section was *Explaining the topic*, when teacher was explaining the process of modifying objects on the screen or was speaking about certain problem about the curriculum. Frequent sections like *Preparing the object, Modeling the object, Preparing the world enviroment, Adding new material, Changing material properties, Setting up the camera* and *Adjusting light* were just describing what exactly we were doing in the Blender

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at that time. Section *Importing* gave students details of the import of textures, models and shaders.

An important part of each lesson was the result of the render, which is not possible in offline teaching with more complex assignments as we did not had the necessary hardware in the assigned classroom. It was recommended by teacher to render in the *Cycles engine* for the best possible rendering quality, such as object illumination, shading or transparency of the object (Koteswara Rao *et al.*, 2021). There is also another render engine called *EEVEE,* which use cheaper, faster, less accurate calculation to shadows and reflections to cut down render times. But *EEVEE* cannot simulate light rays unlike *Cycles* and the final result often distorts the material of the object and also its reflection or shadow (Koteswara Rao *et al.*, 2021). Most of the students, who were enrolled in course, own the recommended technology for *Cycles engine* and mostly they submitted their assignments after the class at home. Not every assignment was needed to be done in Cycles. this was resolved in *Render* section.

At the end, there was a *Conclusion* section at the end of each video. This section was summarizing the video content with a reminder from teacher about the assignment.

Participants

A total of 42 students were enrolled in our course, whose previous experience with Blender was at the level of beginner to intermediate. All of them had to watch every video to complete assignments in the course.

Video statistics

It is important to make the tutorial video not only instructional, but also interesting to watch. Bunce, Flens and Neiles (2010) analyzed student's attention while watching a video. Their results revealed that students' attention alternates between being engaged and non-engaged in very cycles of 4 or 5 minutes. They also looked at the length of time students spent on a video and whether students attempted an assessment problem at the end of the video. Results are that shorter videos had the most significant engagement. Also, Staziaki et al. (2021) investigated technical aspects and best practices of creating educational content on YouTube. Among other aspects, the optimal video length was discussed in their paper, but there was no evidence found on optimal video length for lectures.

Based on these results, we tried our best to make tutorial videos as short as possible, with every information needed. We wanted to motivate our students to watch every video till the end. If the videos did not go through the editing process, their average length would be 28 minutes. We were able to halve the lenght of the videos by editing them to (mean) 14 minutes (Table 1).

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Table 10: Comparision of video lengths (edited and original) and their difference

	Video length after editing in seconds	Full length in seconds	Diff	Diff in %
Video 1	1164	2688	1524	56.7
Video 2	410	467	57	12.2
Video 3	1073	2552	1479	58
Video 4	1019	1597	578	36.2
Video 5	637	1382	745	53.9
Video 6	770	1518	748	49.3
Mean	845.5	1700.7	855.2	44.4
Sum	5073	10204	5131	266.3
Min	410	467	57	12.2
Max	1164	2688	1524	58

Data collection and analysis

Every tutorial video we made was uploaded on very popular video-sharing platform, YouTube (Kemp, 2022). It is free to use and it allows its viewers to stop the video, speed up or slow down any video. Users can post comments under the video or show satisfaction by liking or disliking it. It also offers easy sharing between users on any social media websites.

For content creators, it is also possible for them to see their video statistics in the YouTube Analytics section (Kadoic and Oreski, 2021). Here are many metrics which matters for us.

Our videos were uploaded as *Unlisted*, that means they are not available for public, only via URL link. This link was available for students in online course.

We focused on Audience retention, which shows us the percentage of viewers watching and leaving the video at each moment. YouTube elevates videos with strong audience retention their search rankings and suggestions because these can effectively capture viewers' attention (Oppl *et al.*, 2019).

In the analytics report for audience retention, there are two graphs available:

- Absolute audience retention,
- Relative audience retention.

We will work with the Absolute audience retention (AAR). With this variable we are able to know that our viewers spent some time on certain part of the video by pausing it, rewinding, slowing down. Relative audience retention is not important for us as it shows how well our video retains viewers by comparing to all other YouTube videos of similar length (Altman and Jiménez, 2019).

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RESULTS AND DISCUSSION

The variable AAR (Absolute audience retention) is collected for every smaller part of the video. Every examined video is divided into 100 parts. The length of each part is the same and depends on the total length of the video.

The value of AAR was determined for each of the 100 parts of the video. For the first video, we can visualize its value similarly as in the graph (Figure 26). The visualization shows which parts of the video were students returning to.

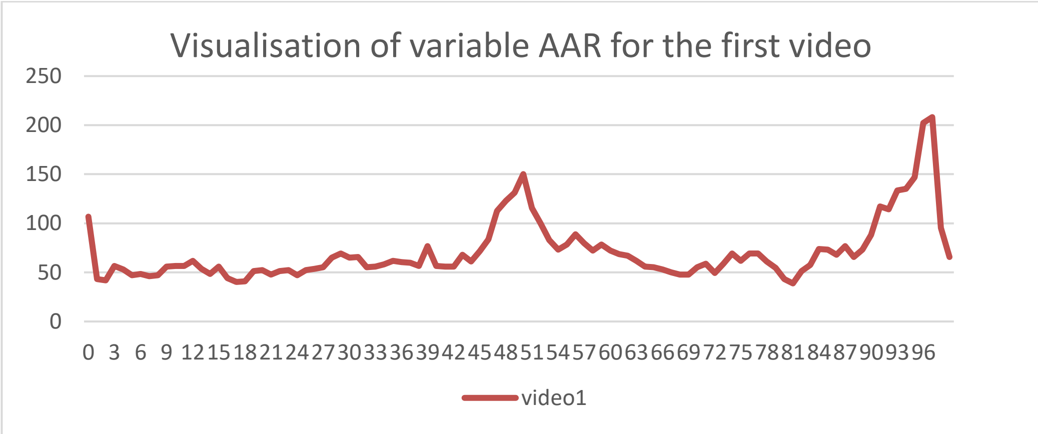

Figure 27: Visualisation of variable AAR for the first video

We can get more interesting results after annotating individual parts of the video (Figure 28).

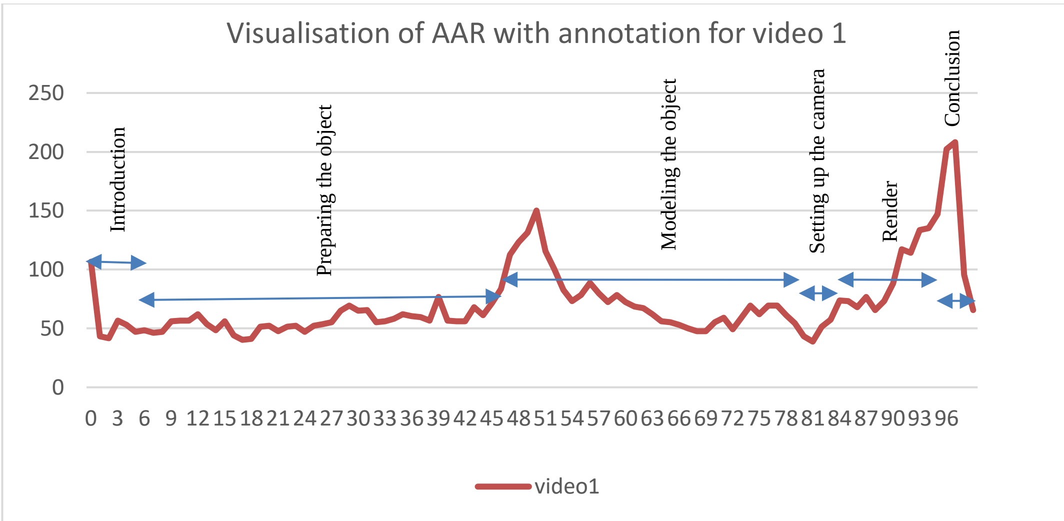

Figure 29: Visualisation of AAR with annotation for video 1

By this way, we annotated all 6 videos. For all videos, we created 12 categories and assigned one to each part of the video that relates to that part. Subsequently, we examined the values of the AAR variable for each category.

The following table (Table 2) shows the values of the basic statistics for the AAR variable in all videos examined.

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Table 11: Descriptive statistics for variable AAR for all groups

	Valid N	Mean	Median	Minimum	Maximum	Lower	Upper	Std.Dev.	Skewness
AAR	600	69.42093	66.67000	25.68000	208.2100	56.01500	81.18000	23.19922	1.241456

The basic statistics for the values of AAR variable for each category are given in the table (Table 3). The sum of Valid N represents a value of 600, i.e. 100 sections for 6 videos.

Table 3: Descriptive statistics for AAR for separate groups (based on content)

AAR for group	Valid N	Mean	Median	Minimum	Maximum	Lower	Upper	Std. Dev.	Skewness
Introduction	30	69.79	61.54	41.79	117.57	52.99	83.33	23.71	0.93
Explaining the topic	92	57.75	56.72	27.27	96.47	48.50	64.93	15.53	0.28
Preparing the object	135	72.00	68.18	31.82	134.83	57.58	84.71	20.51	0.89
Modeling the object	80	77.87	72.39	27.27	208.21	54.85	92.16	36.04	1.22
Setting up the camera	36	63.83	63.16	43.86	122.47	56.14	69.30	14.61	2.09
Render	32	71.96	71.88	36.36	112.16	60.53	79.06	17.09	0.23
Conclusion	30	52.77	49.88	25.68	95.52	37.88	66.22	17.44	0.52
Adjusting light	33	65.92	61.40	50.88	95.95	59.65	70.27	11.43	1.15
Adding new material	28	83.20	85.88	60.61	115.15	74.90	92.16	12.52	0.09
Changing material properties	74	73.06	76.36	31.82	162.35	54.05	87.84	26.89	0.48
Preparing the world enviroment	17	77.79	77.65	56.47	95.29	71.76	84.71	9.95	-0.03
Import	13	67.60	67.06	58.82	78.82	63.53	70.59	5.43	0.47

Box plot showing *variation ranges*, *quartile ranges* and the *median* of the ARR variable for all categories in all videos shown in the graph (Figure 30). The largest amount of re-watched content was observed in the categories *Adding new material*, *Changing material properties* and *Preparing the world environment*. These were the most repeated categories by the students. The lowest median was tracked for the *Explaining the topic* category. This result is also a test of our approach correctness. It is obvious that *Explaining the topic* does not belong to the difficult parts to understand in terms of content. Therefore, there is no need to repeat this content.

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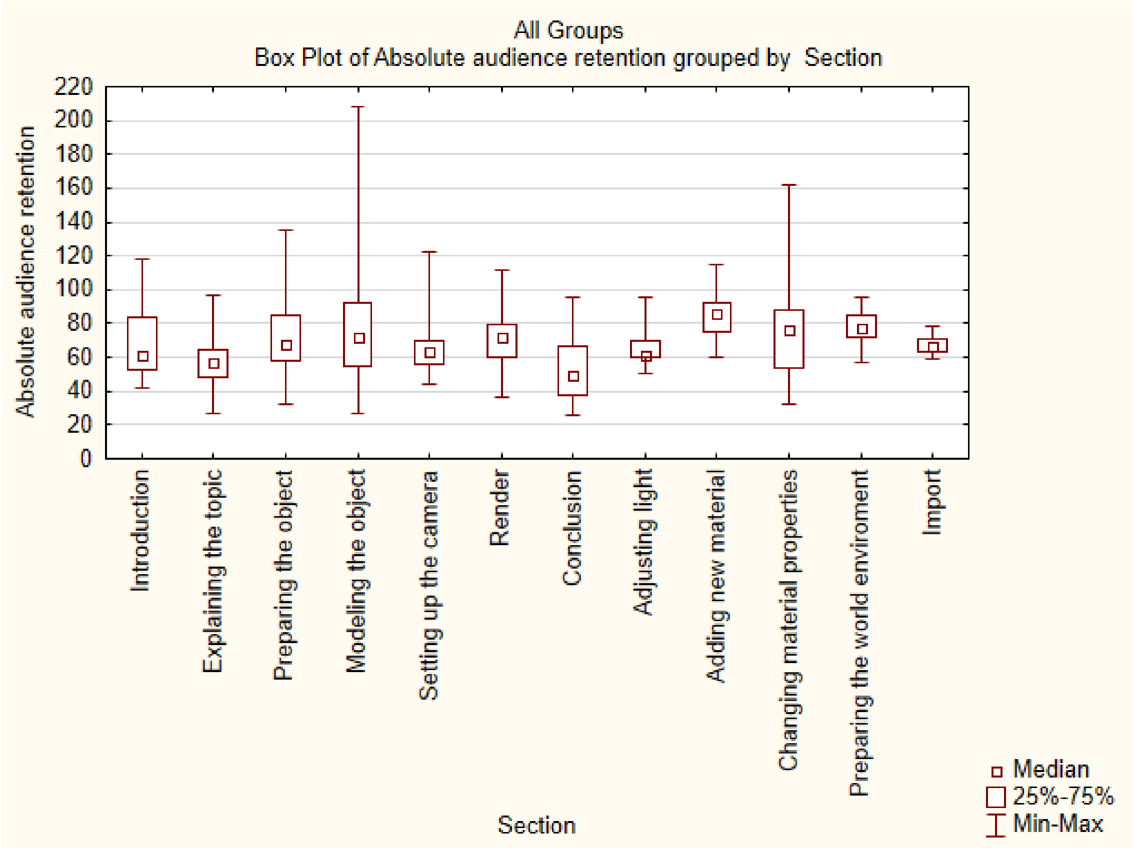

Figure 31: Box plot of AAR in each category

The largest *variation range* was recorded in the categories *Modeling the object* and *Changing material properties*. Large maximum values were also recorded for these two categories. This means there was various rate of return in them. We assume that student's experiences in these areas are different, i.e. for this reason, there was also a different need to return for educational content in these categories. The box plot of the AAR variable in each category for every video is captured by the individual graphs (Figure 4).

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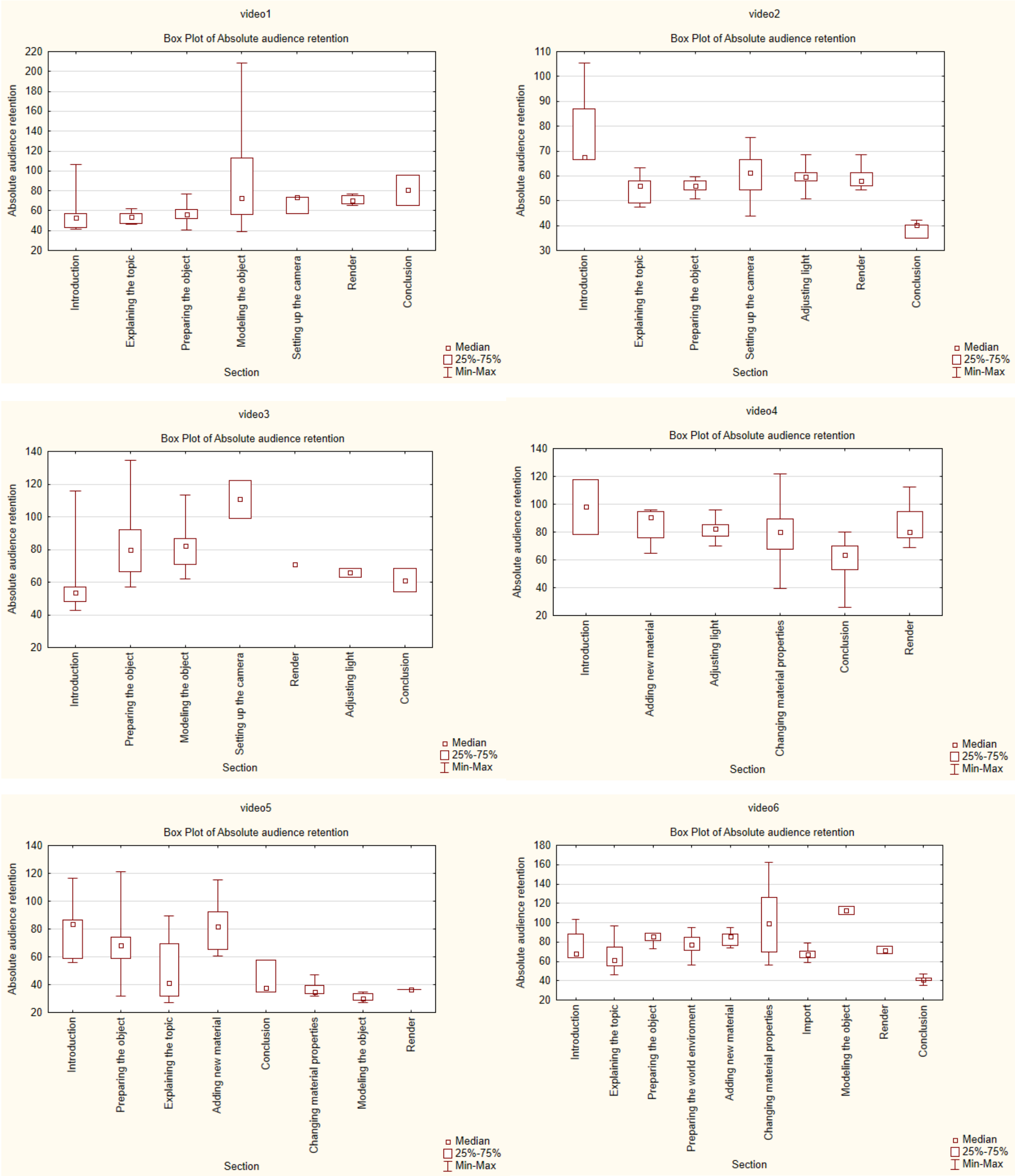

Figure 4: Box plots of AAR in each category for every video.

AAR analysis can help creators of educational videos to identify problematic parts of educational content. However, we cannot assume there were problematic parts only. Students could find these specific parts interesting and that may be reason for re-watch. In this way, the categories with the most return in each video were identified. In the first video it was *Conclusion* and *Modeling the object*, in the second video it was *Introduction* and *Setting up the camera*, in video 3 also *Setting up the camera*, in video 4 *Introduction* and *Adding new material*, in video 5 it was *Introduction*, *Adding new material* and the last video was in the *Modeling the object category.*

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CONCLUSION

In this article we described the possibility of analysing educational videos. We used the variable AAR, which is represented as Absolute audience retention. It is a percentage representing the amount of time people spend consuming video. This variable is mainly used to rank websites for SEO on platforms like YouTube. In our article, we used this variable to evaluate problematic parts of educational content.

It is obvious that we could use more appropriate variables for counting each watched second by visitors. However, this is possible, if the videos are on their own technologies and servers. Due to the higher costs and potential technical issues with custom solutions, YouTube is currently popular among teachers. And the AAR variable can be exported directly from YouTube.

By a simple statistical analysis of the AAR, we can find out which parts of the education content the students returned to. The interpretation of the AAR analysis already needs to be done together by the teachers, the video editors. They can evaluate the parts to which students often returned as interesting content or problematic content that is difficult for students. It is up to the video creators to remake or add such information to this content.

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