



DiVAi 2020

13th International Scientific Conference on Distance Learning in Applied Informatics

Conference proceedings

September 21 - 23, 2020

Štúrovo, Slovakia



Wolters Kluwer

Constantine the Philosopher University in Nitra
Faculty of Natural Sciences
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and

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

DIVAI 2020

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Preface

Dear readers!

Sixteen 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 into the teaching of informatics subjects. 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 Czech Republic started to use these tools and created educational environments 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 13th year we are going to welcome participants from Ukraine, Russia, Kazakhstan and other countries. The conference and the university education have one thing in common and that is utilization of services and tools of Internet, thus eliminating barriers for 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 of 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 WoS Thomson Reuters for 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 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 an 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 preparation and during the course of the DIVAI 2020 conference and editing of the final publication, which will be sent for indexing to the Thomson Reuters' WoS database. We believe that the publication will be positively accepted not only by the readers, but also by the evaluators from the Thomson Reuters publishing house.

Milan Turčáni
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Gamification in the Education of Hotel Management Pedagogy

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Abstract

There is growing emphasis on teachers in passing knowledge and experience to students because students expect more interaction and communication in the online world.. Currently, there are many schools and educational institutions around the world providing the opportunity to attend part of the training courses using simulation games. Possibilities of simulators will be described in this article.

Keywords

Application; blended learning; e-learning; education; game; process; simulation; smart device..

INTRODUCTION

Simulation game is a technology that enables a user to interact with a simulated environment. Simulation technologies create the illusion of the real world. It is a visual, auditory, tactile or other experience creating a subjective impression of reality using computer imaging equipment. Special audio-visual helmets, glasses, motion sensing, and stimulating touch or other techniques evoking perception and sensation are utilized.

Simulators are a standard part of training for a variety of jobs, including military strategic and tactical command operations, managerial decision-making, or nuclear power plant operation. The area where simulators are likely to have the most significant impact on training is aviation, which has been using flight simulators for over 60 years. (Scerbo et al, 2006)

There is a rising emphasis on teachers in passing their knowledge and experience to students to get students more engaged into the process of education. Current students expect more interaction and communication in the online world. (Oblinger, 2003)

The computer simulation is perceived as predominantly perceptual stimuli that allow the user to manipulate the elements of the model world and create a sense of realism. These simulations are now used in many industries, whether it's the business sector or the activities of different organizations. (Han, 2017) Simulators offer a number of benefits and are increasingly used, for example, in medical education and medical skills training that require physical action.

SIMULATION GAMES

Computer games and simulations are used at all levels of education. Most of the educational games are trying to introduce students to new knowledge and helps them acquire and improve their skills and abilities. (Bouki, Mentzelopoulos & Protopsaltis, 2011).

Perkins (2007) defined the simulations as "imitating any real thing, state or process". One of the first examples of simulation is building a chess game of soldiers in the sixth century. (Harris, 1992)

Modern simulation has come a long way in the first half of the century, but there are still numerous obstacles to its use in education. Costs of equipment, personnel and programs were only recently overcome by extending large collaborative simulation centers. These partnerships support projects for enhancing multidisciplinary, interdisciplinary and multimodal simulation training. (Rosen, 2008)

In medical education, physical models of anatomy and disease were created long before the advent of modern computers. The representation of medical symptoms in the literature can be presented as a precursor to non-technical simulation. (Rosen, 2008)

The introduction of human patient simulation towards the end of the 20th century was an important step in the development of the whole medicine. Innovations in flight simulation, technology and plastics were the basic precursors of medical simulation. Computers facilitated the mathematical description and design of virtual worlds.

Another possibility of using the simulation games is in the field of management. The simulation should provide managerial experience in accounting, problem solving and decision making.

Scope and possibilities of these specific applications will be demonstrated on practical examples.

USE OF THE SIMULATORS IN TEACHING DOCTORS

Many types of simulators are used in health care. There are, for example, scenario-driven simulators. These simulators are based on a branched algorithm that reacts to inputs (entered requirements for examination) and, according to a predetermined procedure, they change the variables to output and displays the results of examinations. The disadvantage of these procedures is the high demands on scenario processing, which must be prepared by experienced doctors. (Kofránek & Kulhanek, 2014)

Another example includes model-driven simulators. These simulators operate on the principle of mathematical and physiological models. The scenario consists in setting the input data and the model variables.

Medical simulators with a robotized patient dummy are very close to reality. In their case, the algorithm performs outputs (gives the results of the examination, controls the parameters of the dummy detectable by visual or physical examination) according to the entered inputs (requirements for examination or administration of appropriate drugs).

An example of such a simulator is METI BabySIM, which teaches practical resuscitation skills. METI BabySIM is an advanced physiology simulator for advanced simulation training

that has eyes that blink, variable pupil size, crying, tears and secretions from ears, eyes and mouth, as well as the ability to bulge fontanel (Radu, Catalina & Doru, 2018).

The results of the study suggest the use of the simulator significantly increased the knowledge of neonatal resuscitation. A group of 500 professionals (323 nurses and 177 doctors) who completed the course showed a significant improvement ($p < 0.001$) after training. Neonatal resuscitation training significantly improved cognitive knowledge of all health groups.

An Austrian joint arthroscopy study indicates that interest in simulator training is increasing. This is primarily to avoid common mistakes and ensure patient safety. (Dammerer et al, 2018) The aim of this study is to analyse the learning curve of medical students and orthopedic surgeons using the virtual knee arthroscopy simulator.

In recent years, there has been a dramatic increase in the use of anaesthesia simulators. Computer simulators are currently used for teaching courses ranging from basic instructions of non-anaesthesiologists to more complicated anaesthesiology of crisis situations.

Another study conducted in Santa Monica, USA, observes the effectiveness of the virtual reality simulator for phlebotomy training. Phlebotomy, or blood collection, is one of the most common medical procedures. So far, there have been no universal standards for student education and performance evaluation. The absence of any standards can lead to injuries and inaccurate results if the procedure is incorrectly performed. (Scerbo et al, 2006) The AccuTouch simulates a needle and allows students to experience the resistance forces associated with insert-ing the needle into the skin and vein.

USE OF THE SIMULATION GAMES IN HOTEL MANAGEMENT EDUCATION

As in many other areas, the simulators can also be used in the field of hotel management education.

Cesin Hospitality - Simulation of hotel and restaurant management

The aim of simulation game is to improve the business skills of students in the hotel business. It is used primarily by universities in tourism and hospitality programs.

The goal is to achieve success within teams. The game is focused on the management of operating profit, net profit, return on assets and cash flows. The simulation includes major hotel industry specific situations. The game develops participants' ability to identify, analyse, and influence key operational processes that affect hotel and restaurant operations in a competitive environment. (CESIM, 2018)

Virtual Business Hotel

Virtual Business Hotel is a game that allows students to take control of a complete hotel. This simulation of hotel processes is focused mainly on modelling the internal functioning of the hotel. The game includes price and revenue management, marketing, customer service (reception), social media feedback, restaurant management, gastronomy, cleaning and financial reports (Knowledge matters, 2018).

HOTS – hotel simulation

Another representative of the interactive game is the HOTS hotel simulation based on the management of a large hotel. Players control a virtual environment reflecting the real world. Performances in the hotel's Hots simulation can be targeted at different educational goals, which include, for example: strategic management, finance, risk management, social media, revenue management, and many others (Russel, 2017)

This hotel simulation is often used as part of management training and team training activities. Companies use it as part of learning and development activities.

Hotel Giant

This game specializes more in designing and simulating hotel environment, less in complex hotel operation.

The architecture is fully up to the player. Users can really arrange everything from common rooms, Internet cafes, bars, swimming pools to the detailed design of the room equipment. After opening the hotel the player just follows the wishes and complaints of guests and accommodates them. (Dobrovsky, 2002)

PROTUR HOTEL SIMULATOR

The application PROTUR is developed by the authors' team for training students of the hotel school and hotel staff.

The following diagram schematically captures the frame algorithm simulator.

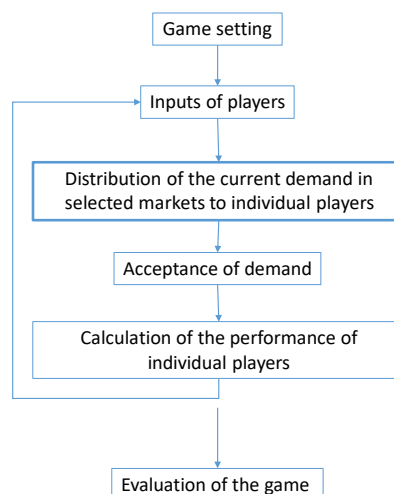


Figure 1: Frame algorithm.

The simulator is prepared in two basic modes. In the case of on-line mode, players compete with each other on the market for current demand and players also control the operating side of the hotel.

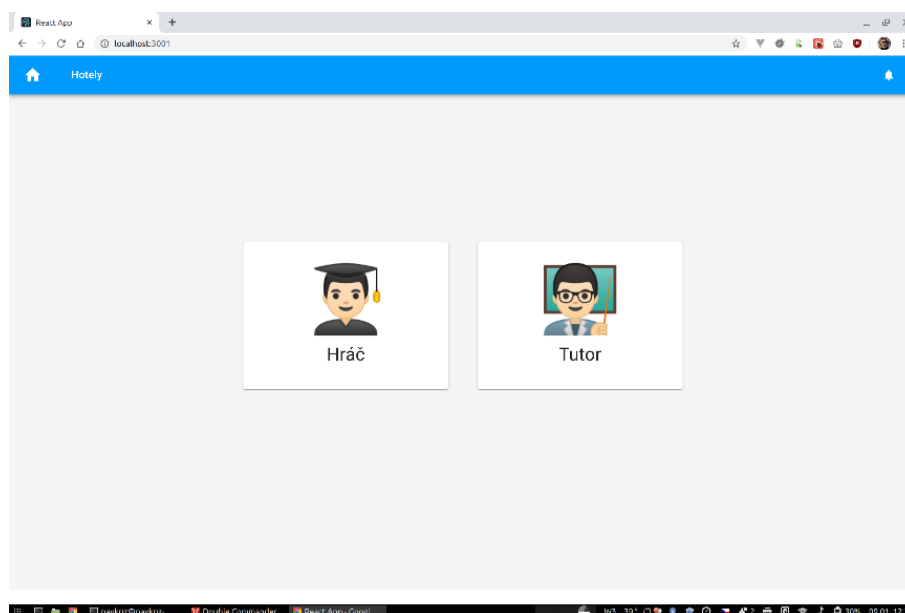


Figure 2: Start screen - select a mode

In the off-line mode, players do not compete with each other in the markets, every-one has the full amount of demand regardless of the games of the others, and as for the hotel's operational side, it is firmly assigned by the game manager. In this case, players decide only in revenue management processes.

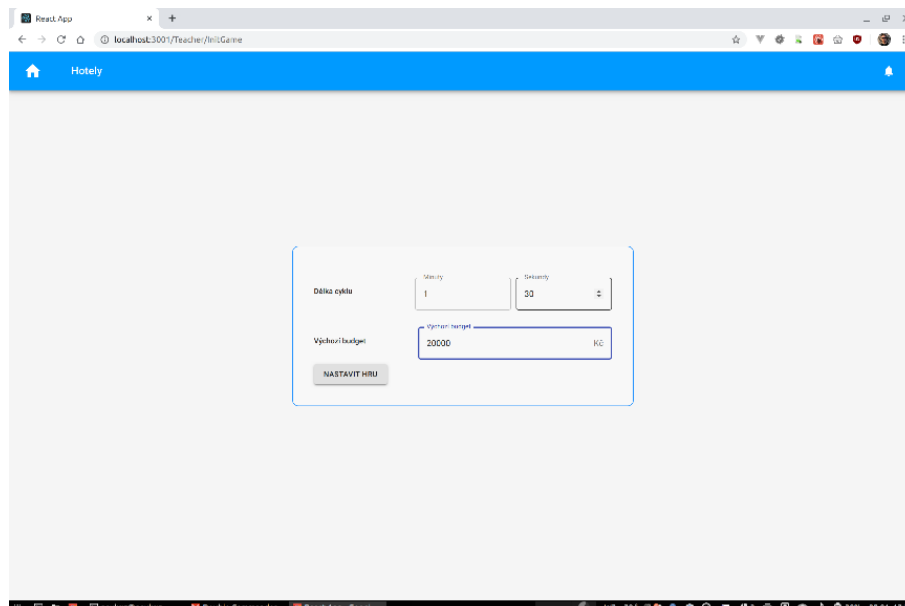


Figure 3: Setting the simulation parameters

The hotel process simulator uses the following technologies:

- typescript
- javascript
- react

- component for the table in the frontend section
- JSON for data manipulation

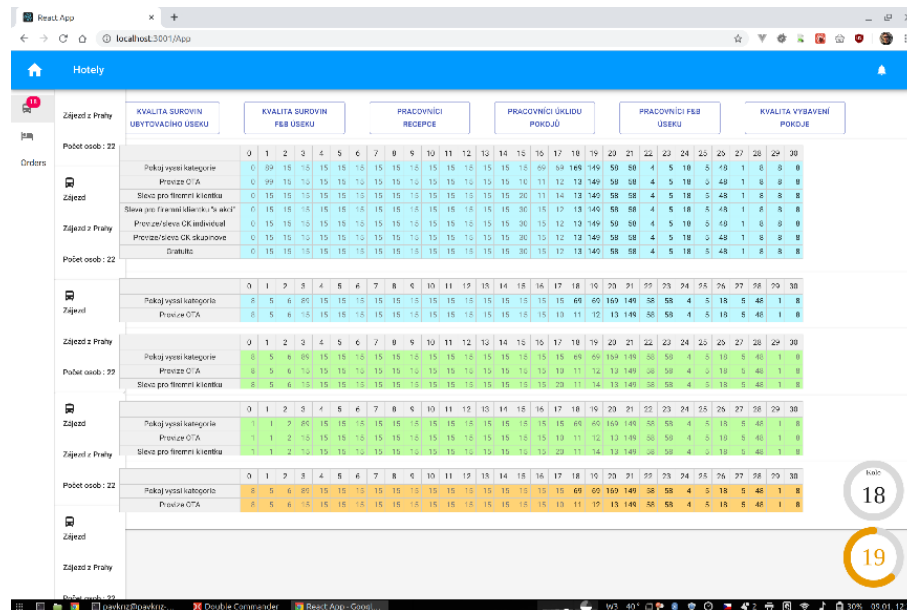


Figure 4: Basic game screen

The current pilot version of the hotel process simulator allows the following activities:

- set the initial game parameters of the simulation
- start the simulation (game)
- time the simulation, i.e. counting the time for each game round
- generate random bids - a temporary solution before the demand distribution model is implemented

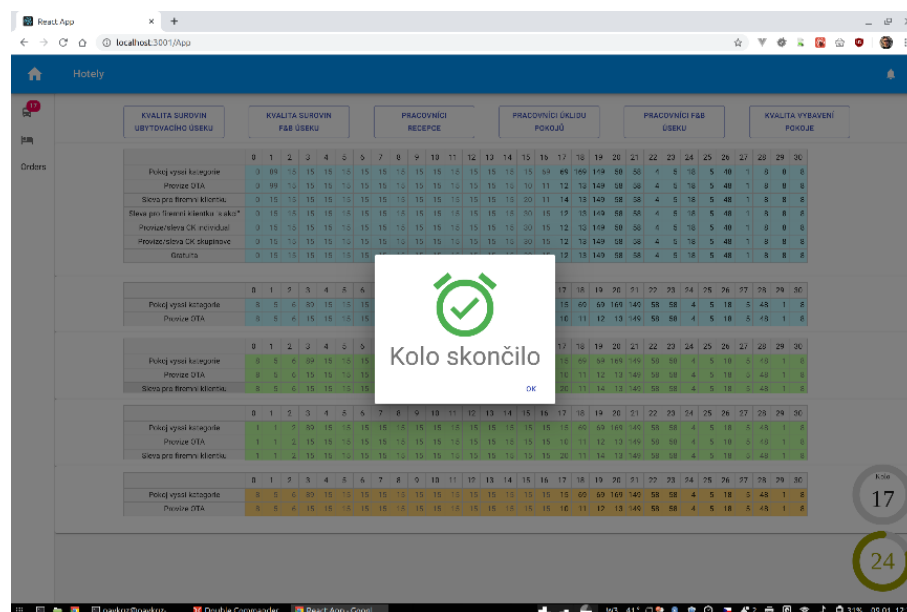


Figure 5: Simulation process

CONCLUSION

Hotel simulators offer excellent tools that can be used in educational activities. The aim is to provide students with a gentle and playful way technique enabling them understand the basic principles and improve their decision making skills.

Currently there are on the market a large number of all kinds of games that relate to the hotel industry. Development of the game market constantly moves forward, it is important to be able to accept and work with new information. Automated world forces us to invent new innovations that ultimately make life easier for us.

Augmented reality has emerged as an important concept in the hotel industry in recent years by enabling hotels and other related businesses to improve the physical environment they sell or improve their cognition experience of the environment.

ACKNOWLEDGEMENT

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Adaptation of the Learning Process using the Internet of Things

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Abstract

The article describes the design of a sensory network based on the Internet of Things (IoT), which will be able to monitor the emotional state of individual students, verify the functionality of the proposed system, implement innovative methods in education and adapt teaching materials based on data obtained from the sensory network. New content and methodologies developing students' analytical and creative thinking by streamlining teaching processes in applied informatics will be later reflected in professional practice through greater erudition. Research in the field of education discusses and defines two important goals in terms of diversification of higher education, the creation of a comprehensive sensory system in the field of IoT, which will record and evaluate the emotional state of individual students and on the other system will be able to adapt real-time teaching materials for the monitored student. The expected result is a streamlining of the teaching process, which will have an impact on the student in an increasing level of knowledge.

Keywords

IoT, sensor, emotional state, physiological functions, HRV

INTRODUCTION

New requirements are placed on recent education system in terms of the amount and diversity of knowledge, but also the speed of their development. Most people nowadays have a high school diploma and universities are more fulfilled than ever. However, today's demand for education is not just about quantitative growth, but above all about quality. The quality of education can be ensured through the diversification of disciplines and the individualisation of education. Our thoughts are not about transformation classical education into an interactive and hypermedia format level, but rather introduces the new ways of acquiring knowledge and building education.

Static information structures on the web, whose task is to provide information, are becoming obsolete. New web systems are beginning to emerge, which are becoming more and more complex. For the application of these systems, there is an increasing need to disseminate information from heterogeneous sources managed by these systems with adaptation to the user or the environment in which the user is located. The aim is to present personal data to the user as relevant as possible in a way that suits the user. Education has

always been one of the most popular areas for adaptable hypermedia systems. Several interesting methods and techniques of adaptive hypermedia systems were originally developed for various educational systems. Several of the early adaptive education systems were inspired by intelligent learning systems and were created as an attempt to combine intelligent learning systems and educational hypermedia. With the rapid development of the Internet, electronic education systems have become more and more popular. The electronic education system takes care of the following functions: delivery of study materials to students through the Internet, recording of learning progress and portfolios, management of learning content, assessment and other (S. Lee, Barker, & Kumar, 2011).

Adaptivity in the proposed e-activities is an important element of personalization of teaching, in which dominate two roles. The role of the tutor, which is responsible for the content and management of the created e-activity and the role of the user, i.e. one who enters education and goes through the educational e-product. The efforts of the authors (Thompson, 2015) is to point out the possibilities of creating and applying a user model. It should meet the following criteria: it should be a hypertext or hypermedia system, and it should be able to adapt the hypermedia to use.

The educational process gradually begins to focus on the personality of the student and the teacher acts as a tutor. E-learning has become part of today's education also thanks to the diverse use, from the presentation of digital content to teaching management systems, the Learning Management System (LMS). Mass education in the classroom or with the help of classical e-learning is not able to respond to the individual needs of the student. Some students are delayed and bored, on the other hand for some the pace is too fast and they do not know everything. Other students are satisfied with the subject of education but may not be satisfied with the teaching style of a particular teacher. Over time, these students may become opposed to the teacher and the subjects they teach, resulting in often worsened academic performance.

When acquiring new knowledge, it is advisable to have precisely set educational goals. However, the goals of the teaching process must be perceived on three levels, namely:

- cognitive area (knowledge, skills and competences),
- affective area (emotional area, attitudes and value orientation),
- psychomotor area (motor skills and habits, movement skills, working with devices).

Personalization of education is a way for students to learn about their previous knowledge, skills and learning styles. We consider a learning style to be a set of attitudes and behaviours that determine an individual's preferred way of learning.

The article aims to focus on the development of a complex sensory system and the evaluation of the emotional state using the physiological functions of the user himself. The article aims to use the obtained physiological data through non-invasive sensors as background materials to determine and classify the emotional state of the user. Based on the evaluated state, it will be possible to adapt the educational material to the student.

RELATED WORKS

The Internet of Things is the latest and most improved concept in the field of IT. This is a technological revolution that represents the future of computer technology. The Internet

of Things can also be seen as a global network that enables the communication between people to each other, between people and things and things to each other while providing a unique identity for each object. The Internet of Things is talking about a world where anything can connect and communicate in an intelligent way better than ever before. It is revolutionary that these physical information systems are now beginning to develop, and some even work for the most part without human intervention (Madakam, Lake, Lake, Lake, & Communications, 2015).

A closer look at the Internet of Things reveals two important pillars: "Internet" and "Things", which require further clarification. Although any object capable of connecting to the Internet appears to fall into the "Things" category, this notation is used to include a more general group of entities, including intelligent devices, sensors, human beings, and any other object aware of its context, and can communicate with other entities and make it available anytime and anywhere. This means that objects must be accessible without any time or space restrictions (Buyya & Dastjerdi, 2016).

Initially, radio frequency identification (RFID) was the dominant technology in the development of the Internet of Things, but with further technological advances, wireless sensor networks (WSN) and Bluetooth-enabled devices have become a major trend in the Internet of Things. Many other technologies and devices including barcodes, location services, SoA, NFC, Wimax, ZigBee, cloud computing, etc. are also used to create a comprehensive network of the Internet of Things (Mehta, Sahni, & Khanna, 2018).

The Internet of Things is now becoming an integral part of everyday life. The representation is present at every step, whether in the household or industry. Taking advantage of IoT opens the door to a new world where many things can be handled much more efficiently and easily (Coates, Hammoudeh, & Holmes, 2017). Although many devices can connect to a network, it is not possible to interconnect them or manage them remotely. The aim is to connect all objects into one system to manage and administer information in real-time from anywhere and at any time (Gómez, Huete, Hoyos, Perez, & Grigori, 2013).

The Internet of Things can include common devices that we use every day in the home to automate processes, devices that are built into cars and other means of transport, medical devices and other (Kummerfeld & Kay, 2017). The very purpose of the Internet of Things is to connect different types of objects with different intentions into one common platform (Kummerfeld & Kay, 2017; López, Ranasinghe, Harrison, McFarlane, & Computing, 2012).

Using various IoT devices, it is possible to create own sensory network that will be able to measure the physiological functions of the user. The article aims to point out common IoT devices (wearable) such as smart wristbands (Francisti & Balogh, 2018), smartwatches, thermal cameras, web cameras, motion sensors and more. With the help of these devices, it is possible to identify the physiological states of the users and, based on the classification, it is also possible to assign the respective emotional states to the individual physiological functions.

According to a survey carried out by Feidakis, Daradoumis and Cabella (Feidakis, Daradoumis, & Caballé, 2011), in which the classification of emotions based on basic models is given, 66 emotions can be divided into two groups: ten basic emotions (anger, expectation, distrust, fear, happiness, joy, love, sadness, surprise, trust) and 56 secondary emotions.

Most research uses variations of Russell's circulatory model of emotions (Figure 1), which provides a distribution of basic emotions in two-dimensional space in terms of valence and excitement. Such an approach makes it possible to define the desired emotion and evaluate its intensity only by analysing the two dimensions (Russell & psychology, 1980).

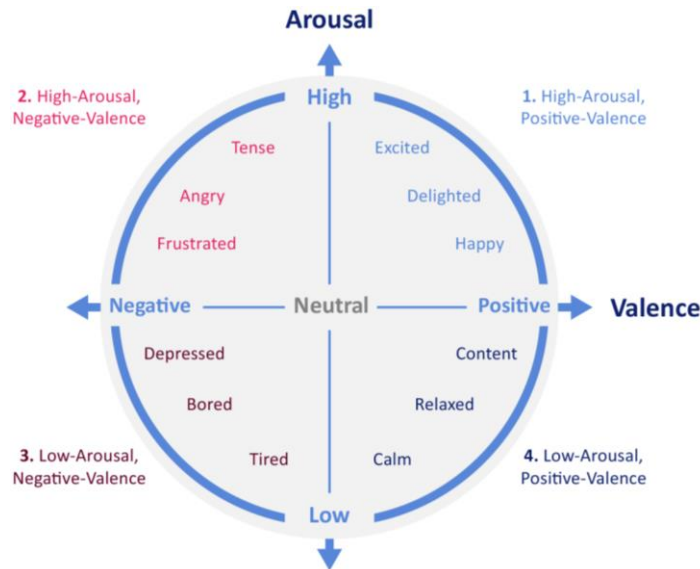


Figure 1: Russell's circulatory model of emotion (Russell & psychology, 1980)

Using the model described above will clarify the classification and evaluation of emotions, but there are still many problems related to the evaluation of emotions, in particular the choice of measurement methods and the evaluation of results, the choice of hardware and software of measurement. Besides, the issue of recognizing and evaluating emotions is complicated by an interdisciplinary nature: emotion recognition and strength assessment are the subjects of psychological sciences while measuring and evaluating human body parameters are related to medical sciences and measurement techniques also sensor data and solutions are the subjects of mechatronics.

MATERIAL AND METHODS

Emotion assessment methods can be divided into two main groups according to the basic techniques used to recognize emotions: self-healing techniques based on self-assessment of emotions by completing various questionnaires (Isomursu, Tähti, Väinämö, & Kuutti, 2007) (Wallbott & Scherer, 1989) and machine evaluation techniques based on the measurement of various parameters of the human body. Also, there are frequent cases of the simultaneous use of several methods to increase the reliability of the obtained results. According to research by Scherer and Gonçalves, each emotion can be assessed by analysing the five main components of emotion (behavioural tendencies, physiological responses, motor expressions, cognitive assessment and subjective feelings), but only the first four can be assessed automatically and can indicate information about the user's emotional state during interaction without its interruption. Subjective feelings are usually assessed only using self-assessment methods (Scherer, 2005) (Gonçalves et al., 2017).

Automatic recognition of emotions is usually performed by measuring various parameters of the human body or electrical impulses in the nervous system and analysing their changes. The most popular techniques are electroencephalography, measurement of skin resistance, blood pressure, heart rate, eye activity and motion analysis.

Heart rate variability (HRV)

HRV is a technique for assessing emotional state based on measuring heart rate variability, which means fluctuations in rhythm over some time. In contrast to the mean deviation of the heart rate, which is expressed in the period of 60s, the HRV analysis examines the fluctuation of the nuance in each cycle of the heart rhythm and its regularity (Hsieh & Chin, 2011). Heart rate variability is regulated by the synergistic action of two branches of the autonomic nervous system, namely the sympathetic and parasympathetic nervous systems. Heart rate is the net effect of parasympathetic nerves, which slow down the heart rhythm, and sympathetic nerves, which speed it up. These changes are influenced by emotions, stress and physical exercise (Benezeth et al., 2018). Besides, HRV depends on age and gender, and other factors include physical and mental stress, smoking, alcohol, coffee, overweight and blood pressure, as well as glucose levels, infectious agents and depression. Hereditary genes also significantly affect heart rate variability. Low HRV indicates a state of relaxation, while increased HRV indicates a potential state of mental stress or frustration (Haag, Goronzy, Schaich, & Williams, 2004).

The classic technique for measuring HRV is the ECG, which measures the primary electro-biological signal related to cardiac activity and provides the ability to define the time between heart rate pulses as a function of time (Hsieh & Chin, 2011). The interval from the ECG signal can be extracted using conventional peak detection techniques, which allow the duration between each peak to be defined and form an HRV signal that expresses the change in the interval between peaks over time.

The common method of HRV analysis usually includes analytical methods in the time and frequency domain (Hsieh & Chin, 2011). The various studies based on analyses in one or both domains are briefly summarized in a study by Mikuckas et al. (Mikuckas et al., 2014). The application of HRV to emotion recognition is complicated by the fact that HRV influences other factors, and various signal filtering and function extraction techniques are implemented to address this problem. There are approximately 14 different parameters that can be extracted by HRV analysis. A detailed description of these parameters and their relationship to the main emotions is given by the authors' Zhu, Ji and Liu in the research (Zhu, Ji, & Liu, 2019). The most common technique used for HRV analyses is to calculate the power spectral density (PSD) of the signal (Mikuckas et al., 2014). PSD represents the spectral power density of the time series as a function of frequency. Typical HRV measurements obtained from frequency domain analysis are forces within frequency bands and force ratios. The amount of energy contained in a frequency band can be obtained by integrating the PSD into the limits of the frequency bands (Mikuckas et al., 2014).

The main disadvantages of ECG-based HRV are the properties of the ECG, in particular, the complexity of the sensors and the high requirements for the measurement procedure to minimize the impact on the environment. An alternative to ECG-based HRV is photoplethysmography (PPG). Photoplethysmography is a technique for detecting changes in the microvascular volume of blood in tissues. The principle of this technology is very simple and requires only a light source and a photodetector. The light source illuminates the

tissue and the photodetector measures small changes in transmitted or reflected light (Figure 2) associated with changes in tissue perfusion (Benezeth et al., 2018).

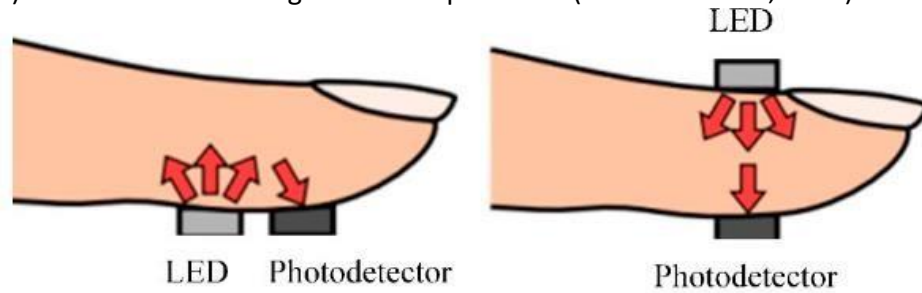


Figure 2: Principles of PPG left reflection mode and right transmission mode (Benezeth et al., 2018).

The PPG signal (Figure 3) consists of two main components:

- The static part of the signal depends on the structure of the tissue and the average blood volume of the arterial and venous parts of the blood changes very slowly depending on the breathing,
- The dynamic part represents the changes in blood volume that occur between the systolic and diastolic phases of the heart cycle (Tamura, Maeda, Sekine, & Yoshida, 2014).

PPG signals, which are analogous to time-domain voltage values, are analysed using methods similar to those used for ECG-based HRV analysis. The main difference between PPG and ECG-based analysis is signal filtering using high-pass filters before defining peaks and generating the HRV signal. PPG can only be performed with one sensor attached to the finger or with multiple sensors attached to the right and left earlobes (Allen, 2007).

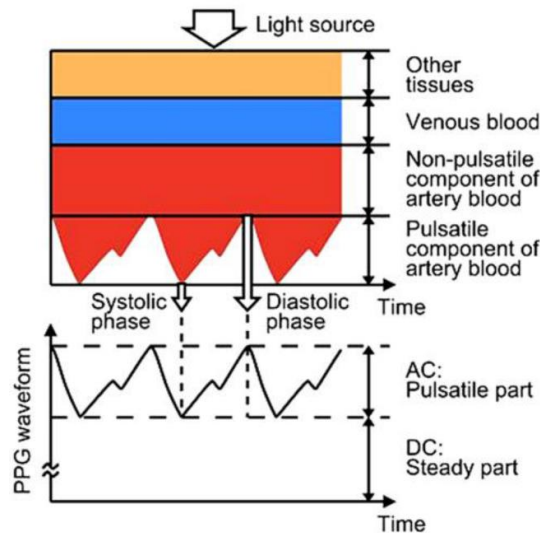


Figure 3: Example of the PPG signal (Tamura et al., 2014).

There are several studies that demonstrate the successful implementation of this technique and demonstrate its advantages over an ECG (Jeyhani, Mahdiani, Peltokangas, & Vehkaoja, 2015). In research by Allen (Allen, 2007) a comparison between the ECG signal and the PPG signal is given (Figure 4), which demonstrates the strict relationships between the two signals. The delay of PPTp and PPTf in the PPG signal represents the time of transition until the heart rate reaches the measurement point.

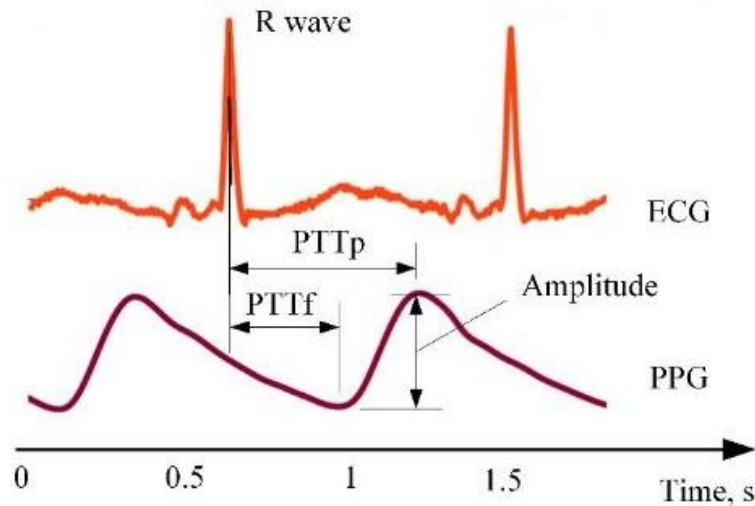


Figure 4: Comparison of signals from PPG and ECG. (Elgendi et al., 2019)

Recently, there has been a growing interest in remote photoplethysmography (rPPG), which can restore the cardiovascular pulse wave by measuring variations in backscattered light at a distance, using only ambient light and inexpensive vision systems (Benezeth et al., 2018). Remote sensing makes it possible to significantly increase the level of human comfort during the measurement process, but this reduces the signal-to-noise ratio and increases the need for more advanced signal processing and analysis algorithms. In research by Maritsch (Maritsch et al., 2019) Machine learning algorithms have been implemented to increase the accuracy of HRV measurements performed by smartwatches. The results of this research prove that ML is a useful tool for analysing PPG measurement data and extracting the required functions.

A brief overview of research aimed at recognizing emotions using HRV is given in Table 1.

Table 1: An overview of scientific research focused on the recognition and evaluation of emotions using HRV (own design).

Bearing	Emotions	Methods	Hardware and software
This study aimed to recognize emotions using EEG and peripheral signals.	High / low valence and excitement	HRV, EEG, GSR, blood pressure, breathing	Biosemi Active system II. GSR sensor, plethysmograph, breathing tape (Chanel, Ansari-Asl, & Pun, 2007)
Creating a new identification method happiness and sadness	Happiness and sadness	HRV, skin temperature (SKT)	SKT sensor, PPG sensor (Park, Kim, Hwang, & Lee, 2013)

This project aimed to design a non-invasive system that will be able to recognize human emotions using intelligent sensors.	Happiness (excitement), sadness, relaxed (neutral) and angry	HRV, skin temperature SKT, GSR	Custom PPG sensor, temperature sensor DS600 from Maxim - Dallas, custom GSR sensor (Quazi, Mukhopadhyay, Suryadevara, & Huang, 2012)
This article describes the development of a wearable sensor platform for monitoring mental stress.	Mental stress	HRV, GSR, breathing	Heart rate monitor (HRM) (Polar WearLink +; Polar Electro Inc.), respiratory sensor (SA9311M; Thought Technology Ltd.), GSR sensor (E243; In Vivo Metric Systems Corp.). EMG module (TDE205; Bio-Medical Instruments, Inc.)(Choi, Ahmed, & Gutierrez-Osuna, 2011)
This article examined the ability of PPG recognize emotions.	High / low valence and excitement	HRV	PPG sensor (M. S. Lee et al., 2019)
This research proposes a new framework for emotion recognition for computer prediction of human emotions using wearable biosensors.	Happiness / joy, anger, fear, disgust, sadness	HRV, GSR, SKT, activity recognition	PPG sensor, GSR sensor, SKT, fingertip temperature; EMG gyroscopes and accelerometer for activity recognition, Android smartphone for data collection (M. S. Lee et al., 2019)

It is clear from Table 1 that HRV is a relatively popular and powerful technique for recognizing emotions. The results of the review that the situation in this area is at odds with the situation with EEG or ECG, where researchers focus on the full development of PPG and rPPG techniques, including the development of new configurations, wearable PPG sensors, improved signal analysis and measurement methods and research new areas of application.

The main advantage of PPG-based HRV lies in the absence of a requirement for special training on humans for measurement. Usually, it is enough to touch the active surface of the sensor for a few seconds. The rPPG method provides the possibility of non-contact measurements. The cheap PPG device and its accessibility for all potential users are so simple that even the touch screen of a regular smartphone can be used as a PPG sensor. These features of methodology reveal the potential for its implementation in a wide range of applications, especially in the field of human-machine-IoT interaction, as sensors of this type can be easily installed in joysticks and other machine controllers and can be hidden from the end-user.

In special cases where the number of emotions or their accuracy of detection requires conditions, the HRV technique needs to be supplemented by other techniques such as ECG, GSR and data fusion. This situation develops a high potential for the application of big data analysis techniques.

EXPERIMENT AND RESULT

As there has been a recent increase in interest in remote photoplethysmography (rPPG) as already mentioned in (Benezeth et al., 2018) we compared smart wristbands (Francisti & Balogh, 2019). We also compared the individual wristbands with a reference device, which was the BOSO TM-2430 holster, which is commonly used in the medical environment. Simultaneously with the pressure holster, we also measured the heart rate using smart wristbands at precisely set time intervals. Subsequently, we evaluated the measured data from the holster and the individual wristbands and compared their accuracy based on comparative statistics. When measuring the heart rate, we used a holster (A&D BOSO TM - 2430), which recorded the pressure and heart rate, and we also used the following wristbands:

- Mi Band 2
- Mi Band 3
- Mi Smart Band 4
- Fitbit Charge 3
- Huawei band 3 pro
- Samsung Galaxy fit e
- Watchking Smart T8s
- Watchking Smart Q8s

The holster was set to record a pulse every 30 minutes. The exception was the night mode from 10 pm to 7 am, when the holster recorded a pulse for each hour. Since the holster also recorded data other than the pulse, we first had to modify the file from unnecessary data so that only information about the date, time and pulse remained in the table, to which we also added a column with information about the person's activities.

During measuring the heart rate, we recorded the changes of the wristbands in the table (Table 2) to remember the intervals putting a wristband on the wrist. According to that schedule, the names obtained from the holster were comparable to the data obtained from a particular wristband.

Table 2 Time schedule for pulse measurement

Wristband	Date	Start time	End time
Fitbit Charge 3	4.3.2020	15:09	18:20
Huawei band 3 pro	4.3.2020	15:09	18:20
Mi Band 2	4.3.2020	18:20	20:40
Watch smart Q8s	4.3.2020	20:40	23:53
Samsung galaxy fit e	4.3.2020	20:43	23:43
Mi Band 3	4.3.2020	23:48	6:30
Watchking smart T8s	5.3.2020	0:00	5:00
Mi Band 4	5.3.2020	6:30	16:00
Fitbit Charge 3	5.3.2020	7:30	16:00

Examining (comparing), we found that among the smart wristbands with accurate heart rate measurement we can include Fitbit and Mi Band 4.

Table 3 Comparison of measured data from the holster, Fitbit and Mi Band 4 bracelet

Time	Fitbit (average)	Mi Band 4 (average)	Holster	Activity
7:30	83	93	90	breakfast
8:00	87	112	107	car driving
9:00	72	95	96	work - administrative
9:30	76	87	90	meeting
10:00	99	72	69	meeting
10:30	76	76	75	preparing for teaching
11:00	96	100	85	active teaching - exercises
11:30	73	75	76	active teaching - exercises
12:00	99	79	81	active teaching - exercises
12:30	72	74	75	active teaching - exercises
13:00	78	105	88	active teaching - lecture
13:30	74	83	83	active teaching - lecture
14:00	84	80	85	active teaching - lecture
14:30	84	79	76	active teaching - lecture
15:00	74	86	88	active teaching - exercises
16:00	67	77	88	active teaching - exercises

When we summarize all the results from the comparison of the Mi Band 4 wristband with the holster, we can say that the measurement was more accurate than with the Fitbit Charge 3 wristband (Table 3). It follows that the Mi Band 4 is the most accurate measuring device of all the smart wristbands used in the experiment, which means that the measured values between the holster and the Mi Band 4 wristband are related and the differences between the values are not statistically significant.

We determined the statistical significance based on the percentage deviation between the measured values of the pulses, which we calculated as follows:

$$O = |(100 - ((N * 100)/H)|$$

Where:

- O the deviation is given in %,
- N is the value of the pulse measured using a wristband,
- H is the pulse value measured with a holster.

Deviation values are recorded in absolute value to remove negative values if the pulse values measured with the holster are smaller than those measured with the wristband.

CONCLUSION

The reliability, accuracy and speed of evaluating emotions strongly depend not only on the measurement method and sensor used but also on the signal processing and technique used in the analysis. The choice of measurement methods and sensors is a complex process in which a large number of questions are asked. Physiological parameters can be measured in the same way as the physical principles of signal acquisition. The measurement of technology concerning individual sensors creates a huge number of choices. More attempts have been made to classify emotions, sensors and universal selection algorithms. The first

step is to select the measurement parameters and methods, while the second step is to select the sensors.

We assume that at the beginning of the method selection it is necessary to define whether we are interested in a conscious or unconscious reaction, or maybe both methods at the same time. The research, based on conscious answers is relatively simple and does not require any special hardware but requires a lot of attention when preparing questionnaires. On the contrary, the results of self-evaluation are not so reliable and there is a possibility that a person will not correctly recognize his emotions or provide inaccurate answers to unpleasant questions. Methods based on unconscious responses usually provide more reliable results, but require more measurement attempts and increase high hardware requirements.

Methods based on unconscious reactions provide many possibilities. Because all reactions in the human body are controlled by electrical signals generated in the central nervous system, we can conclude that electrical parameters are the primary entities that provide most accurate results, and measuring non-electrical signals returns the human body's response to an electrical signal. Measurement of electrical parameters has two properties: it is possible to use methods based on direct (self-generating) sensors when measuring the signal covered by the central nervous system (EEG, ECG, HRV, EMG, EOG), or measurements based on modulation, i.e. when changes in the human body modulate the properties of the sensor (GSR).

By further research and by creating a comprehensive system for measuring physiological states and subsequent classification of the emotional state, we want to confirm the impact and influence of the emotional state on the teaching process. We assume that we will be able to adapt the teaching materials, learning style and approach to specific students according to their current emotional state. We assume that the adaptive system will be more flexible and effective for students in acquiring new knowledge.

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Conference Papers

Section:

Information Technologies Supporting Learning

Serious Games for Learning in Informal Learning Environments – Psychological View

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Abstract

The results of PISA 2018 for Slovenia show a high level of functional literacy, science literacy and mathematical literacy at the end of compulsory school. This result is shadowed by results, which measure students' emotional condition in school: 35% of Slovene students feel stressed and 52% feel concerned. The circumstances call for immediate engagement in searching teaching methods for raising learning motivation among students. Intelligent serious games could be the right answer if implemented psychologically grounded and focused on the learning outcomes. The paper presents the results of part of the survey prepared in the frame of Green Energy Skills for Youth, European project in which preferences for different kinds of computer games were examined, and the preferences and attitudes for different attributes of the games. This data were studied from the perspective of students' age and gender. The results show, that computer games, if we want them to reach their educational goal, should be designed on the ground of psychological knowledge and differently for different groups of players – they should take in to the account the preferences and attitudes of the population, the addressee of the gaming situation.

Keywords

Intelligent Serious Games. Learning Outcomes. Students' Preferences. Motivation

INTRODUCTION

Intelligent serious games are raising many hopes for education in following decades (Flogie et al, 2020) They should be an answer of educational system to avoid the growing number of students, which fell the school and teachers are dull – nearly 70% of high school dropouts in USA said, they were not motivated to work hard (Bridgeland, Bilulio & Morison, 2006). Intelligent serious games are namely built on learning principles, they provide personalized learning opportunities, they offer more engagement for the learner, they teach 21st century skills and they provide an environment for authentic and relevant assessment

(McClarty et al, 2012). Intelligent serious games provide opportunity for continued practice. Important in this context for the player/learner is, that negative consequences are not typically associated with failure. Even more: failure is a typical integral part of playing - and of learning (Gee, 2009; Klopfer, Osterweil & Salen, 2009).

Intelligent serious games provide a high level of motivation for the player (Flogie et al, 2020). This motivation is driven from players' belief about how good he will be and of his interest to achieve the goal (Jalongo, 2007). An EU study on the sample of 500 teachers confirmed, the motivation is significantly greater when computer games are integrated into the educational process (Joyce, Gerhard & Debry, 2009). Gaming gives in the context of curricula of different school subjects an excellent opportunity for the formative assessment, which is the process by which data about students' knowledge and skills are used to form the subsequent instruction (Heritage, 2010). Intelligent serious games are often mentioned as an important means for teaching 21st century skills because they can accommodate a wide variety of learning styles within a complex decision making context (Squire, 2006).

Intelligent serious games provide the opportunity for personalized learning, which can be/is of particular importance for students (Flogie et al, 2020). Games can be adapted based on students' preferences. Appropriate scaffolding can be provided in games through the use of levels. In traditional classroom settings, a student that does not master a concept, could be left with the gap in their knowledge foundation. In contrast, digital games inherently force the player to master a concept in order to advance. Players are able to repeat the same scenario until they master the concept (McClarty, 2012). Good designed intelligent serious games are challenging but achievable – they confront students with tasks/challenges that are matched to their skill level in order to maximize his/their engagement (Kiili, 2005). This puts intelligent serious game in the context of constructivists' theory – it is similar to Vygotsky's zone of proximal development, which is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development under adult guidance, or collaboration with more capable peers" (Vygotsky, 2006, 86 in McClarity, 2012).

The possibility of providing personalized learning opportunities in a way that the game "tailors education to ensure that every pupil achieves the higher standard possible" (OECD, 2006, p. 24) makes intelligent serious games extremely interesting for the education of students with special needs. Research focused on learning process of people with impairments (mental or sensorial) had revealed that serious games are an excellent didactical tool for reaching their educational goals.

This was a strategy behind the planning the project Green Energy Skills for Youth, an European project focused in to the developing green lifestyle habits, green economy awareness. One of the central questions before starting the defining the curriculum of the games and creating the games, was to determine the playing preferences and computer playing habits of the targeted young population, to avoid the early ISG educational gaming solution, which often missed the aim of their production.

METHODOLOGY

This paper reports on a part of survey data, gathered at the beginning stages of the project before the development of ISG. The presented part of the survey addresses following questions:

- Are there any age/gender-conditioned differences regarding like or dislike educative computer games?
- Are there any age/gender-conditioned differences regarding the preference to different types of computer games?
- Are there any age/gender-conditioned differences regarding the attributes of the computer game?

Participants

The majority of the sample, whose' surveys were evaluated (1521), belonged to the population between 15 and 18 (53.9%), followed by the population between 8 and 11 (26.4%). Only 19%.5 of the sample belonged to the age group between 12 and 14. Defining the sample according to the gender: 63.72% surveys were filled in by the girls and 37.28% by boys.

Data analysis

Firstly, surveys were checked with the focus, whether a participant answered all the questions in a way, that his opinion/knowledge was expressed clearly and understandable. In this procedure 135 surveys were excluded. The remained 1521 surveys were statistically analysed with SPSS 19.0. (SPSS)

RESULTS

Are there any age/gender-conditioned differences regarding like or dislike educative computer games?

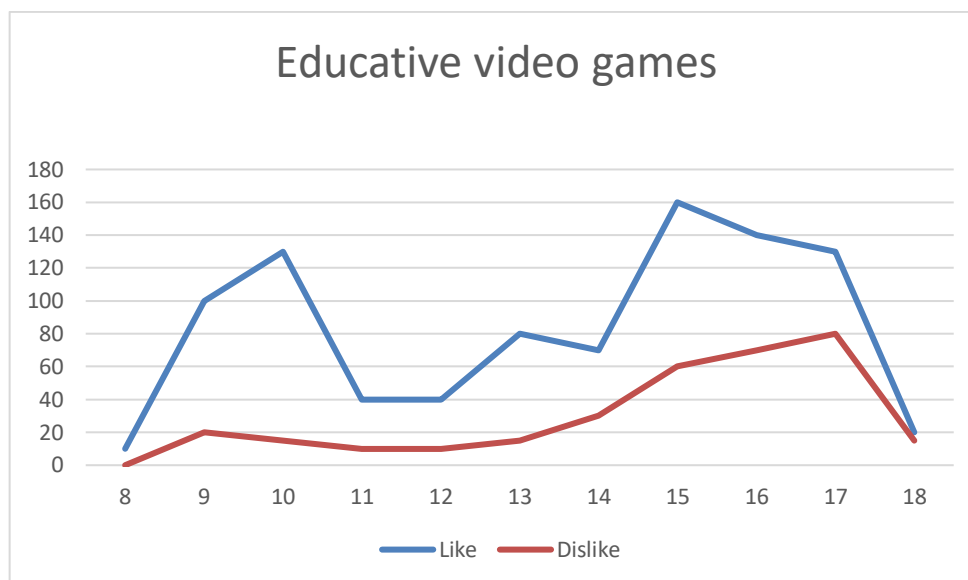


Figure 1: Age distribution of like (yellow) or dislike (red) behaviours for educative video games.

Educational type of computer games is, according to results, liked by all ages, particularly within the population between ages 15 and 17 and at the age 8 and 10. But the preference toward the type of the computer game is strongly connected with the gender. The results are persuasive: girls like (prefer) educational computer games and dislike the action computer games. And boys like action computer games and do not want to be educated while they are playing on their computers.

Are there any age/gender-conditioned differences regarding the preference to different types of computer games?

In survey children's' and young peoples' preferences for different types of computer games were examined. The participant could choose from the following list of types of computer game:

- action,
- adventure,
- arcade,
- educational,
- family,
- puzzle,
- role-playing,
- -simulation, - strategy or
- trivial.

A participant was instructed he could choose as many possibilities, he wished.

Let's have a closer look at the results about preferences and no preferences toward puzzle video games.

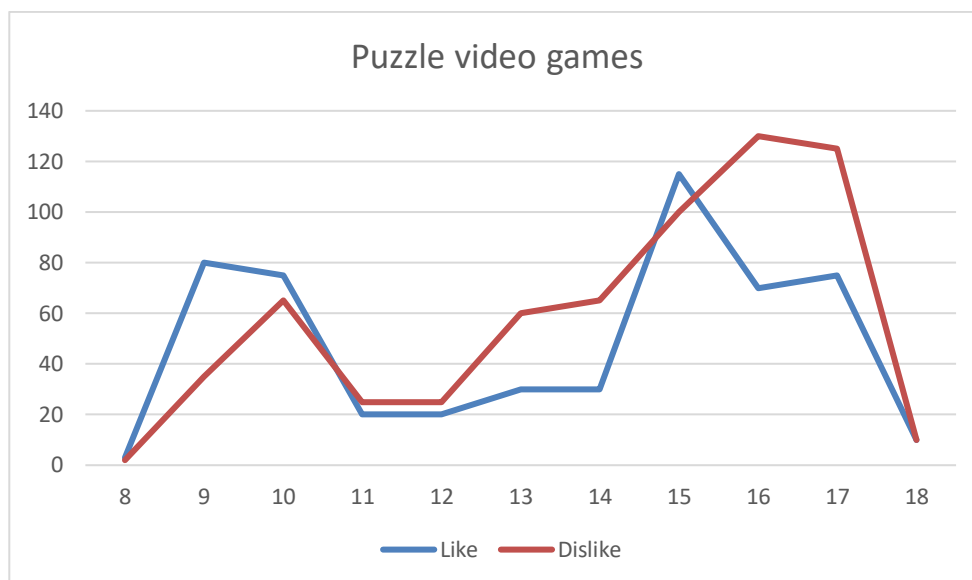


Figure 2: Age distribution of like (yellow) or dislike (red) behaviours for puzzle video games (left) and

According to the results, young children tend to appreciate puzzle computer games. This appreciation is typical for ages under 10. On the other side, young people at the age of 13 and later refuse to play this type of computer games. This dislike has a clear growing tendency between ages of 11 and 18 and reaches the top at the ages between 15 and 17.



Figure 3: Age distribution of like or dislike behaviours for strategy video games

According to the results, older children/young people tend to appreciate strategic computer games. This appreciation is typical for ages higher than 15. On the other side, children at the age of 10 and younger children refuse to play this type of computer games. This dislike clearly reaches the top at the age between 8 and 10.

The evaluation of the answers to the question about appreciation of other listed computer video games and comparing the answers of children and young people of

different ages shows, there are computer games types, which are liked by young players of any age group. The results suggest that the games of the type 'arcade', 'adventures' and 'educational', belong to this group.

Are there any age/gender-conditioned differences regarding the attributes of computer game?

The survey also checked what attributes are important in the process of decision whether play or not to play the computer game.

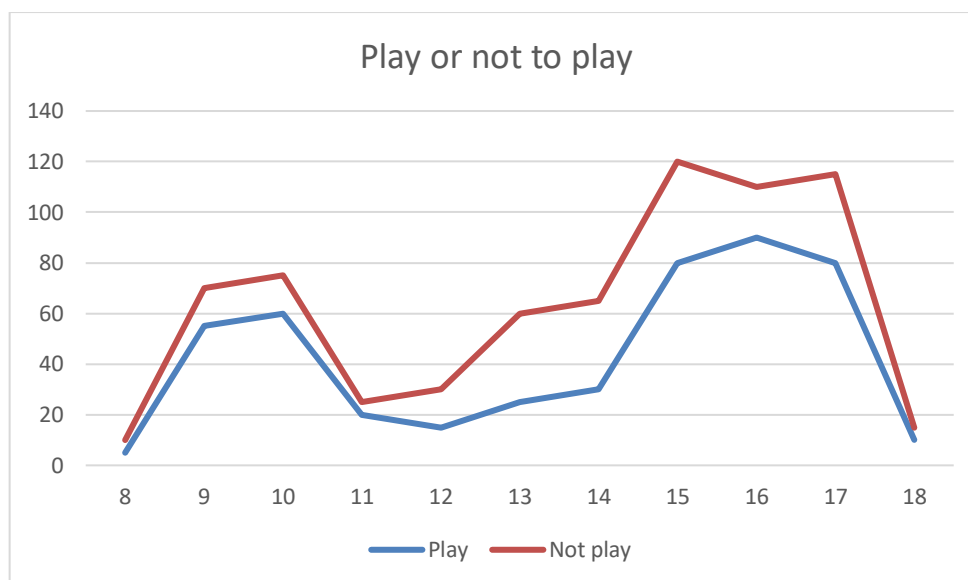


Figure 4: Is difficulty important for your decision 'to play' or 'not to play' the game?

Results show, that the difficulty is a strong predictor for 'staying in the game', playing and learning. The high values of 'not to play' confirm the fact, that the motivation to stay in the game is conditioned with its' difficulty level in the zone of players' proximal development (Vygotsky). The play must be challenging and a good result reachable, when the player engages all his potentials. This means, it must be demanding enough and not too easy, otherwise the player will judge it as dull and boring.

Are there any gender-conditioned differences regarding the preferences toward different types of video games? The Green Energy Skills for Youth project survey checked also the gender-conditioned differences in preferences for/while playing computer games. The figures 5 and 6 show the gender-conditioned preferences toward educational computer video games and action computer video games.

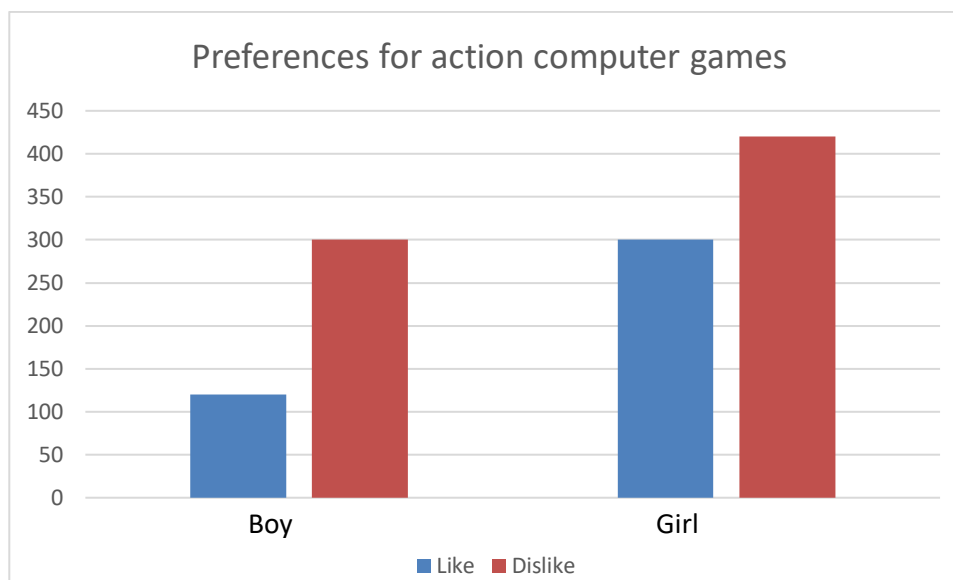


Figure 5: Gender conditioned preferences for action computer games according to gender and for educational computer games according to gender.

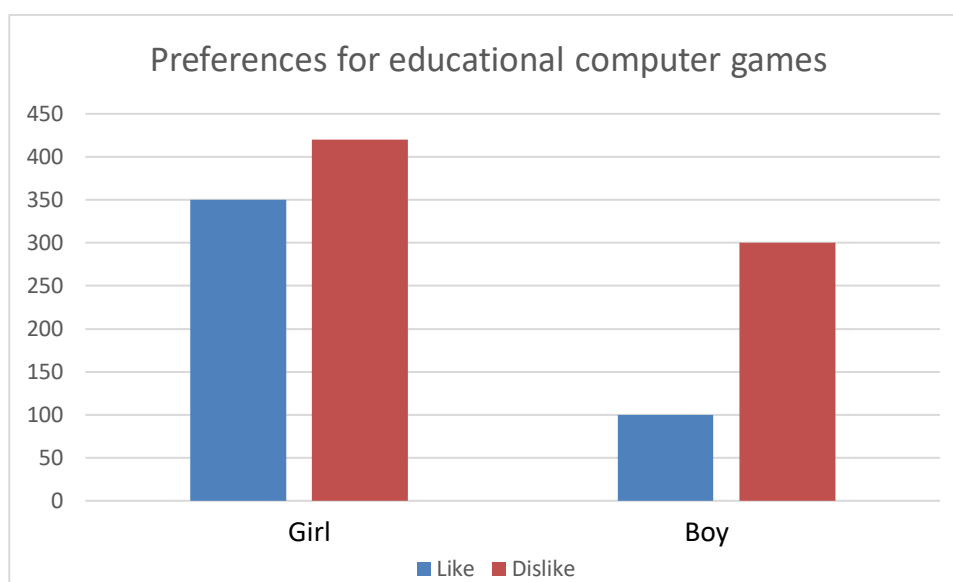


Figure 6: Gender conditioned preferences for educative computer video games.

According to the results the preference toward the type of the computer game is strongly connected with the gender. The results are persuasive: girls like (prefer) educational computer games and dislike the action computer games. And boys like action computer games and do not want to be educated while they are playing on their computers.

DISCUSSION AND CONCLUSION

According to the Green Energy for Youth surveys' results, a differentiation has to be taken in to the account while designing intelligent serious games for learning green lifestyle habits and green economy awareness on the base of knowledge about the green energy. Intelligent serious games should be student centred and customised. Individual

customization is necessary to address the diversity within the target groups of learning population. To achieve this this, following aspects should be considered when developing the games. To arrange set of games that address different groups of beneficiaries and that offer different levels of difficulty. Games should have different layers/levels based on achievements to stimulate the users. This would raise the effectiveness of the games' regarding its' curriculum. A good ISG must contain a transparent (clear visible) reward mechanism. Learning outcomes are achieved through practice, through game playing. Feedback should be provided at the end of the level/room/game to stimulate the user to try again if needed.

If we want to reach the educational goal, intelligent serious games should be designed differently for different groups of players – they should take in to the account the preferences and attitudes of the addressee of the playing situation.

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ICT as Innovation From The Point of View of Students of Primary School Teaching

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Abstract

The paper focuses on the students of primary school teaching from two countries: Slovakia and the Czech Republic. Technologies penetrate the educational process at all levels. But how do future teachers perceive them? A key issue is the attitude towards innovation in ICT students in pregraduate training. Based on a research focused on the teachers' attitude towards technology, we chose Rogers' Diffusion of Innovation Theory as a starting point. Kankaanrinta's questionnaire (2000) and the Czech version from Černochová (2001) were used as a research tool. It is not a standardized tool, but it has been used in several surveys and therefore it was possible to compare it with earlier results of the questionnaire. The research sample consisted of 365 respondents (186 Czech students and 179 Slovak students). The distribution of students into different adopter categories (Innovators, Early Adopters, Early Majority, Late Majority, Laggards) is similar for both nationalities. Respondents from both countries also agreed on the level of agreement (in the most and least rated) items. We compared our results with the results of similar researches – in one of the most relevant surveys of Zounek, Sebera (2005), we can also observe an increase in innovators and a declining number of sceptics, which may indicate an upward trend in acceptance of innovation with a focus on ICT in the Czech-Slovak context.

Keywords

Diffusion of innovation. Educational innovation. Pregraduate teacher training.

INTRODUCTION

The implementation of information and communication technologies into the educational process at all its levels (including kindergartens) has been under way for several years. This is what the pregraduate teacher training is trying to respond to. It is not only about using technology in teaching at university, but also about how to didactically and effectively integrate information and communications technology in teaching itself in primary and secondary schools. But how do future teachers perceive technologies? Students usually use ICT in their studies, in communication, etc. Do they perceive it as a

natural part of teaching though? Will they be the innovators who will be using ICT? Will ICT be understood as a common didactic tool?

A research study entitled „ICT in collaborative learning in the classrooms of primary and secondary education“ discusses the impact of information and communication technologies on cooperative learning methods in primary and secondary education. The research methodology was based on the analysis of teacher interviews from a representative sample of schools, and the results show that teachers believe they have a

great potential to increase ICT activities for collaboration among students. (Garcia, 2014).

Chráska's comparative research (2015) – The acceptance of ICT by teachers and its development between 2004 and 2015 – aimed at identifying the shift of teachers' views on the use of ICT in their teacher's work between 2004 and 2015. As a research method, a questionnaire with 16 assertions with which they expressed a level of agreement was used. „The expected positive shift towards more intensive use of ICT, more virtual communication and use of the Internet was found. It has also been shown that, according to the agreement with individual assertions, teachers can be divided into two different groups, one of which rather accepts ICT and uses it in teaching more often, while the other one does not want to implement ICT in teaching. The first group is more numerous and with 57% of the respondents prevails. The research also shows that teachers are divided into these two groups according to their personal ICT preference.“ (Chráska, 2015).

ICILS 2013 (International Computer and Information Literacy Study), which aims to acquire knowledge about pupils' skills in the area of computer and information literacy (CIL), also dealt with this issue. It is the first international comparative study monitoring the readiness of pupils for life in information society, i.e. the capability to use computers to search, create and share information for the successful functioning of the individual at home, school, workplace and in society. At the international level, the study is coordinated by the International Association for the Evaluation of Educational Achievement (IEA). In the Czech Republic, it is implemented by the Czech School Inspectorate, which identifies the differences in CIL results both between countries and between schools within individual countries so that the observed differences can be related to the way of providing education in the area of CIL. Furthermore, the survey identifies the link between the success of pupils and various aspects of educational systems, technological background of schools, family background and individual characteristics of pupils. The tested group of pupils in the Czech Republic were pupils of the 8th grade of primary schools and corresponding grades of grammar schools with multi-year attendance. The results show that Czech pupils are far above the ICILS average in performing tasks. What teachers think about ICT is also interesting for our research. For instance, 75% of teachers believe that the use of ICT in teaching will lead to a deterioration of pupils' writing, 71% think it limits the direct communication among pupils, and 46% of teachers think it leads to a deterioration in numerous skills (ICILS, 2016).

Yuksel (2015) studied the categories of innovation adopters and the individual level of innovation among pre-service teachers. 420 respondents participated in the study. Rogers' questionnaire was used as a research tool. The study revealed that the field of study and gender of participants significantly changed their level of innovativeness. Most female participants were Early Majority, while most male participants were Early Adopters. The

analysis showed that male participants were highly innovative in contrast to female participants. The study indicated that, unlike Rogers' bell-shaped standard distribution of adopter categories, the distribution in this study was positively skewed.

The results support the idea that pre-service teachers, especially in some particular fields of study, need to change their perception of innovation. Evidence also suggests that Rogers' model of innovation-decision process should be taken into account when planning course objectives.

Cirus et al. (2019) focused primarily on pupils' digital literacy prior to teaching the compulsory subject Information and Communication Technologies. At the same time, they examined teachers' view of technology using Černochová's questionnaire (2001) as a research tool. First grade teachers were the respondents. Their summary results are shown in Table 2.

Zounek and Sebera (2005) examined the attitudes of students of teaching towards ICT in education in order to determine the individual rate of innovation. Their research was based on Rogers' Diffusion of Innovation Theory. They examined whether there were differences between students of two different faculties (or fields of study) and whether gender differences in attitudes could be identified. The results of their research showed that students in the sample belong mainly to the group of „pragmatists“ and „conservatives“. For our research, these results are suitable for comparison (see Table 2). Using Rogers' Diffusion of Innovation Theory, Sasaki (2018) analyzed the implementation processes for new educational policies in Japan as multi-faceted and sensitive to the influences of stakeholders' social value systems. It was a long-term research in which the author monitored the results of three targeted curricular policy administrations (1994-2002 and 2003-2013). Rogers' theory is especially appropriate as it has proven successful in providing tools to identify why and how quickly an innovation achieves (or fails to achieve) its intended goals, including in the fields of education (e.g., Lee, Hsieh & Hsu, 2011) and educational policy (e.g., Dingfelder & Mandell, 2011). Furthermore, the theory's underlying assumption that innovation is accepted through communication over time as a result of stakeholders' values and beliefs is also relevant when the alignment of the three targeted variables, which inevitably involve different types of stakeholders, was examined. Yet, despite its potential, few studies have adopted this theory to explain longitudinal changes in one country's language policies.

Our aim was to find out how future primary school teachers perceive ICT innovation. We were interested in comparing students from two culturally close countries – the Czech Republic and Slovakia. We set our objectives as follows:

- Describe the perception of innovation from the perspective of Czech students.
- Describe the perception of innovation from the perspective of Slovak students.
- Verify whether the obtained distributions correspond to Rogers' typology based on the Diffusion of Innovation Theory.
- Perform comparisons with researches focused on the view or perception of innovation.

Based on the objectives, the following questions were formulated:

- What is the attitude of Czech students to innovation in ICT?

- What is the attitude of Slovak students to innovation in ICT?

We set the hypothesis:

H1: The attitude of Czech and Slovak students of primary school teaching towards innovation in the area of information and communication technologies will not be different.

METHODS

Considering the research objectives and questions, quantitative design of research was chosen, an exploratory research method was used, and a questionnaire was chosen as the basic research technique. We proceeded from Rogers' Diffusion of Innovation Theory where it is possible to identify the key factors affecting the uneven spread of innovation. It is about the nature of innovation, communication and the dynamics of the process that is shaped by the social framework. On the level of an individual who decides to accept or reject innovation, we talk about the process.

Rogers characterizes this process as a process of decreasing the uncertainty among the potential innovation adopters (Rogers, 2003) and in his book further proposes attributes of innovation that would fulfill the above-mentioned description of the diffusion of innovation process (Sahin, 2006). Suitable attributes of innovation include relative advantage, compatibility, complexity, trialability, and observability:

- Relative Advantage, which Rogers defines as the degree to which an innovation is perceived as being better than the original idea or object it supersedes, whereas the higher the relative advantage of innovation, the faster it will be adopted by individual members of a social system;
- Compatibility, which Rogers defines as the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters, whereas the more compatible the innovation, the faster it will be adopted by individual members of a social system;
- Complexity, which Rogers defines as the degree to which an innovation is perceived as relatively difficult to understand and use, whereas the higher the complexity of innovation, the slower it will be adopted by individual members of a social system;
- Trialability, which Rogers defines as the degree to which an innovation may be experimented with on a limited basis, or tested in a limited series, whereas the higher the trialability of innovation, the faster it will be adopted by individual members of a social system;
- Observability, which Rogers defines as the degree to which the results of an innovation are visible to others, whereas the higher the observability of innovation, the faster it will be adopted by individual members of a social system (Rogers, 2003).

In addition to the first attribute of innovation, we can add that if teachers see that technology has value in their instruction, then they will use it (McKenzie, 2001; Spotts,

1999), regardless of whether the incentive to adopt it was internal or external. Regarding the compatibility, Hoerup adds that each innovation changes teachers' approach to their own teaching by influencing their opinions, beliefs and values.

In the relevant chapter of his book, Rogers argues that innovation offering more relative advantage, compatibility, simplicity, trialability, and observability will be adopted by individual members of the social system faster, while he warns that the process of adopting innovation, which offers clear improvements to the current situation, is difficult (Rogers, 2003). However, research has shown that the above mentioned attributes of innovation do indeed increase the likelihood of adopting a new technology into teaching (Anderson, 1998; Bennett, Bennett, 2003; Parisot, 1997).

Rogers defines the rate of adoption as the relative speed with which an innovation is adopted by individual members of a social system (Rogers, 2003), for instance the number of individuals who adopted the innovation for a period of time can be measured as the rate of adoption of the innovation (Sahin, 2006). The above mentioned perceived attributes of an innovation are significant predictors of the rate of adoption (Sahin, 2006). The entire innovation-decision process involves five steps which typically follow each other in a time-ordered manner (Sahin, 2006), forming in terms of time an innovationdecision period that represents the time it takes to complete the process (Rogers, 2003) divided into conceptual stages of knowledge, persuasion, decision, implementation, and confirmation:

- Knowledge occurs when an individual learns about the existence of innovation and acquires some knowledge of how innovation works.
- Persuasion occurs when the individual has a positive or negative attitude towards the innovation.
- Decision occurs when the individual embarks on a series of activities that lead to the choice to adopt or reject the innovation.
- Implementation occurs when an innovation is put into practice.
- Confirmation occurs when the individual looks for support for his or her innovation decision, however the decision can be reversed if the individual is exposed to conflicting facts (Rogers, 2003).

Rogers (2003) defines a total of five categories of innovation adopters: innovators (technology enthusiasts), early adopters (visionaries), early majority (pragmatists), late majority (conservatives) a laggards (skeptics).

A Czech version of questionnaire (Kankaanrinta, 2000, Černochová, 2001) which contained a total of 55 questions was used for the research. We specifically worked with data from the first part of the questionnaire. This part focuses on finding groups of adopters and consists of five pentads of claims, and respondents, using a scale from 1 to 5, expressed the level of agreement or disagreement with individual claims. Each set of claims is formulated to be as responsive and reflective as possible, so that the respondents can express their views according to the five groups of Rogers' categories, i.e. innovator, early adopter, early majority, late majority, and laggard.

The research group consisted of 186 Czech students of 1st grade primary school teaching and 179 Slovak students of the same study programme. There were 3 men in the sample of Czech students and 2 men in the sample of Slovak students. Given these numbers,

we did not consider gender differences in the view of innovation in ICT. The average age of tested students from both countries was 22.4 years. The reliability of the research tool relating to all items (Cronbach's alfa between 0,73 - 0,99) refers to the overall internal consistency of the research tool.

RESULTS

Based on the score from each of the five claims, we obtained a distribution of respondents from both groups in terms of their perception of ICT innovation. Early majority (Slovak students 54%, Czech students 60%) clearly prevailed in both groups of the respondents. According to Rogers' theory even other groups were comparable (Figure 1, 2, 3).

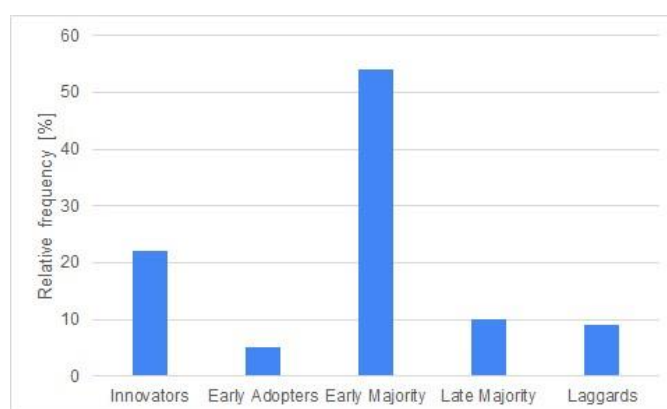


Figure 1: Distribution of Slovak students

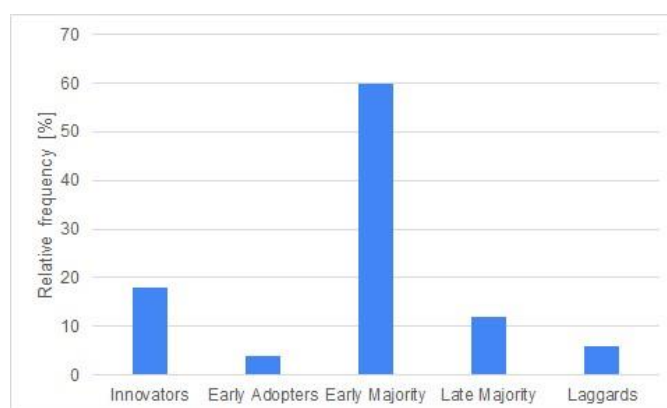


Figure 2: Distribution of Czech students

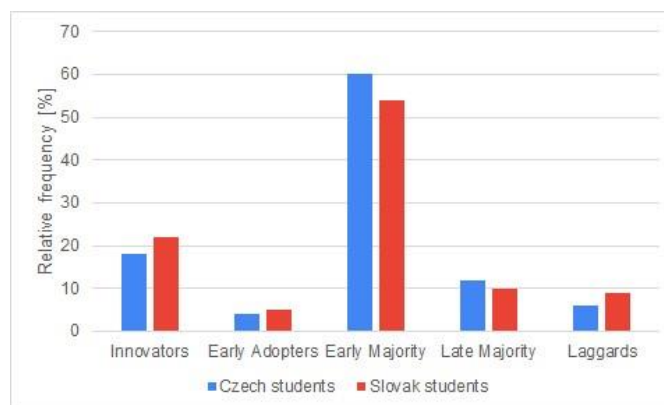


Figure 3: Comparison of both groups of respondents

The results also indicate that a relatively large percentage are innovators, while a very small percentage of students can be described as visionaries (early adopters) and skeptics (laggards).

When comparing the answers of Czech and Slovak students we found almost no differences in answers. For testing the hypothesis H1, we chose non-parametric tests of Mann-Whitney and Kolmogorov-Smirnov due to the nature of the data (based on normality tests – Omnibus test, Kurtosis test and Skewness test the data normality was not confirmed). In both tests, $p > 0.05$ (Mann-Whitney test with $p=0.384678$, Kolmogorov-Smirnov test with $p=0.884814$). We can therefore state that the view of innovations in the field of information and communication technologies is similar for Slovak students as for Czech students (Table 1).

Tab. 1 Division of Slovak and Czech students into categories

Adopter categories	Slovak students	Czech students
Innovators	22 %	18 %
Early Adopters	5 %	4 %
Early Majority	54 %	60 %
Late Majority	10 %	12 %
Laggards	9 %	6 %

The agreement of students of both nationalities was reflected in the most and least rated items. Items with the highest score:

- Before using any ICT application, I want to know if it is useful.
- If my teacher encourages the use of ICT, I use it.
- I hope I will eventually be able to use at least the most useful and proven ICT applications.

Items with the lowest score:

- I wish I never had to use ICT applications.

- I will be among the last to decide to use ICT.
- I will only use ICT if I have to.

DISCUSSION

A comparison of our research with similar studies based on Rogers' Diffusion of Innovation Theory is presented in Table 2. The most relevant research (research carried out with students) is from 2005 (Zounek, Sebera). Compared to our findings, we can observe an increasing percentage of innovators and a decline in the number of laggards.

It is very interesting that the percentage of early adopters is almost unchanged.

Tab. 2 Relevant researches

Categories	Kankaanrinta (2000)	Rogers (2003)	Zounek, Sebera (2005)	Yuksel (2015)	Cirus et al. (2019)	Czech students	Slovak students
Innovator	3	2.5	10	7.1	13.2	18	22
Early adopter	13	13.5	3	30.2	6.6	4	5
Early majority	34	34	66	39.5	69.2	60	54
Late majority	34	34	20	21	8.8	12	10
Laggard	16	16	1	2.1	2.2	6	9

Yuksel (2015) also examined teachers in pregraduate teacher training, however, his results were very different from our findings. It is possible that the fact that they were students of five different fields of teaching (CEIT, Math, Chemistry, History, Turkish P) and that in the research sample 68.6% were female and 31.4% were male has played a significant role here (Yuksel, 2015).

Our aim was to understand the view of Slovak and Czech students on innovations in the field of information and communication technologies in the above mentioned context. Based on the performed statistical analysis, we can state that the distribution of students with respect to the acceptance of innovation in the given area is almost identical in the Czech Republic and in Slovakia. In both countries, the educational system is very similar (even historically) and testing was conducted at faculties of education, i.e. faculties with comparable profiles, which is an important aspect. Our hypothesis, in which we did not anticipate a different view of innovation between Czech and Slovak students, was confirmed on the basis of the mentioned above. There are several factors which justify the absence of a difference. It can be assumed that if students came from differently oriented schools, different fields of study and countries, as Zounek, Sebera (2005) presented in their research, the distribution of acceptance of innovation would most likely look different. In our further research, we do not consider it relevant to study why we did not find differences between students in relation to the issues discussed, but rather to focus on the presented distribution of acceptance of innovation.

In the context of relevant researches (Table 2), we can observe in our results a trend of increasing the number of innovators and declining skeptics. The research sample consisted of students with an average age of 22.5 (born in 1995-2001). They can be labeled in several ways – Net Generation (Tapscott, 1997), digital natives who are “native speakers” of the digital language (Prensky, 2001) or even Generation Z (Howe, Strauss, 2008). Regardless of their designation, young people are generally considered to be experts in digital technology, they are characterized as well-experienced users of internet technologies, even from an early age as often reported. Technological development in recent years has brought an extreme amount of changes that a student/teacher needs to respond to. Items with the highest score may also be related to this: *before using any ICT application, I want to know if it is useful... if my teacher encourages the use of ICT, I use it... I hope I will eventually be able to use at least the most useful and proven ICT applications*. Rogers (2003) classified information adopters into 5 categories and their distribution in the population in accordance with the normal distribution. Therefore, at the other end of the curve, we will always find skeptics who, with great presumption, rated the items as: *I wish I never had to use ICT applications, I will be among the last to decide to use ICT, I will only use ICT if I have to*.

So what should be the result of our research and analyses? Meaningful use of technologies, their inclusion in creativity, innovation in pregraduate education, teacher-mediated education aimed not only at the pupil but also at the parent in the educational use of ICT, for instance even in the after school time. It is a continuous development of digital skills and activities that combine ICT and learning activities, activities to improve teachers' competence to use digital technologies in primary and pre-school education. Information and communication technologies are more often perceived as an innovative and inevitable tool of education which supports social, language and cognitive level as well as the literacy of young learners. Nowadays information and communication technologies are not perceived as a set of risks at schools. It is discussed how to use these innovations in a more lucrative and beneficial way in order to build literacy of the future society (Belášová, Fedorko and Smatanová, 2015). The role of institutional education is to complement the acquired skills with a systematic approach and professional development in order to increase the population of people who naturally move from skeptics to innovators.

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Development of Tests Module in Education Interactive Portal

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Abstract

Distance learning is today's trend in education. Most of the available solutions provide the functionality of the system for teaching and testing. Playing a computer game as free time is also booming. The interactive educational portal designed by us offers the possibility of learning playfully in the right form of games. Therefore, it was necessary to design and implement a module that allows it to create test questions that be available to students in the game. All functionalities of the test module are available primarily for teachers and parents. These are the user roles that make the most of the module's functionality. The main mission of the interactive educational portal with the support of games is to provide new educational opportunities for students of mostly lower grades in primary schools. The basic idea is also to provide a new approach to education. Games are trendy nowadays, and through them, it is possible to streamline the educational process. Children can play and learn at the same time. Such an approach can minimize students' stress while motivating them to achieve better results. To get bonus points and new features in the game, it be necessary to answer the question added by the teacher according to his needs. By using the interface of administration is possible to set the test module according to the needs of the teacher. All test module data can be in a database stored, with emphasis on permanently deleting tests and questions for which answers already exist. This way, it ensures a complete history of students' responses, which is for the statistical evaluation of results required. This article presents a test module design that allows the teacher to create questions and tests that he can apply to the game world. This system, in addition to the primary task of education, offers the user-teacher the opportunity to analyze test results in the form of data mining algorithms. The presented proposal of this module of tests is prepared to connect for this analytical module and data from evaluating pupils be analyzed.

Keywords

Education portal. Digital games. Module of tests. System architecture

INTRODUCTION

The test module is a vital module of the Interactive learning portal for gathering information for teachers and parents about pupils' knowledge. After deployment of them, the portal becomes a fully-fledged tool for supporting pupils' education at primary schools and for obtaining results on pupils' education. Each parent will be able to see the results of their child and thus gain knowledge of which educational subject should give more attention to teaching. Teachers will be able to compare the results from the module of tests with the

results in the classroom. In case of disagreement in the results, it is possible to identify the causes of the difference in outcomes (e.g., stress at school, lack of concentration due to classmates, etc.). The module of tests is also a tool for repeating the chosen issue for pupils from the comfort of home. An advantage is a playful form of education for the pupil and motivation through the reward in the game. The teacher himself formulates questions with an emphasis on the needs arising from the curriculum of the subject. It may also be an advantage for the pupil-teacher that questions from other teachers can use in his test. The sharing of whole tests among teachers is also encouraged, which can make their work more efficient and faster.

The primary mission of the interactive games-supported education portal is to provide new learning opportunities for mostly lower-grade pupils in primary schools. The basic idea is also to offer a new approach to education. Games are trendy nowadays, and it is possible to streamline the educational process. Children can play and learn at the same time. Such an approach can minimize the stress of pupils and, at the same time, motivate them to achieve better results. Pupils to earn bonus points and new features in the game, they will be necessary to answer a question that the teacher has added according to his needs.

Developing of the interactive educational portal is part of project teaching at the Faculty of Management and Informatics of the University of Zilina in Zilina. It builds on the existing system of an educational portal with the support of games (Kostolný *et al.*, 2018). The portal currently offers an administration environment for various user roles. Depending on the account type of the user, several available functionalities are adapted. Suggested user roles include pupil, teacher, parent, administrator, school administrator, analyst, and demo. Currently in educational portal implemented the user roles of the pupil, teacher, administrator, and a unique user role with one user account. The remaining user roles can be set up, but functionality is not available for such user accounts. By default, the administrator has the right to perform all functions within the portal. Other roles have only the necessary functionality available. For the pupil is an accessible game module, through which he can educate. It currently has three games available to play. The administration interface offers the pupil a preview of their profile. An overview of pupils is presently available for teachers, with the option of editing pupil accounts. The demo role offer to view the portal for anonymous users. Through this role is the portal better promoted to the public.

At present, the portal supports the administration of basic functionalities, such as adding users with a given user role for the selected school, bulk importing user accounts, managing user permissions, an overview of users with supported operation create, read, update, delete, and so on. The current state of the portal can be found on the website of the project (IVP FRI, 2020).

EDUCATIONAL PORTAL ARCHITECTURE

The portal is composed of four main modules, such as server application, administration module, game module, and analytical module, which is in the draft version.

Server application

The server application is created in a Representational state transfer architecture style (RESTfull) Web API programmed in .NET CORE technology. It provides all the necessary functionalities and performs all logical operations of the portal. You need to authenticate in this module to work with the portal. The microservice architecture of this module is more detailed described in the publication (Kostolny and Bohacik, 2019). As can be seen in Figure 1, the server part consists of several libraries. Each library represents a logical entity that can ensure the modularity of the server part of the application.

The administration interface (API) is a library that contains the endpoints needed for the portal administration interface. API includes the functionality associated with authentication, user account creation, password change, logs, authority management, class management, and so on.

The game module API contains endpoints for storing information about the start of a new game, respectively, a new round in the game. It also provides storage and retrieval of game results. The shared API contains a standard functionality that needed for all other server part modules. It currently manages authentication and authorization logic, provides exception management, and includes universal models for paging lists. The security of the server part is supplied by JSON Web Token authentication, which presents as an Internet standard for creating access tokens based on JavaScript Object Technology (JSON) technology (Jones, Bradley and Sakimura, 2015).

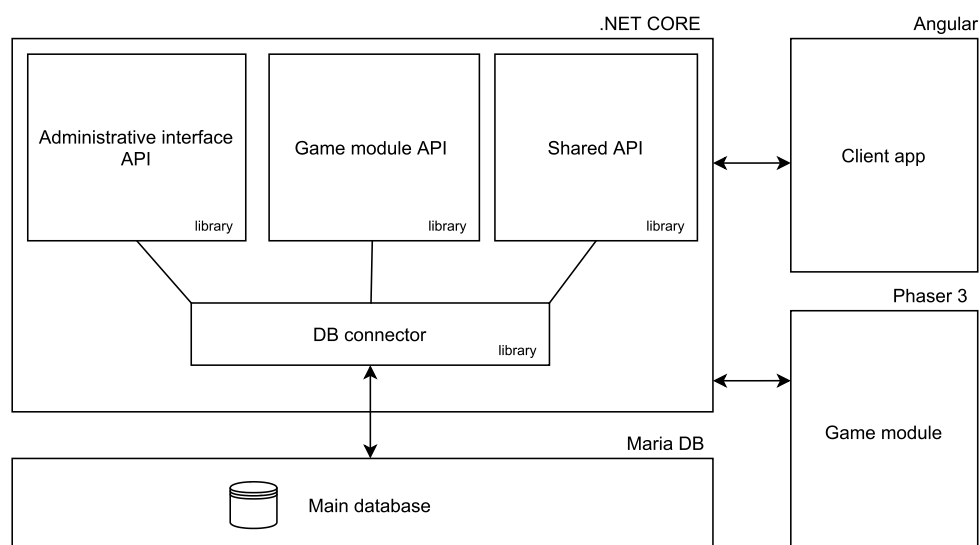


Figure 1: Architecture model of the portal before the implementation of the test module.

A database connector is a library implemented to allow all API libraries to communicate with a database. This library provides others with a database context and the necessary objects that map to database tables.

Modul of administration

The administration interface provides the primary user-portal interaction communicates with the server part of the application. Executes requests to the server and receives responses. These answers are in JSON format. The collected data is further

displayed to the client in a mild form in the client application. The administration module using the Angular 7 framework using the Nebular UI library example of a home screen is in Figure 2. The application administration module with an analytical layer better specified in the paper. (Levashenko *et al.*, 2016).

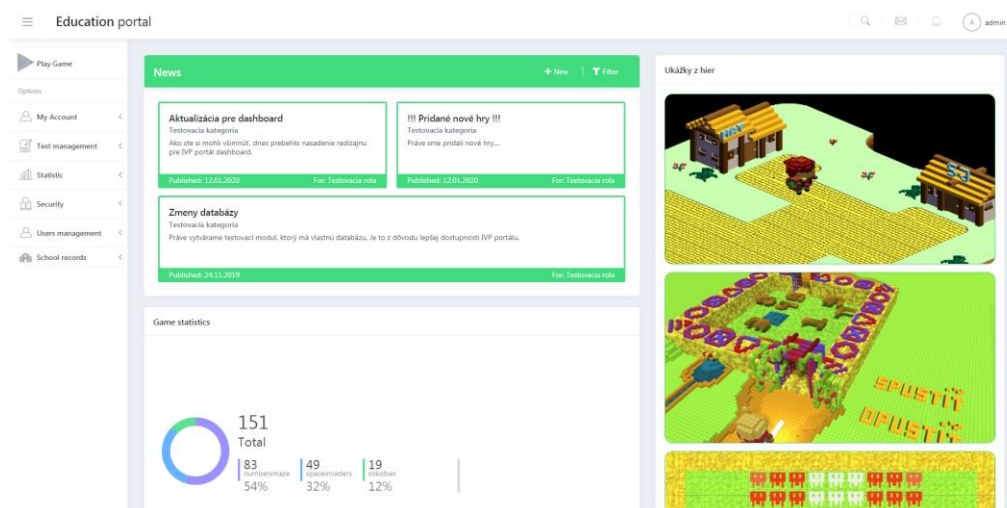


Figure 2: Home screen of the administration interface.

Game module

This module is the basis for interaction with pupils. The game module communicates with the server part and informs the administration module when the pupil started the game or completed some rounds of the tournament. Each game can run through the administration interface (dashboard) after successful login. The game module also communicates with the administration module through services. These two modules together form the so-called presentation layer. Closer we were dealing with the development of the game module in the article (Kostolný and Bohacik, 2017).

Requirements for the current system

The interactive educational portal is in a phase where it has prepared games for pupils and the necessary administration for user accounts of various types. For education pupils through the games, it will be required to create a mechanism whereby teachers will be able to enter questions into the system, assign these questions to the game and get results based on the pupil's answers. Therefore, one of the critical requirements for an interactive learning portal is the creation of a test module. The test module will offer teachers the opportunity to create test questions. Each question has a set of attributes that determines its classification. As it is a test module designed for pupils at primary schools, these attributes will be the year, subject, subject of the issue, respectively question category. Next, it is necessary to add functionality to share questions between teachers different schools. The module must provide basic editing questions and filtering, respectively search the list of items. The module will perform the deletion of questions based on whether or not there are answers to that question. If there are no answers, the problem can remove from the database. Otherwise, its status will be switched (moved to the "trash") and will not be available to teachers. Remove of question is not possible because the information needed in the statistical evaluation is not lost.

The test module should be independent of the other modules. If we turn off this module (e. g. for maintenance), children can continue playing, but testing will not be supported. The module will be versatile and will, therefore, apply to a system other than the interactive learning portal.

INTEGRATION OF THE MODULE TO THE PORTAL

The collection of requirements indicated the need to ensure the independence of the test module. The design of the module database is to meet these requirements. This is advantageous in terms of availability. If the primary database fails, the test module database will continue to be available. Another advantage is a more natural exchange of database types. If we need it in the future that it will be necessary to deploy a different kind of database for the test module for some reason, this exchange can be made much easier and faster than if only one central database existed. They arose during the study, two architectural designs as part of the module integration design. The first design work with the idea of clearly microservice architecture. In general, microservices (MS) is as the architectural style that divides an application into a set of services that are highly maintainable and testable (Richardson, 2019). The test module would thus become completely independent. For implementation, it would be necessary to create a so-called Gateway API (GA), which can help to aggregate queries from individual MS. GA would also communicate with the presentation layer (client application, game module).

The advantage of the first design (Figure 3) is to achieve absolute module independence. The integration of this solution is a relatively big problem, as the effort is to interfere as little as possible with the existing system. If we create a new layer of the server part, it would be necessary to reauthenticate and redefine all endpoints at the highest level and create new aggregated parameters to retrieve data from both MSs.

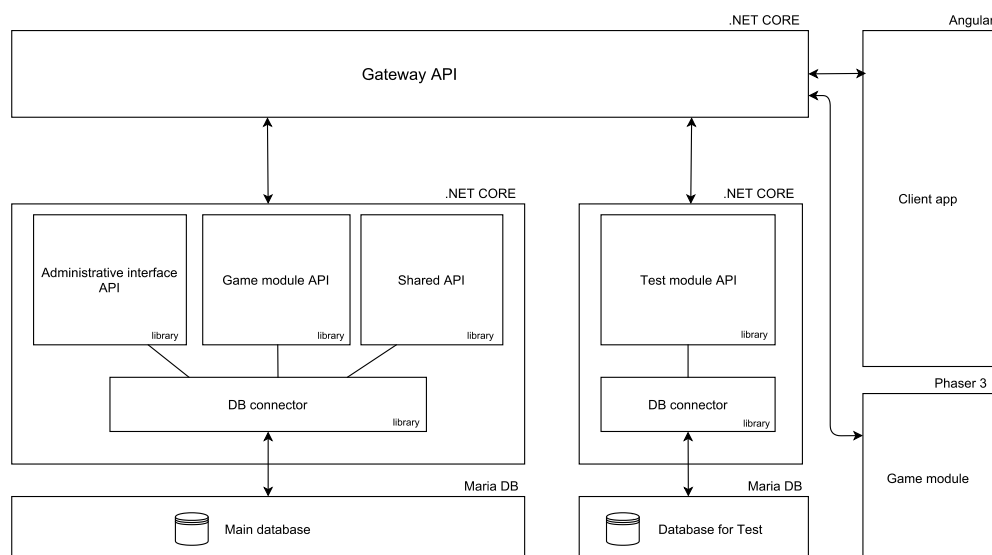


Figure 3: First design of architecture with Gateway API.

The second design (Figure 4) is based on the idea of creating a test module as a library. The significant advantage is that in this case, it is possible to use services from other libraries

because the functionality from other modules are contained in their libraries and exist in one solution. There is also no need to interfere with the existing solution. The idea of its database for the test module is also easy to fulfill. It will have its database connector (library to connect) for connection.

Based on the analysis of the individual integration proposals, the second solution, which is shown in Figure 4.

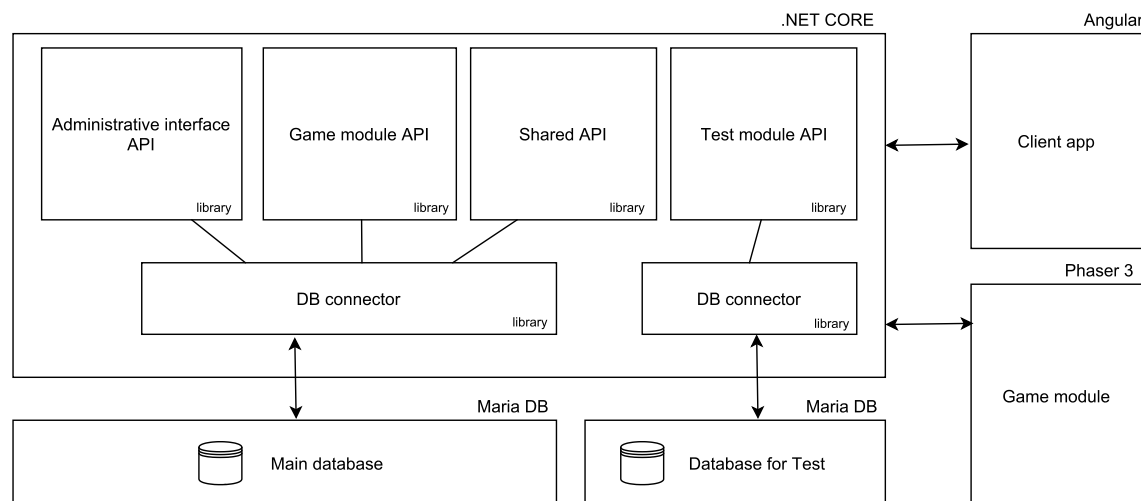


Figure 4: Second design of architecture

PROPOSAL FOR TESTING QUESTIONS

The main menu in the administration will display a link to the "Question List" page. When you open the page, you'll see a list of test questions that are filterable and searchable. This section will have two forms related to creating and editing a test question. The way will appear when you click the appropriate button. Form for creating a new test question that contains the following fields: difficulty, subject, visibility level, category, picture, number of points, question-wording, answer type, and response.

The difficulty is the selection of the year that defines the complexity of the question. Visibility level is the visibility identifier of the problem for other portal users. The type 'public' means that the issue will be available to every teacher or teacher and the user who has access to view question logs. Questions with visibility type "for school" are visible among the staff of the school. Type 'private' means that no one can see the problem except the author. The category is a closer specification of the question. It can define e.g., whole thematic subject. Functionality "Add a picture" can also add a picture to enter a question. This checkbox will decide whether to display the image input field—functionality "Number of points" its for evaluation of the problem. Question-wording is the text input of the question. With answer type can we select the answer type. The module requirements indicate that there are three types of answers to the problem. Last ist response, which depending on the kind of response you have selected, the corresponding text or text field is displayed image response. The number of reactions can be dynamically changed as needed.

Possibilities of creating tests

A test within this test module will be understood as a package of questions that has its title and description, author, and creation date. As shown in Figure 5, each issue has a checkbox, which serves to mark questions. In this way, the Test will be constructed. The user marks all the problems he wants to have in the Test and finally adds a title with a description. After you click the Add Test button, it is automatically added to the test log. Each Test can be further associated with the game. If necessary, it will be possible to assign multiple tests for each pupil. The analysis of the assignment showed the need to tackle classroom management for teachers. It would be very inconvenient to make assignments for each pupil separately. Categorizing pupils into classes will make it easier to assign a set of questions (Test) to a class and a game.

Two lists will be available for teachers as a games list and class list. When he selects one item from each list, he or she will be given information about the assignment of the Test to the game and class at each Test. If the Test has not been assigned to the combination, the assign button will be available. Otherwise, the override button will be active. Each assignment of the Test is identifiable by the Test, play, and class of the pupil.

The test status works the same as the question status. It also has the same status values. Maintaining test states is important because each student's response is tied to the Test. The system allows answering the same question from different tests if necessary. Therefore, it should be impossible to completely delete the test record if there is a response. Each Test will encourage sharing between other teachers and from different schools. The teacher who creates the Test gets the opportunity to share the Test. If they do, the Test will be shown to the teacher in the test records. The teacher to whom the Test was not shared has the opportunity to view the Test in detail but cannot edit it. However, it has all the questions in the Test visible regardless of the visibility level. Such a test can be assigned to the class and the game as needed.

IMPLEMENTATION OF QUESTIONS RECORD

Questions can be filtered by selected attributes using the QuestionFilterComponent component. Searching by text-based queries using the NbSearchComponent part is also supported. Each issue contains the information needed to identify it. The teacher can prepare questions that: created by himself, created by another user, and marked as public, created by another user, and marked their visibility within the same school as the current teacher browsing the questions. This filtering is provided by the server part, which offers the client applications the required data. The question list is provided through the QuestionListComponent component. Each question in the file contains buttons that can be used to call up the question mark, delete, or full view operation. The original proposal foresaw displaying in a table, but for better clarity for the user, ultimately, "tabs" were chosen to display questions (Figure 5).

The Test can be created in such a way that in the question log, the teacher marks all the problems he wants to have in the Test. Then choose the name and description of the Test. By clicking Create Test, the user is redirected to the Test List where the added Test is visible. Test sharing functionality is provided by the ShareDialogComponent component, which includes ShareDialogContentComponent. The first component is displayed as a button, and

when clicked, the second component is called to view a modal window in Figure 6. This window lists all teachers from all schools registered in the interactive portal. You can share a test by selecting a teacher and clicking the Share button.

At the top of the Test Records page, the teacher is offered the option of selecting a game and class. After choosing this data, a new button for assigning the Test to the game will appear for each Test. When you click the Assign Test button, the Test is assigned. If the Test is already assigned, a button for disabling the Test is displayed.

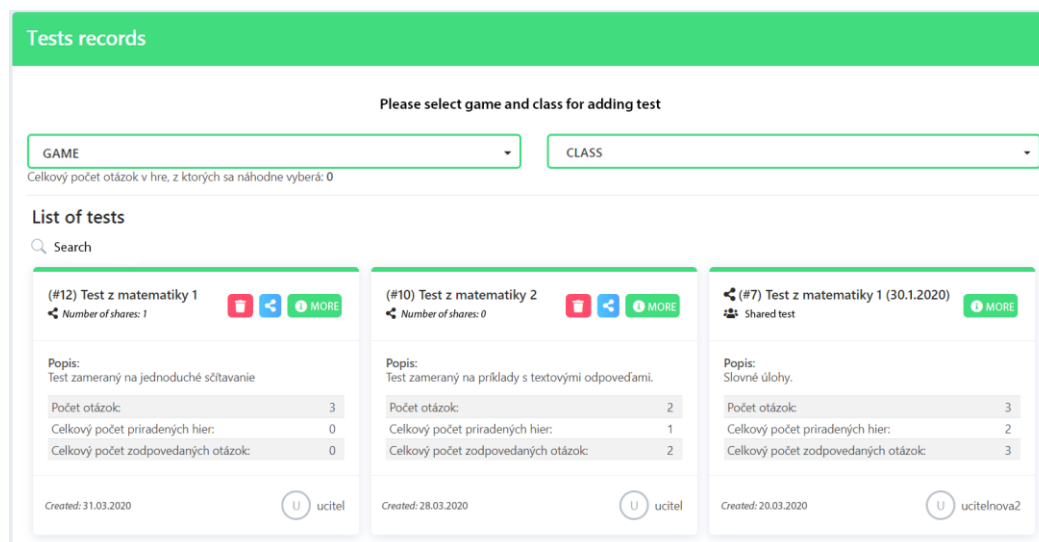


Figure 5: Example list of questions.

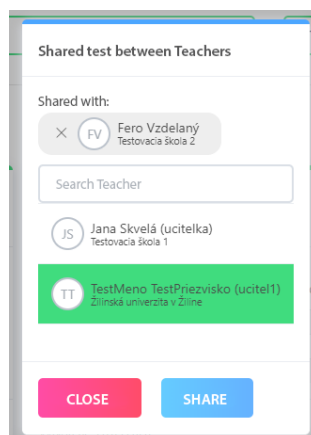


Figure 6: Modal window for test sharing.

Each Test has a detailed overview, which is provided by the TestItemComponent component. This report is divided into four main sections. Necessary information contains the name and description of the Test (Figure 7). Assign displays information about the assignment of the Test to the game and class. Sharing shows the list of teachers the Test which is shared. Test questions contain a list of subjects assigned to the Test. You can expand the detail for each item to see possible answers to the problem.

The described component contains buttons for editing and deleting the Test. When you click to edit a Test, the TestItemEditComponent component is loaded, which similarly

displays the data except that each part of the report is editable. Also, the element has the functionality of adding new questions.

The functionality of adding new questions is ensured by reusing the QuestionListComponent component. This component can also be used when editing a test utilizing the input attribute "editMode." If the value of this attribute is set to true, then the component displays all possible questions that can add to the current Test with filter and search capability. Items that are already being used in the Test are not displayed. Adding additional questions to the Test is done similarly to the Test.

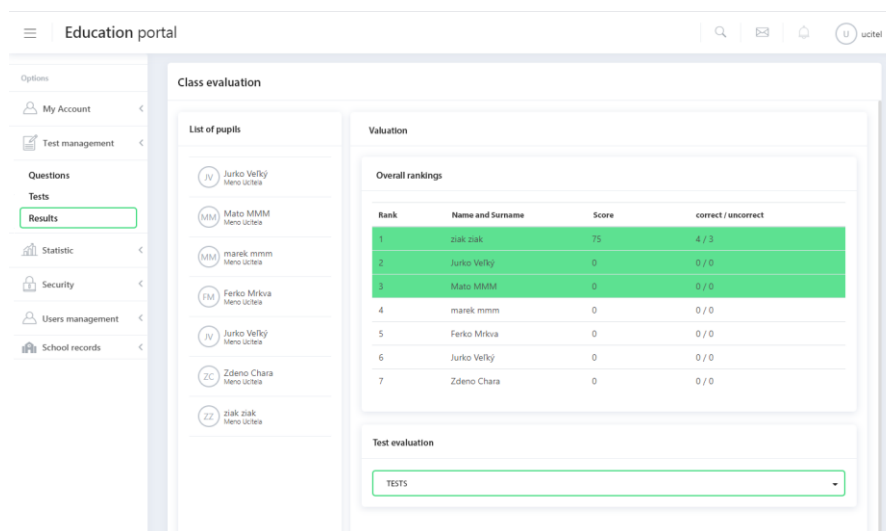


Figure 7: Example of class test evaluation

The pupil who starts the game automatically gets a unique ID with that launch. Based on this ID, it is possible to find out on the server-side which the pupil started the game and which game was started. The test module provides an endpoint for obtaining a random question among all the problems in the associated Tests. A generator offers randomness with even probability distribution. When submitting a question, it is essential to know which items have already been answered. Each question can only be answered once for each student. The final result of the score pupil Test is shown in Figure 8: this data shows two user type teachers and parents of the pupil.

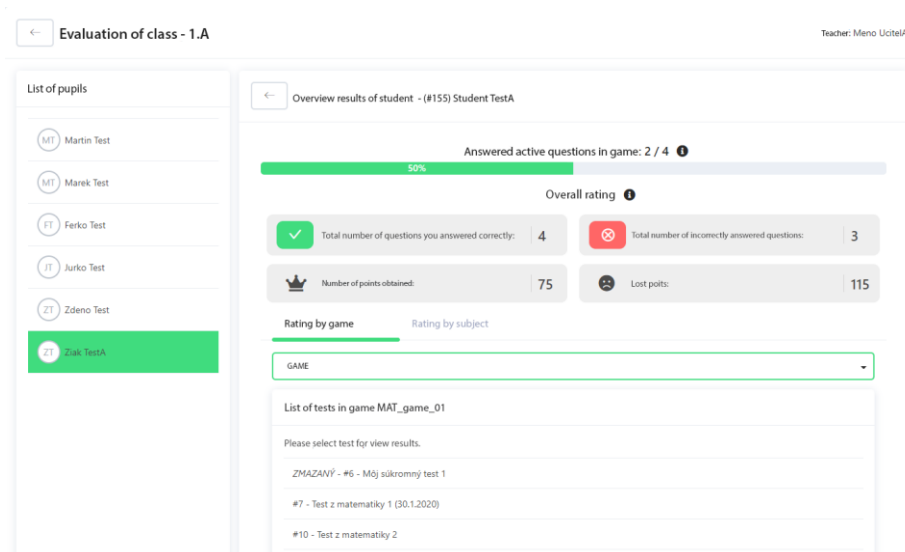


Figure 8: Example of pupil score evaluation.

CONCLUSION

The presented solution module of tests in this article will complement the interactive education system with new functionality that can be implemented in-game modules and in analytical modules. This set of modules will evaluate the results and detect possible anomalies using heuristics or data mining algorithms. Modul of tests allows creating various types of questions that can be applied for all kinds of educational subjects and combine them into the resulting analysis. The teacher can assign to the selected game prepared test or set of questions, where they will be shown either in the form of collection bonuses or a game interruption. At the same time, it is possible to share test questions between teacher teachers, which can help to improve the sharing of knowledge among teachers between schools and to identify problematic learners or problems in pupil grasping more easily.

ACKNOWLEDGEMENT

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Construction Robotic Kits in Education at Elementary School

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Abstract

The main aim of the thesis is to present the results of a questionnaire survey focused on the possibilities of implementation of a programmable robotic kit in education at elementary school. The first part of the paper introduces robotic kits employed at elementary schools in the Czech Republic. The main part of the paper is devoted to the research aimed at mapping the forms and methods of teaching robotics at elementary schools. The research also contains several secondary objectives, such as "What are the most commonly used robotic kits in education?" and "What teaching materials are preferred by pupils in education?" The research part builds on the previous survey, which complements and expands with other results. This work provides an overview of important findings that were used as a basis for the creation of teaching materials. Important findings include: students want to work in smaller groups of 2 to 3 students, they want to work at their own pace according to the illustrated worksheet for at least 2 hours. This paper gives an overview of the important findings that were used as basis for the creation of teaching materials. The final part of the paper presents created teaching materials, which contain a methodical part designed for teachers and a working part designed for pupils. All created materials were verified in teaching at elementary schools.

Keywords

Robot. Robotic Construction Kit. Elementary School. Worksheet.

INTRODUCTION

Currently, the topics of programming and robotics are being included in the standard curriculum of elementary schools, according to the ISCED classification (International Standard Classification of Education) it is Level 1 (Primary education) and Level 2 (Lower secondary education). Increasing emphasis is placed on supporting the development of algorithmic thinking of pupils and understanding the principles on which the present highly technical world is based.

Robotic construction kits are a suitable tool for teaching programming as well as for building simple machines and structures. They are also suitable for modelling and simulation of real systems (Hubálovský, Šedivý 2013). The range of robotic kits or learning robots is becoming wider every year and schools can choose the best ones according to their

requirements and possibilities. The paper presents an overview of the most widespread robotic kits used in schools in the Czech Republic.

Virmes research (Virmes, 2014) focuses on educational robotics, its description, division, definition, and especially the influence on the educational process in the interaction with children. Research questions focus on observing the interaction of children with educational robotics, they focus on the course of interaction, the type of interaction, the way of working with educational robotics and the effects of interaction. Lego Mindstorms uses NXT as a robotic set in research, Topobo as a construction kit and the RUBI robot from social robots. The last two named robotic kits are not used in elementary schools in the Czech Republic.

Lego Mindstorms uses the robotic kit in his research Shih (Shih, 2013). The topic of the research is understanding the factors that influence teachers' intention to use Lego Mindstorms robotic kits in elementary school. The study, using the Technology Acceptance Model, collected data from 17 elementary school teachers in Kaohsiung and Pingtung counties in Taiwan. The SEM (Structural Equation Modeling) method was used to test the hypotheses. Somyürek uses the same robotic kit in his study, which focuses on the integration of robotics into education and examines the learning of pupils' design skills (Somyürek, 2015). The development of digital skills in the field of STEM using robotic kits in elementary school is being investigated by Kvenild (Kvenild, 2017).

Lego Mindstorms EV3

The construction kit Lego is very popular and widespread among children. Originally a wooden kit that gained worldwide success after the start of plastic parts production. A wide range of different plastic parts makes the Lego kit a suitable tool for building any model or robot. As early as 1998, Lego introduced the RCX control unit, which made it possible to create full-featured interactive robotic models. A newer type of Mindstorms NXT control unit with a large graphic display and new types of sensors was introduced in 2006. In 2013, the latest version of Lego Mindstorms, the EV3, came with the latest NXT sensors. The basic I/O elements include a touch sensor, an ultrasonic distance sensor, a color sensor, a gyroscope and two types of motors. We can also use sensors from other manufacturers that extend the use of robotic kits in other fields, such as physics, chemistry and biology. Lego offers other robotic kits designed for younger pupils, such as Lego WeDo 2.0 and Lego Spike. Using Bluetooth technology, we can control robotic models using both tablets and smartphones. This is another step to support today's generation of Homo Sapiens Digital, as Prensky (2009) states in his article.

Fischertechnik

German plastic kit is similar to the Danish Lego kit. They offer many sets and models, some using interactive elements or designed for robotics and automation. There is a Mini Bot set for line-up, as well as several sets of the ROBO TX version or a more modern ROBO TXT version with a TXT controller that has its own 2.4-inch touch screen. A new feature of Fischertechnik is a set of modern 3D printers. The supplied robot programming software is ROBO Pro Software, which allows you to program the robot model using icons flowchart.

Merkur

Merkur is considered to be a traditional Czech brand in the production of metal construction kits. Thanks to its construction parts, the kit allows to build any model, as

proved by Otto Wichterle with his contact lens machine. Nowadays, thanks to the connection of electrical components and microcontrollers, we can build any robotic model and program it as needed. Merkur only offers sets of specific robotic models. Popular

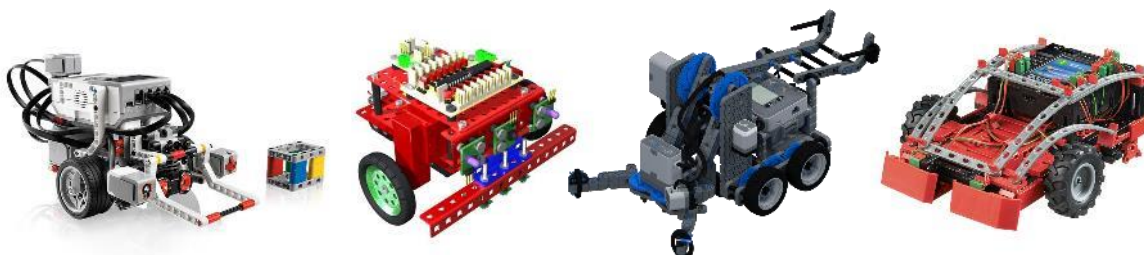


Figure 1: Construction robotic kits: Lego Mindstorms EV3, Merkur, VEX IQ and Fischertechnik (Coufal 2016, LEGO 2020, VEX IQ 2020)

robotic assemblies include ATMEL robotic mine or PICAXE robotic mine, the difference is only in the selected microcontroller and its programming. The robotic spider is built as a black line robot. Other robotic sets include the Mini SUMO robot for the sumo robots. In several versions we can try robotic hand.

VEX IQ

The VEX IQ construction kit uses plastic parts and is similar to Lego and Fischertechnik. However, the construction parts of the kit are larger and have a different way of joining the construction of the assembled models. It is also possible to print some pieces on 3D printers. The basic set also includes a remote control to control the robot. Multiple motors and sensors can be connected to the control unit without port resolution. For Lego Mindstorms EV3, it is necessary to differentiate between ports for motors and sensors. The VEX IQ kit is followed by the VEX EDR kit, which uses a metal construction, a more modern control unit, motors and sensors. This kit is designed primarily for students at high schools and universities.

RESEARCH

The presented research builds on and expands the research results from 2016 (Coufal, 2016), whose main objective was to map forms and methods of robotics education at selected schools in the Czech Republic. The main objective of the survey is the same and is complemented by six sub-objectives:

- Based on the data obtained from the questionnaires to find out of hours teaching robotics in one week.
- Based on the data obtained from the questionnaires, map out the types of classrooms used for robotics education.
- Based on the data obtained from the questionnaires to map the types of robotic kits used in schools in the Czech Republic.
- Based on the data obtained from the questionnaires to map the interest in participation in robotic competitions in the Czech Republic.

- Based on the data obtained from the questionnaires to determine the interest in various types of materials used in the teaching of robotics.
- Based on the data obtained from the questionnaires to find out the respondents' interest in robotics.

Based on the stated objectives, I have identified the research problem and research questions. The main objective is: What are the most common forms and methods of teaching used in robotics teaching? Based on partial goals I created partial research questions.

The concept of research

With regard to the objectives of the research, it is determined as the most appropriate research method with elements of quantitative research, which is suitable for obtaining information from a larger number of respondents. The research is complemented by qualitatively evaluated semi-structured interviews with teachers, which clarify and complement students' answers.

Research sample

When addressing the research respondents, a research sample was defined on the basis of criteria that include: use of the robotic set in teaching, involvement of the respondent's questionnaire in education, type of school, involvement in robotic competitions. When collecting data in the questionnaire survey, selected institutions were contacted only in the Czech Republic. In the case of data collection, two forms of the questionnaire were created, the first in paper form and the second in electronic form. The printed version of the questionnaire was created in MS Office Word and then distributed to selected institutions, or sent as an e-mail attachment. An electronic version of the questionnaire was created in Google Forms. Research respondents were sent a link to an electronic form to complete the questionnaire. After sending the electronic link, the questionnaire was completed on various devices, such as a computer, tablet and mobile phone.

Electronic collection of data from the questionnaire survey was advantageous especially in the collection and summarization of obtained data for further processing. The questionnaires were semi-structured divided into four parts and contain a total of 31 questions. The first part of the questionnaire is interested in the respondent, the second part focuses on the actual robotics education experienced by the respondent. The third part of the questionnaire is interested in teaching robotics that the respondent would like to have and prefers. The last part of the questionnaire survey is motivation competition for respondents. The semi-structured type of the questionnaire enables to obtain the field of structured answers as well as answers to open questions. Based on the stated objectives, I created the total of seven individual variables, to which I assigned specific questions from the questionnaire form.

RESULTS OF THE RESEARCH

The results from the completed paper forms were added to the tables containing data from the electronic version of the questionnaire. The data were further processed into tables or visualized using graphs. The answers to the open-ended questions were processed into frequency tables or listed in the summary of answers. This research expands the

number of answers obtained from the original questionnaire (Coufal, 2016), which contained 148 answers from respondents. In the current survey, it was possible to expand the number of respondents' responses to a total of 378 and it was more focused on primary schools. The results are compared in the overall summary as well as in the original and new survey. The evaluation of the research part of the questionnaire survey is compiled into groups according to the assigned research questions.

The first part of the questionnaire focuses on the answer to the question, its gender, age and type of schools attended. 72.11 % of respondents are men, the rest are women. The age distribution of respondents corresponds to the distribution of respondents according to the type of school attended. This primary questionnaire survey is focused on mostly on elementary school pupils, therefore the distribution of respondents by school type is as follows: elementary school 73.81 %, high school 13.76 % and university 12.43 %. In the case of the survey, the distribution of responses was as follows: elementary school 46.62 %, high school 26.35 % and university 27.03 %. The results show a change in the targeting of the questionnaire survey to elementary school pupils. For comparison, the original data containing respondents from other types of schools are given.

Evaluation of the main research question: What are the most common forms and methods of teaching used in robotics education? First, we will focus on the size of the group in which pupils work with a robot kit. Approximately half of 54.76 % of pupils work in pairs, 24.87 % of pupils work in triplets, 14.81 % of pupils work independently, other pupils work in large groups. The results of the previous survey are 58.11 % for pairs of pupils, 25.68 % for threes and 0.68 % for individuals. The last value is very interesting as it represents an increase of 14.13 % of pupils working independently in robotics education. One of the main reasons for this increase is the higher number of robotics kits in schools, which allows more pupils to work independently.

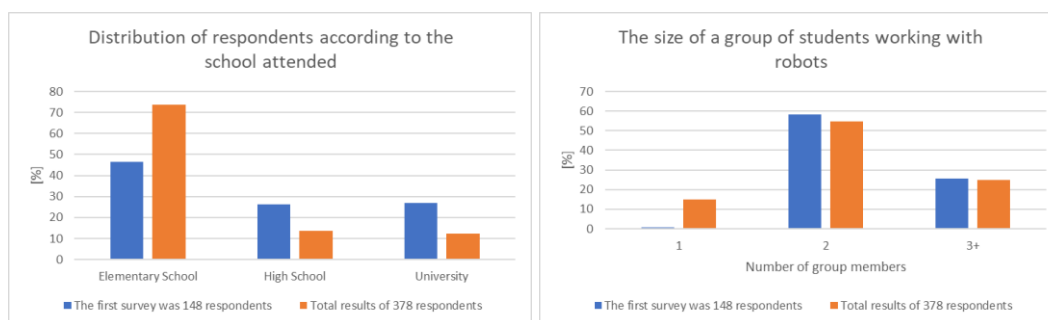


Figure 2: Graphs Distribution of respondents according to the school attended and The size of a group of students working with robots

The answers to the questions focused on collective teaching and project teaching are not completely relevant due to the frequent exact misunderstanding of these terms among the respondents. Nevertheless, 76.72 % report that they have encountered frontal education and a lower number of pupils 62.43 % report teaching in the form of project-based learning. The previous survey shows similar values of 75.68 % for classroom teaching and 60.81 % for project-based learning.

Then I found out the interest of students to work in groups. And what is the preferred size of the working group? The results of both surveys are similar when the vast majority of respondents want to work in a group (93.92 % and 86.24 %). The size of groups that pupils prefer most often consists of 2 or 3 members (86.49 % and now 82.01 %). The proportion of

pupils who prefer larger groups is 7.43 % and newly 4.32 %. Almost three-quarters of pupils welcomed and preferred the possibility to work at their own pace at 74.32 %. The assessment of pupils for their activity was determined by open questions. First respondents commented on the current evaluation method and then they had the opportunity to comment on the preferred evaluation method. The most common answers include grades or verbal evaluation for building a robotic model, for programming a robot or for completing a task, as well as some form of a reward, such as candy. Pupils prefer evaluation for activity in lessons, for effort and for work done, for the functionality of the built robot and for completing the task. There are a small number of other answers: for tests, for knowledge or for helping other pupils.

Table 1: Real and optimal teaching time

Teaching time [hours]	Real teaching time		Optimal teaching time	
	The first survey was 148 respondents	Total results of 378 respondents	The first survey was 148 respondents	Total results of 378 respondents
1	58,11 %	27,78 %	6,88 %	7,43 %
2	41,89 %	66,40 %	28,57 %	31,08 %
3	0,00 %	5,82 %	35,98 %	22,97 %
4	0,00 %	0,00 %	8,20 %	6,08 %
5	0,00 %	0,00 %	10,05 %	14,19 %
6+	0,00 %	0,00 %	10,32 %	18,24 %

The number of hours devoted to teaching robotics is found to be 1 to 2 hours per week. However, pupils' preferences push this level higher and most often want 2 to 3 hours per week (54.05 % and now 58.99 %). In the answers we find groups of students who prefer more hours of instruction, for example 5 hours and another group of students who prefer more hours of robotics per week.

Another part of the questionnaire survey investigated in which classrooms are taught robotics and what are the most used construction robotic kits in education. According to the answers, robotics education is most often carried out in the classrooms of informatics 72.30 % and newly 66.93 %. Further, the lessons take place in regular classrooms. The most used

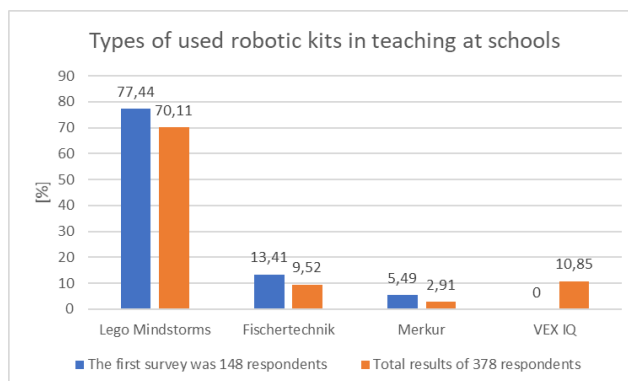


Figure 3: Types of used robotic kits in teaching at schools

robotic kits include Lego Mindstorms 77.44 %, Fischertechnik 13.41 % and Merkur 5.49 %. In the new survey the representation is different: Lego Mindstorms 70.11 %, Fischertechnik 9.52 %, and VEX IQ 10.85 %. At the time of the first questionnaire survey, the kit VEX IQ was not yet on the market.

In addition, the survey was focused on finding out how to program robotic models. And also finding out pupils' interest in robotic competitions.

Another part of the investigation is devoted to the teaching materials used. Pupils most often encounter the use of presentations and worksheets, or a combination of both (74.53 % and 89.15 %) in robotics education. However, pupils prefer to use worksheets and work together with the teacher (81.08 % and newly 78.01 %). According to presentations, only 10.81 % and 4.23 % of pupils prefer teaching. Other parts of the questionnaire focused on the form of teaching materials and their distribution, difficulty and evaluation.

The last part of the questionnaire survey examined the interest of pupils in teaching robotics. We choose the most common answers to open questions. Pupils like to learn robotics: building robots, playing with a kit, it's fun, competing, and doing their own projects. Pupils do not like: little time to teach, programming in English, finding mistakes in the program, difficult tasks. A significant part of pupils (78.38 % and newly 90.21 %) would like to have enough space to create their own projects in robotics education.

TEACHING MATERIALS

Teaching materials are important for the implementation of programmable construction robotic kits in education. The results of the questionnaire survey show the preferences of pupils in the form of teaching material. The most requested and at the same time the most frequently used teaching material is the worksheet, which is intended for work in a group. The size of the optimal group for working with a robotic construction kit is 2 to 3 pupils. The time required to work with the worksheet should be a maximum of 2 lessons. The worksheet should contain clear pictures and illustrations to complete the tasks. Tasks should be short, clear and divided into smaller units or tasks. The worksheet should include pupils' self-assessment. Teaching materials are designed for the most common used and at the same time the most used robotic construction kit Lego Mindstorms in version EV3.

Based on these findings, a set of teaching materials has been created that extends the set of already created and validated teaching materials in the previous work (Coufal, 2016). The teaching material contains a methodological part for teachers and a working part for pupils. The structure of the methodological part of the teaching material is created according to Maňák (2003, 2003), Kalhous (2002) and Hubálovská and Hubálovský (2016). The methodological part of the teaching material intended for teachers contains teaching objectives, which define the activities of pupils working with the teaching material. The necessary aids necessary for the pupil's activity are listed below. The main part of the methodological material is the teaching process with a worksheet. The procedure consists of the following parts:

- prolog
- motivation

- mobilization of the previous knowledge system
- exposure to new knowledge
- fixation of new curriculum
- practicing.

Prolog contains an introduction to the objectives and course of the lesson. The second part of motivation serves to motivate pupils to work with the worksheet. The third part identifies, mobilizes and reminds already know important knowledge that serves for further work with the worksheet. In the part of exposition of new knowledge, we transfer new knowledge and skills to the pupils, which they then fix in the next part. A part of the exercise is used to better and long-term consolidate the acquired knowledge and skills.

In the conclusion of the methodological part of the teaching material is stated how to work with the assessment and self-evaluation of pupils when working with the worksheet. Most of the teaching material is a worksheet for the work of pupils with a robot kit. The worksheet is divided into smaller parts, which contain individual tasks that follow each other. In the final part of the worksheet there is a part for pupils' self-evaluation. Worksheet topics focus on working with robot movement, working with sensors, solving simple tasks and solving competition tasks. Figure 4 shows an example of selected teaching material.

The verification of the created teaching materials took place at five elementary schools

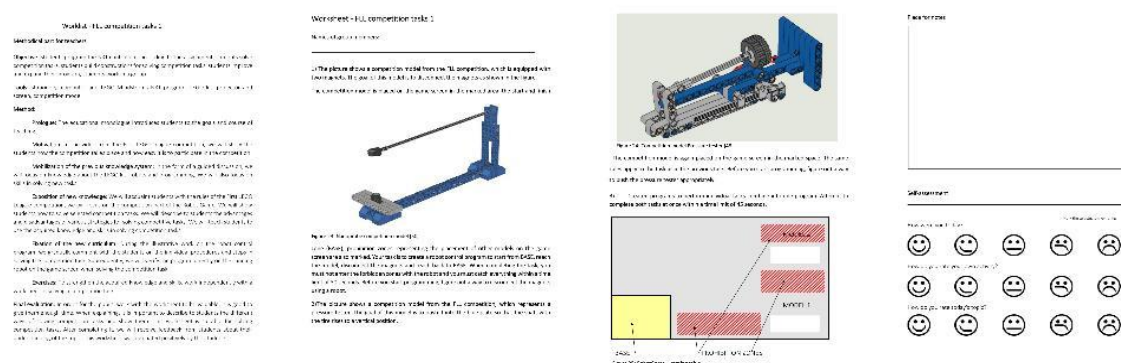


Figure 4: Demonstration of teaching material for solving problems with competition models

of various types: a small village school without teaching with robotic kits, a larger village school with its own robotic kits, a large city schools equipped with or without robotic kits. Teaching materials were verified both in regular classes and in leisure clubs at these schools. They were modified based on the feedback from the lessons with the created teaching materials (Hubálovská 2015, Voborník 2016).

CONCLUSION

This article focuses on the robotic kits used in teaching at elementary schools in the Czech Republic. Provides an overview of the most commonly used kits. The main research part consists of a questionnaire survey, which maps the forms and methods of teaching robotics in elementary schools and other sub-objectives. The research builds on previous

surveys, which complement and expand on further results. Based on finding out the form of real teaching and based on the requirements of students, a set of teaching materials was created for the use of robotic kits in teaching at elementary schools. The main findings are: the most used robotic kit is Lego Mindstorms, normal teaching time is 2 hours, students most often work in pairs, at the same time students want to work in smaller groups of 2 to 3 students, students want to work with a working illustrated sheet. The set of created teaching materials intended for teachers and pupils was verified in teaching at elementary schools.

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Development of E-learning Platform for Education on Sustainable Development

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Abstract

Sustainability is a concept approached at national and international level. Organizations apply the implications of sustainability to optimize their processes and operations. The company must apply the directions of sustainable development to improve the air quality and the quality of life. In this sense, education for sustainability is essential. This education must start from the first level of learning. Sustainability education functions as a strong reason for teaching and learning today. It can be defined as a transformative learning process, which equips students, teachers, schools and informal educators with the knowledge and ways of thinking so that society can achieve economic prosperity and quality of life. The learning modalities are different, but online platforms are gaining the attractiveness of individuals. These platforms are accessible to all individuals, and the learner can monitor their evolution and access them when available. This paper presents the functionality of a platform for education on sustainable development (EDS). This platform integrates two levels of learning: basic and advanced packages. The platform is available in several foreign languages. The following researches will focus on the efficiency of the platform.

Keywords

Sustainability education, sustainability, education, e-learning, online platform, sustainable organization.

INTRODUCTION

Sustainability is an approach increasingly addressed. The current situation at global level encourages efforts for sustainability. Sustainability presupposes that an enterprise has

the capacity to secure its long-term resources and to anticipate its future needs, effectively and equitably utilizing the resources within the organizational activities. This is a reference definition, developed since 1987 by Norwegian Prime Minister Gro Harlem Brundtland in the report entitled "Our Common Future", carried out by the World Commission for Environment and Development, under the leadership of the United Nations. Sustainability does not just mean ecology, but it also strikes a balance between the three responsibilities: economic, social and environmental. These responsibilities are incorporated in most existing definitions in the literature, where there are a number of concerns for social equity and economic development. Sustainable development starts at the individual level. In this sense, starting from the individual, the route for sustainable development is followed (Burianová et al., 2016; Dolenc, 2015). An important aspect in this regard is to encourage individuals to consider significant future-oriented issues.

Sustainability education aims to train thinking and acting in ways that will protect the future well-being of our people (Oluwagbemi et al., 2014; Libbrecht et al., 2015; Maněnová et al., 2014), organizations and our planet. Sustainability education includes learning about:

environmental dimension - water, trees, land, ecosystems, energy, waste, urban living, transport; actions we can take to prevent, reduce or change activities that are harmful to the environment.

social dimension - the interactions between the natural environment and human activities and their consequences, improving welfare, improving air quality, increasing the level of individual development, reducing poverty.

economic dimension - increasing the economic level, cost efficiency, improving the level of globalization.

The paper is structure in two directions: the presentation of the competences for sustainable development and the presentation of an online platform for education on sustainable development. In the conclusions part, the paper presents the future research directions.

COMPETENCES FOR EDUCATION ON SUSTAINABLE DEVELOPMENT

Global education for sustainability starts from the basic elements to the intercultural education. General topics covered for sustainable education are present in Figure 1. Development education includes elements about developing the skills and abilities related to sustainable development (Balogh et al., 2016; Biro, 2013). Human right education includes legislative measures related to human rights and its obligations. Education for peace and conflict prevention refers to preventive actions for a healthy and conflict-free life. Intercultural education emphasizes international cooperation. Global dimension follows at global development directions (Cornelius-White et al., 2010). Education for Citizenship involves the balanced action of people in everything they do.

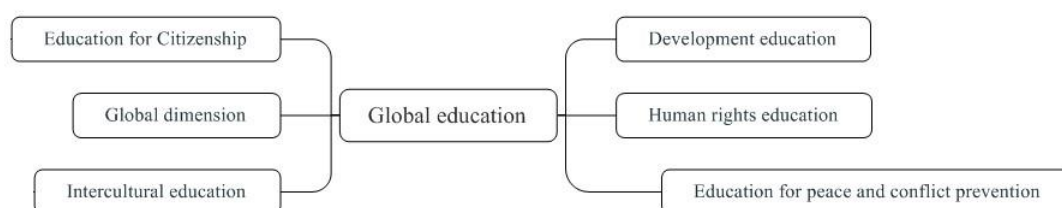


Figure 1: Global education for EDS

The competences that an EDS educator must possess are shown in Figure 2. Competence is the set of demonstrable characteristics and skills that allows the educator to transmit EDS information to students. For sustainability education, these competences are structured in four directions:

- Learning to know
- Learning to do
- Learning to live together
- Learning to be addresses

By evaluating each category of competencies that the educator must have, the implications of the competences map presented in Figure 2 can be outlined.

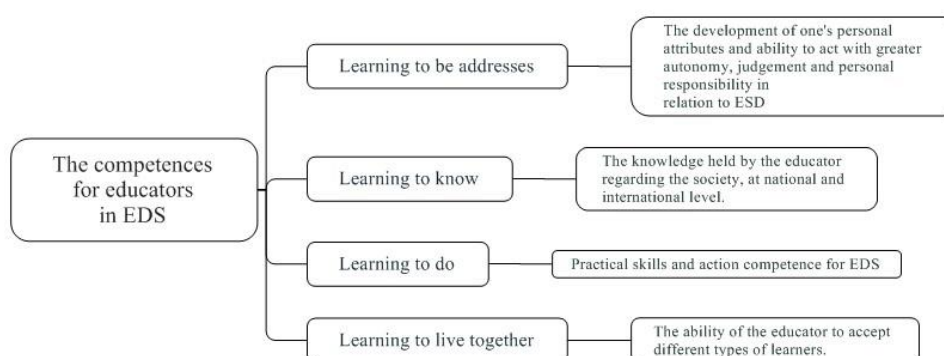


Figure 2: Types of competences of the teacher

The main concepts that learners can develop through EDS include:

- Sustainability - the ability of individuals, groups and communities to meet their needs and aspirations so as not to affect future generations' development.
- Responsibility - balanced involvement in all activities, including society.
- Equity - respect for all life, nature, economy, society, social justice, intergenerational equity, finite resources, and balanced involvement.
- Interdependence - biodiversity, community, interconnectivity, connection, cultural diversity, democracy, globalization.

- Responsibility for action - making informed decisions, enterprise, resilience and regeneration, capacity for real evaluation of organizations.

The following table presents the relationships between education (Strnadová et al., 2015; Flogie et al., 2015; Hubálovský, 2012) and sustainability.

Table 1: Relationship between education and sustainability

Dimension	Concept of EDS	Implication of sustainability	Expected direction to be learned
Social responsibility	We learn about how we must learn activities to support society	Elements related to the civil society	Important elements of society
Environmental responsibility	We will learn about the environment, waste management, air quality management, limiting natural resources	Natural resources management and greenhouse gas management.	The important elements of the environment and the interacting factors.
Economic responsibility	We will learn about economics and cost efficiency.	Balancing costs and making investments more efficient.	Ability to evaluate investment and production costs.
Transportation	We will learn about transport, the types of transport and the level of pollution.	Responsibility for action - making informed decisions	The ability to decide on the type of transport.
Fair trade	We will learn about trade and equitable methods of action, appropriate sales behaviour.	Equity and responsibility for action - making informed decisions	The ability to decide on the type of fair trade.
Green production	We will learn about the life cycle and the implications of the production processes.	Responsibility for action - making informed decisions and production management	Efficiency of the product life cycle.

TEACHSUS PLATFORM FOR ESD

TeachSus is an innovative and interactive platform to educate students in the field of sustainability. This solution for EDS was developed within the project "Teaching and Educating for Sustainability". The platform is available for trainees from all countries and integrates current information. This platform was developed within the project together with partners from different countries. TeachSUS platform includes:

- identifying the level of learning of the learner in sustainability,
- the learner's learning according to the knowledge they have,
- a forum for discussions,

- a centre for sustainability.

The courses are oriented in two directions: technical and soft skills. For each category, there are a series of courses. Figure 3 presents these elements.

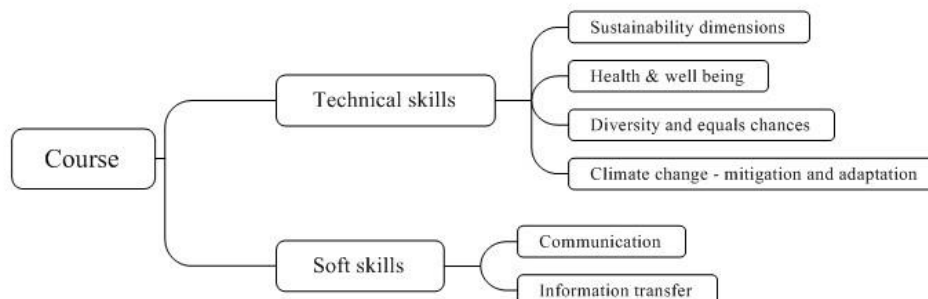


Figure 3: TeachSUS platform

TeachSUS platform is dynamic and attractive, Figure 4. To address the levels of learners, the platform is designed for beginner and advanced learners. The knowledge is different for the two levels, and the EDS must be adapted to them. It integrates two categories of learning according to the level of the individual:

- the basic package,
- the advanced package.

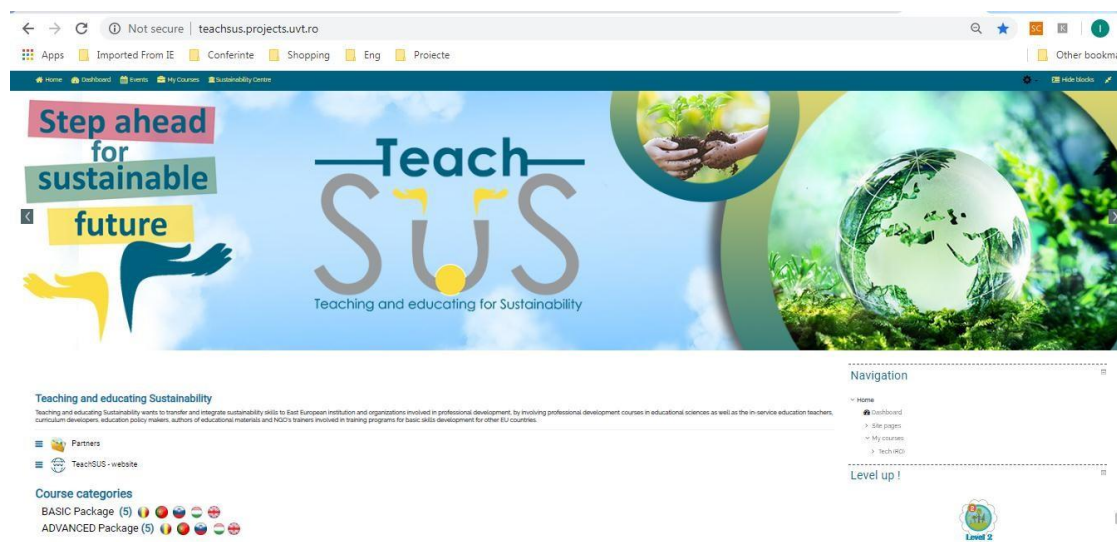


Figure 4: TeachSUS platform

To increase the attractiveness and to identify the level of the learner, a minigame is used and a short basic question, Figure 5. Gamification accelerates experimental learning. Gamification means learning about what goes well and what motivates learners in games. One of the motivating elements of the games is that the player always wants to continue.

The games create that fun thing that causes the trainee to play forever and ever. Perception level and motivation are essential elements of gamification.



Figure 5: TeachSUS platform – let's play a game

For each student there is an evolution of the performance and the preparation. Figure 6 shows the level reached for each student. The management of the learning level contributes to the motivation of the students and to the improvement of the learning results. Each trainee will be informed in real time about the courses taken and the levels achieved.

	First name / Surname	Last in course	Progress Bar	Progress
	Donath Liliana	Monday, 3 February 2020, 11:19 AM	<div></div>	0%
	Gabriela Mircea	Never	<div></div>	0%
	Hintya Andras	Never	<div></div>	0%
	Ivascu Larisa	Friday, 28 February 2020, 9:34 PM	<div></div>	0%
	Licz Anton	Never	<div></div>	0%
	Mihaela Muntean	Monday, 24 February 2020, 12:35 PM	<div></div>	100%
	Neamtu Mihaela	Wednesday, 19 February 2020, 5:28 PM	<div></div>	0%
	Neniciou Adina	Never	<div></div>	0%
	Nicoleta SIRGHI	Never	<div></div>	0%
	Pcardoso Pcardoso	Never	<div></div>	0%
	Rozman Tomislav	Never	<div></div>	0%
	Teacher Teacher Test	Friday, 28 June 2019, 11:0 PM	<div></div>	0%

Figure 6: TeachSUS platform – Overview of students

Another feature of this platform is the Sustainability Centre, Figure 7. This centre will connect with a number of existing research units at the entity level. A series of researches

will be carried out in collaboration with the industry in the field of sustainable development. This centre integrates a series of research with impact among researchers.

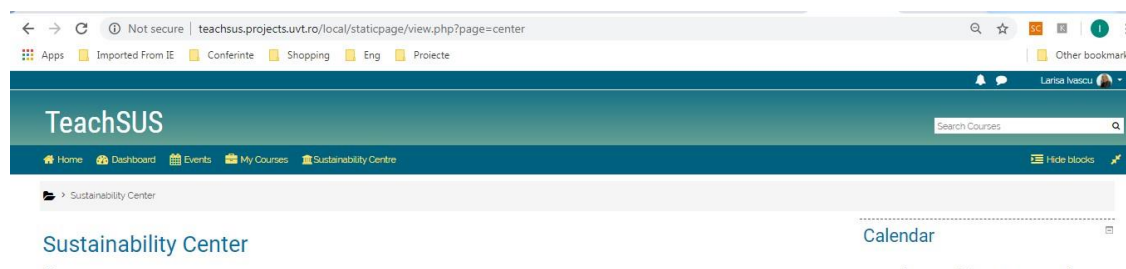


Figure 7: Sustainability Centre

Online learning presents a number of benefits for learners. These advantages include flexibility, time efficiency, access to information when the learner has time, high information and others (Kordigel Aberšek, 2016; Strnadová et al., 2015b; Reichel et al., 2014). This platform developed for EDS has the following advantages:

- information about ESD in several different formats
- efficient method of providing information
- resources are available anywhere and anytime
- Web-based learning promotes active and independent learning
- through discussion boards and chats, you are able to interact with everyone online
- graphic learning helps increase motivation
- the materials are available in several foreign languages
- the graphics of the materials allow easy learning
- displaying the bar for evolution helps motivate the students
- the materials are complete, systemic and accessible
- confidentiality of individuals by creating personal accounts.

DISCUSSION AND CONCLUSIONS

Education for sustainability enables the acquisition of knowledge, skills, attitudes and values necessary to shape a sustainable future. The objective of this platform is to increase the level of education of the population in the field of sustainability. The courses for education target the main problems of sustainable development: climate change, disaster risk reduction, waste management, energy from renewable sources, biodiversity, poverty reduction and sustainable consumption. TeachSUS platform meet sustainable development objectives of Agenda 2030. Educators have strong competences in the field of sustainability and teaching. By evaluating the presented solution, the following can be concluded:

- Sustainable development is an approach appreciated and implemented at national and international level. The demand for information in this field is high.
- The web address of the TeachSUS platform is <http://teachsus.projects.uvt.ro/>
- The platform motivates and empowers students to change their behaviour and to take appropriate measures for sustainable development. Education for sustainable development promotes skills such as critical thinking, imagining future scenarios and making decisions collaboratively.
- Education for sustainable development requires major changes in the way education is practiced today.
- TeachSUS platform was developed for the two levels: basic and advanced skills.
- The modules are developed in accordance with the main approaches to sustainability.
- The solution integrates technical and software skills for sustainability.
- The functionality of the solution offers confidence, motivation and involvement.
- The Sustainability Centre aims to have national and international connections.
- Concerns for sustainable development concern the evolution of the environment and global demands. It takes into account the needs of the individual, the organization and the clusters to grow healthy.

Future research will focus on updating sustainability information in line with global requirements. The functionality of the platform will expand in different fields and areas of action.

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Teaching through the use and development of mobile applications

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Abstract

More and more users are using mobile devices and the Internet of Things. Especially for children and young people, these technologies are becoming increasingly popular. Many children prefer mobile devices and use desktop computers less. Adult users also prefer to access the Internet and communicate from their mobile devices than from desktop computers. The article aims to find out how the use of mobile devices has changed in recent years and what time pupils and students use mobile applications. The respondents' estimate was compared with the actual time of using mobile devices during the day. This article describes the possibilities of using mobile applications in teaching, especially in study courses dealing with programming and development of mobile devices. The questionnaire survey focused on how students evaluate courses and how students perceive the education of mobile application development. The observation method was also used. The motivation and activity of the students during the case studies was monitored. Research shows that mobile devices and mobile applications can serve as suitable learning tools. Case studies conducted with high school and university students describe the possibilities of teaching mobile application development. These studies show opportunities in teaching the development and use of mobile technologies. Results confirm more efficient teaching of algorithmization and programming.

Keywords

Application, case study, development, education, mobile device, programming, questionnaire.

INTRODUCTION

Mobile technology is currently developing very rapidly and is involved in all aspects of life. A large part of the population uses devices such as smartphones, tablets, laptops, convertible devices, smartwatches and readers. Mobile devices represent a breakthrough in the use of computers and require a new approach. Greater emphasis is placed on the use of cloud services and data synchronisation with other devices. The use of mobile devices is increasing (Pachler, Cook, Bachmair, 2010). The number of Internet accesses from mobile devices is higher than from the desktops. Mobile devices are especially popular among children and young people (Burianova, Turcani, Balogh, Mudrak, 2018) (Chassiakos, Radesky, Christakis, Moreno, Cross, 2016) (Radesky, Schumacher, Zuckerman, 2014) (StatCounter, 2020).

The thesis aims to find out how and how often pupils and students use the application on mobile devices. A questionnaire survey was used to find out, in which the respondents mentioned the most frequently used mobile apps and the way of working with mobile applications. The estimated time of respondents in using mobile applications was also compared with real use. The aim was to find out if young people are aware of how much time they spend using mobile apps. A hypothesis was established:

H1: Pupils and students are not able to correctly estimate the time spent using mobile applications.

Mobile applications are trendy among young people, and therefore it is appropriate to use this interest to motivate them in teaching. The second hypothesis was verified using case studies.

H2: The interest in mobile applications can be used as motivation in teaching programming.

METHODOLOGY

The use of mobile applications was investigated among primary and secondary school pupils as well as among university students.

In 2004, 2013 and 2019, a questionnaire survey was conducted among students of the bachelor's study program Applied Informatics. Another questionnaire survey was conducted in two other groups of respondents. The first group consisted of 32 primary school pupils and the second group consisted of 138 secondary school pupils. The questionnaires included six questions that examined respondents' age, time spent using mobile devices, types of mobile devices used, popular mobile applications, and cloud services. The items were open and closed. The questionnaires were anonymous, but the students placed their mark on them. Forty-one respondents then monitored the real-time use of mobile applications for a week. The real-time and estimated time were then compared using a t-Test.

Subsequently, case studies were performed. The influence of using mobile devices in teaching programming was investigated. The first case study was conducted among 134 students of the bachelor's degree in Applied Informatics and high school pupils. During the teaching, the motivation of pupils and students and practical skills acquired in education were monitored.

Data were processed using t-Test. The results were processed using MS Excel and the statistical software Wizard for the Mac OS X operating system and the statistical software Statistics Visualizer for iPad (Chráska, 2007).

RESULTS

Results of the questionnaire survey

The first survey was conducted in 2004 among 63 bachelor students. The aim of the survey was to find out how students use mobile devices. Most students used a laptop. Only a minor part used other mobile devices.

A second survey was carried out at the end of 2013. It was attended by 113 undergraduate students. Of these, 66 were full-time students, 57 were distance students. The survey confirmed an increase in mobile usage. Among the students, the most commonly used mobile device was a laptop in addition to a mobile phone. 64% of respondents used the notebook in 2004, 89% in 2013.

The most significant difference between the survey results was seen in the use of smartphones. While in 2004 only 8% of students owned a smartphone, in 2013 it was 78%, in 2019 it was 100%. In 2019, a survey was conducted among 52 students. There were 36 full - time students and 16 distance students. The number of mobile devices used increased again.

The following graph (Figure 1) compares the survey results between students in 2004 and 2019. As expected, all students currently use smartphones. The use of tablets and laptops has increased. Students no longer use PDA and Cell phone.

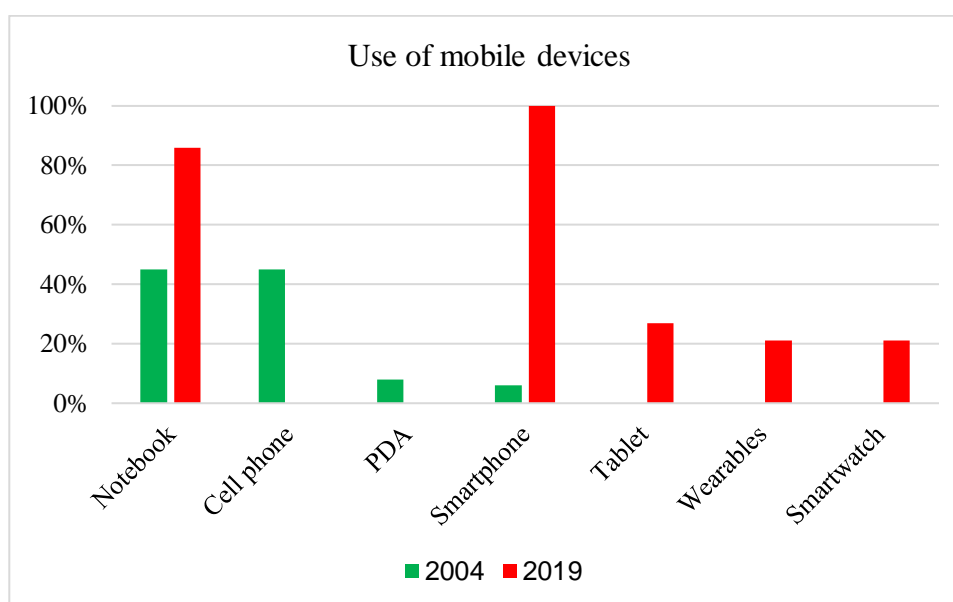


Figure 1: Comparison of research results among students in 2004 and 2019.

The graph in Figure 2 shows a comparison of the results of the questionnaire survey in three groups of respondents. The first group were primary school pupils. The second group consisted of high school pupils, and the third group consisted of university students. The results show a comparison of the answers to the question: How often do you use gaming apps on your mobile device? (1 = many times a day, 2 = once or twice a day, 3 = occasionally, several times a week, 4 = using very little, 5 = not using at all). The results confirm that younger children mainly play mobile games. With age, the use of games on mobile devices is declining. On the contrary, the use of mobile applications for social networks and communication is increasing (Kuhnel, Seiler, Honal, Ifenthaler, 2018).

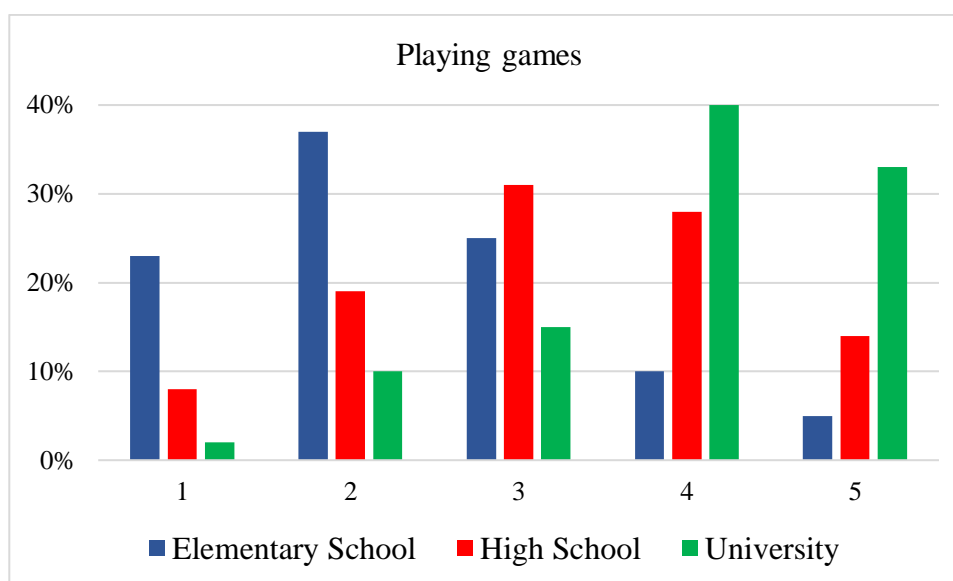


Figure 2: Compare mobile usage.

One group of respondents was aged 13 to 19 years. The average age was 15.8 years and median 16 years. Respondents said they use mobile devices on average 210 minutes per day (Figure 3).

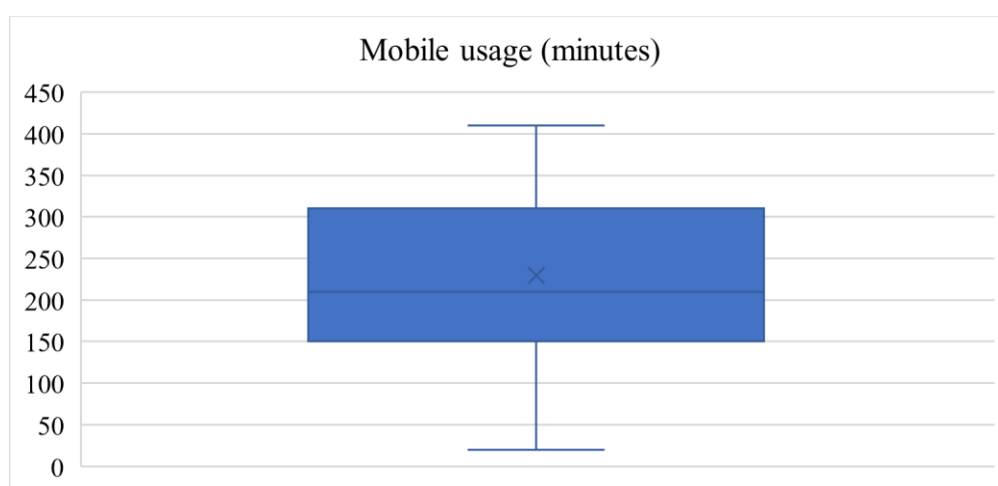


Figure 3: Estimate time spent using mobile devices.

Figure 4 shows that the most popular apps are Instagram, YouTube, Facebook and Games. 68% of respondents use Instagram and consider it the most popular mobile app. The results show that respondents mainly use mobile devices to consume content, entertainment and communication. Few respondents use mobile applications to teach, create and process data.

There is a difference in the use of mobile devices in different age categories. Younger respondents in another survey that we conducted in 2018 had other popular apps. The average age of respondents was 13.5 years. 60% of respondents have the most popular gaming applications. 50% is YouTube as a favorite app. 55% as when using communication applications (Messenger, Skype). 50% is a popular application for social networks (Facebook, Instagram) (Kuhnel, Seiler, Honal, Ifenthaler, 2018).

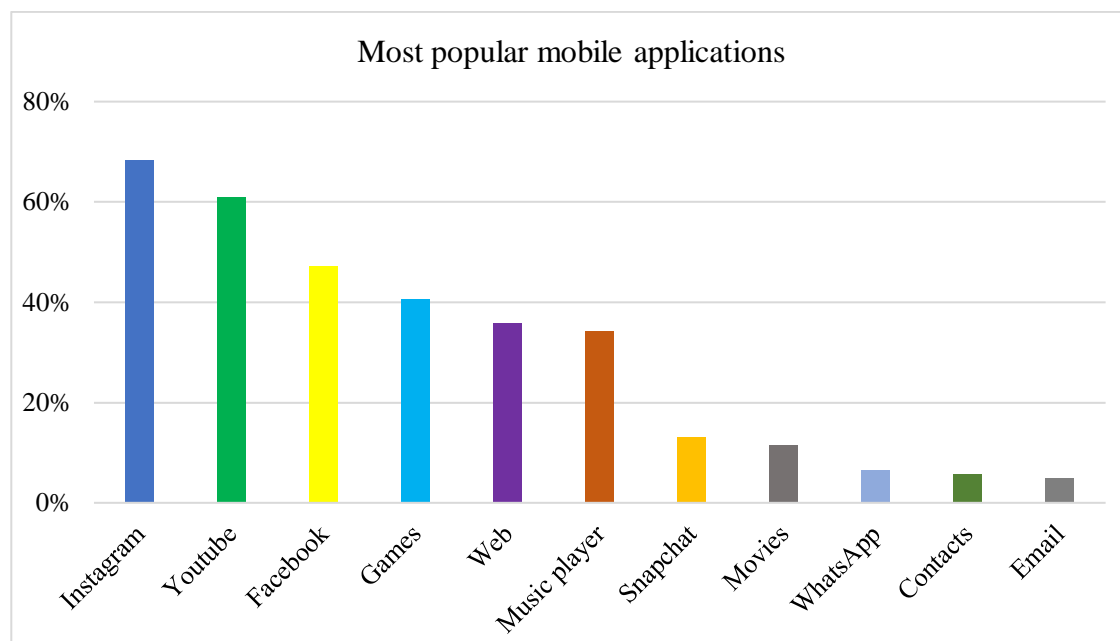


Figure 4: Most popular mobile applications.

Results of the comparison of the use of mobile applications

Forty-one respondents in four study groups marked their questionnaires with their brand. Subsequently, in one week, they monitored the actual use of mobile applications. Time measurement was performed either using system tools or with the help of the QualityTime mobile app. Respondents' estimates were then compared with actual times.

The following two charts show the results of ten pupils in the first tracked group. The graphs show a comparison between real and expected usage times for mobile devices. In the monitored group, the average difference between real and estimated mobile use times was only two minutes. Similar results were also observed in the other controlled groups of students. In 36% of the respondents, the difference was not significant between the estimate and the real-time of using mobile devices.

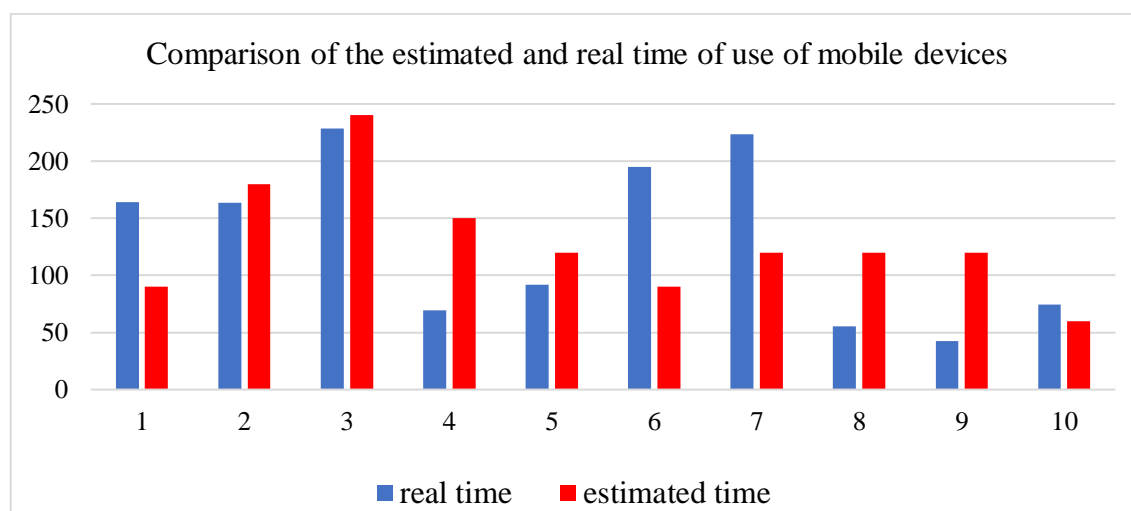


Figure 5: Comparison of the estimated and real time of use of mobile devices.

Figure 6 shows how ten respondents often use mobile devices. Respondents on their mobile devices watched which of mobile applications they use and how long. The survey confirmed that young people use mobile devices for a long time during the day. Often this is at the expense of other activities.

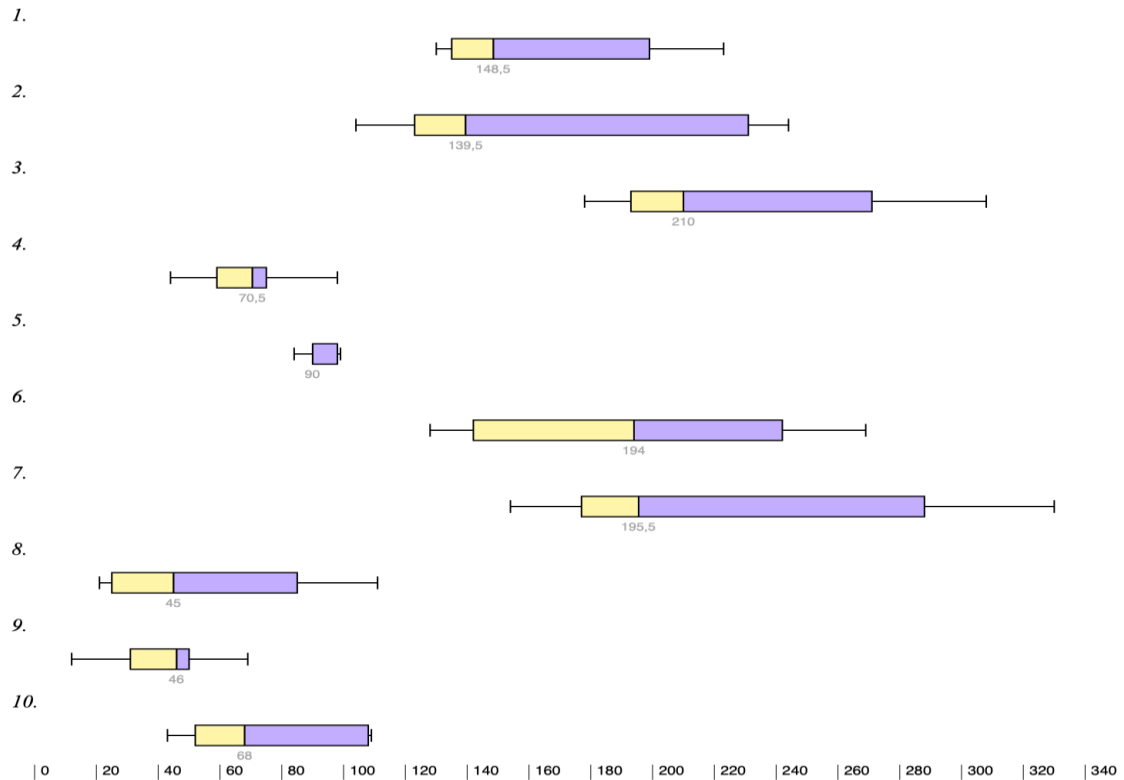


Figure 6: Time to use mobile devices.

Table 1 shows the results of the t-Test. The results show that at the significance level of 0.05, it is not possible to reject the null hypothesis. Respondents' estimates do not differ significantly from the measured times. Twenty respondents had real-time using mobile devices higher than their estimate. On average, the time was 34 minutes longer. Twenty-one respondents, on the other hand, estimated that they used mobile applications more than they actually did. On average, the time was 25 minutes shorter.

Table 1: This caption has to be centred.

t-Test: Paired Two Sample for Means	Real time	Time estimation
Mean	205,7317073	202,0487805
Variance	10532,10122	11162,14756
Observations	41	41
Results		
t Stat	0,596136366	
P(T<=t) one-tail	0,27722144	
t Critical one-tail	1,683851013	
P(T<=t) two-tail	0,554442881	

t Critical two-tail

2,02107539

Teaching programming through mobile application development

Mobile devices can serve as a means of learning programming. Teaching programming through mobile application development can strongly motivate pupils. This fact can be seen in the growing interest of students in the subject Development of mobile applications and topics of bachelor theses focused on mobile technologies. Programming teaching through mobile application development can also be applied in high schools. Students are interested in this type of education and are able to create mobile applications. Mobile application development courses were prepared for secondary school pupils. The course participants were from different high schools and had different programming skills. Only four pupils had a basic knowledge of object-oriented programming, four pupils did not have programming skills, and 11 participants only learned structured programming. None of the participants had experience with iOS development or computers running Mac OS X. The course aimed to show pupils procedures based on appropriate architecture, design patterns and framework usage. These are the procedures currently used to develop applications in practice. The course consisted of five meetings lasting three hours. Pupils were interested in mobile technology. Using examples of mobile application development, pupils naturally learned about modern programming techniques (ZahidaParveen, Nazish, 2016).

Other case studies were conducted among students of the bachelor's degree in the subject Mobile Application Development. The students were interested in this course, and they were also active during the lessons.

As found in practical lessons and courses for high school pupils and university students, learning programming through mobile application development has the following benefits:

- Mobile application development is motivating for pupils because there is interest in mobile application development courses.
- Students program practical applications. As a result, teachers can avoid the often widespread creation of ad hoc examples that have no practical use and serve only to practice the topic. Instead, these examples demotivate pupils, and many teachers resort to them because it is easier for them to create tasks.
- Students will learn practical examples of modern programming procedures. An object-oriented approach is needed. Using appropriate methods, students will acquire the right habits that they can apply in the development of desktop applications.
- The structure of today's mobile operating systems requires developers to use appropriate frameworks, design, and architectural patterns that are often used only marginally in classical programming teaching.
- Students learn a comprehensive view of application development and are not limited to standalone language constructions.

Teaching programming through mobile application development also has drawbacks such as:

- Developing mobile applications is more challenging for pupils than simple console programs.

- Pupils need to learn development tools that are often more complex and less transparent for beginners. A specific part of education should be devoted to familiarization with the development environment.
- Specific development platforms and programming languages must be used. The choice of programming languages is usually limited according to the particular mobile platform.
- Insufficient equipment in some schools prevents the expansion of teaching.

The case studies were conducted in seven study courses. A total of 134 pupils and students from secondary schools and universities attended courses. At the end of each session, pupils and students completed a questionnaire in which they rated the course. 81% of respondents said they liked learning how to develop mobile apps. On the other hand, only 6% of respondents considered the development of mobile applications complex and did not like the course.

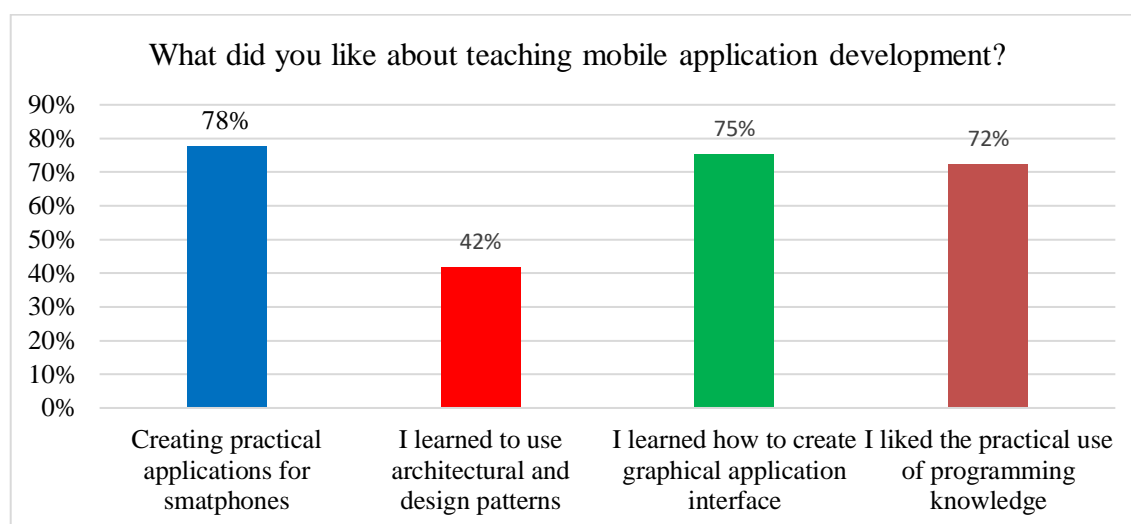


Figure 7: Evaluation of study courses.

Students can test their mobile applications on their mobile device or use a simulator for iOS or an emulator for OS Android. A simulator or an emulator can be run on a personal computer. Students can try using devices that are not physically available. The simulator allows you to test the created application. Android Studio used development for Android devices. The development environment can be used on computers running MS Windows, Linux and macOS. Java was used as a programming language, which the students already knew from previous programming courses. Developing for iOS devices is more complicated. For the development of native applications, it is necessary to have computers with operating system macOS. The second obstacle is that pupils have to learn the new Swift programming language. Student observations and case study results show that Swift is not too complicated and challenging for students (García, Espada, Pelayo G-Bustelo, Cueva Lovelle, 2015).

Mobile applications can serve as a suitable tool for learning programming. Case studies and experiments have shown that children enjoy working with mobile applications. For example, Scratch jr., Ozobot Bit, Programmer, Move The Turtle mobile apps can be used to teach children. We also tried the Playground mobile app. The Playgrounds mobile app on

the iPad proved to be suitable for teaching algorithms and the Swift language. Children learn in the form of a game in which children perform tasks and control a character who passes through a changing flying island, collects gems, passes through portals and the like.

DISCUSSION

As expected, the results of the survey confirm the increased use of mobile devices. Over the last fifteen years, the regular use of mobile devices in everyday life and teaching has improved. New devices such as smartphones, tablets, wearables and smartwatch have appeared. Other devices, on the other hand, have disappeared among young people, such as simple cell phones or PDAs.

They use these technologies during the day for a long time. The results show that respondents mainly use mobile devices to consume content, entertainment and communication. Few respondents use mobile applications to teach, create and process data. Research results show that this depends on the age category of mobile users. Younger respondents mainly used mobile games. This result was to be expected. Teenagers prefer communication and social networks. Some respondents used mobile applications to help them in their daily lives or at school. For example, communication, information retrieval, public transport and the like. Statistical results show that respondents are aware of how long they have been using mobile applications during the day. An essential task of educational institutions is to show that mobile devices and applications can be used not only for entertainment but also for teaching, improving lifestyle, better communication and practical daily activities.

Observations during the case studies confirmed the second hypothesis. Pupils' motivation was higher than in standard programming lessons. The reason was not only the interest in mobile applications but also the fact that students programmed practical applications that they could use in their mobile devices. In ordinary programming lessons, programs are often created that cannot be used much in practice, and many children are less motivated to do so. This situation should be reflected in educational institutions. Instead of theoretical programs focused mainly on mathematical programming tasks, it is more appropriate to program mobile applications. Suitable tools for desktop and mobile devices are available for all levels of education.

CONCLUSION

The results of the survey confirm that young people use modern digital technologies, especially smartphones and tablets, to a large extent. Research results show that this depends on the age category of mobile users. Mobile devices play an increasingly important role, including in the classroom. In the field of computer science and programming, mobile devices can serve not only as a subject but also as a means of learning. Mobile learning applications, manuals, reference guides, electronic textbooks, tutorials or video lectures can be used. Another possibility is to teach programming through mobile application development. This approach has the advantage of increasing student motivation and the urgency to use modern programming techniques, frameworks and role models. Students create practical applications that are more appealing to them than examples aimed only at

mastering necessary programming procedures, and students can acquire the right habits, skills and knowledge relevant to program development. Case studies have shown that mobile application development motivates pupils. They then learn to program and design applications correctly.

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Modern Technology in the Form of Mobile Applications of Augmented Reality in Human Biology Education for Future School Teachers

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Abstract

With the development of new technologies, there is a growing demand for the implementation of modern teaching methods in university education. An important part of education is the training of future teachers. New technologies and modern teaching methods make study more attractive and provide students with greater motivation to understand concepts. In our paper, we present "augmented reality" technology as part of the use of mobile technologies in biology education for future primary school teachers. The research carried out for students of the first year of bachelor study at the Faculty of Education, Comenius University. We used constructivist theories of learning by using these "augmented reality" applications to understand anatomical concepts. The research findings confirmed that the students motivated by the new method, easily acquired new knowledge, cooperated very well and their learning was constructive. However, not all selected applications were eligible for the activity. Some applications (e.g. "AR Human Anatomy" and "The Brain App") had simple and poorly elaborated graphics. However, all students enjoyed the activity using the AR mobile apps and everyone agree to use the AR apps in their future practice.

Keywords

Augmented reality. Mobile applications. Biology education. Teacher training.

INTRODUCTION

With the development of new technologies, there is a growing demand for the implementation of modern teaching methods in university education. An important part of this education is precisely preparing students for their future profession as teachers. New technologies and modern teaching methods make study more attractive and provide students with greater motivation to understand concepts. Information technology provides us with many opportunities in the field of education; we will discuss one of them: Augmented Reality (AR).

In the following study, we present AR technology as part of the use of mobile technologies in the teaching of human biology. AR is the integration of virtual images into the real world, so reality augment by virtual elements (Ganguly, 2010). The integration of such images arises by information and communication technologies (ICT) by mobile camera

device (tablet or mobile phone with android). Teaching with AR mobile apps is more effective and allows students to participate in the learning process (Azuma et al., 2011). In study, we focus on the effectiveness of using the selected AR applications of human anatomy in teaching of students; pre-service teachers for primary level. In the study, we examine if demanding a subject (for example human anatomy and physiology) is more understandable for students. We also examine if there is more motivating for them to learn this challenging subject using AR technology. Finally, we present a students' opinions on the use of mobile technologies and AR applications in university education.

METHODS

We conducted the research with the group of 14 students (4 men and 10 women) of the first year of the bachelor study in the teacher-training program for future teachers. The average age of the students was 21.29 years. Of these, 85.7% (12 out of 14) had biology at secondary school, but only 28.6% (4 out of 14) were also graduated in biology. We realized the pedagogical experiment in May 2019 at Faculty of Education of the Comenius University in Bratislava.

As part of the repetition of neurohumoral regulation of child growth and development, we used AR applications to help students understand the issue. We used the applications "Anatomy 4D (2019)", "AR Human Anatomy (2019)" and "AR Human Atlas (2019)", that depict individual organs within the human organism, thus providing an explanation of the interrelationships of individual anatomic systems. We also used the applications "The Brain iExplore (2019)", "The Brain App (2019)" and "Human Brain - Augmented Reality (2019)", that are focused on individual parts of the brain. It is for this detailed representation of the brain that the applications in question may be helpful in teaching the neural regulation of growth and development. At the same time, we chose a constructionist approach in teaching, because constructionism, respectively constructionist theory of learning deals with learning with understanding (Stoffová & Štrbo, 2016). We consider it important to note that the same students have absolved a frontal organizational form of lesson, as well as a lesson with constructive concepts using mobile technology and AR applications.

Students had pre-installed the applications on their mobile phones and each group received a card with a specific marker to show 4D models of human body organs. The students, who were divided into four groups (two groups of three and two groups of four), were given simple tasks and we watched how they would cooperate on the tasks. In the course of the qualitative research, we wanted to see the effect of the AR applications on the learning, taking into consideration the constructivists approach. Using these applications on the mobile phone, students could use augmented reality to study the anatomy of neural and endocrine systems that appeared in three dimensions. The students worked with neural and endocrine systems to understand neurohumoral regulation of growth and development during the lesson of "somatic child development". The task of the students was to identify the body structures in AR applications, which are involved in the growth and development of the child and then describe this function. Students had 90 minutes to complete the task.

We recorded the students' access to the curriculum in the videos. From the video recordings, we identified individual categories and subcategories according to the terms and activities that students used in the lesson. The coding results are in Table 1. We

supplemented the qualitative type of research by a quantitative evaluation using an electronic questionnaire consisting of 13 questions. The first two questions contained age and gender of students. The other two questions included data on the completion of biology at secondary school. We used six closed questions, four semi-closed and three open. We used semi-closed questions to justify the students' choice, open questions to give students an idea of how to work with mobile technologies and AR applications, as well as their real interest in the form of teaching. Students completed the questionnaire after completing the lesson.

RESULTS

We summarized the results of the open coding research in the following table 1:

Table 1: Categories of students' activities

CATEGORY	SUBCATEGORY	EXPRESSIONS AND ACTIVITIES
1. Influence of mobile AR technology on understanding of anatomical terms and relationships	1. Identification of brain parts in 4D space	"This is telencephalon"; "We have a left and right hemispheres"; "I saw a spinal cord down"; "This is about the frontal lobe"; "Cerebellum is down"; "It's a pons or a mesencephalon"; "There should be a small cerebellum inside"; "We see the brain, but we don't see its parts"
	2. Easily distinguish the central and peripheral parts of the nervous system in the 4D space	"The brain is not the entire nervous system" ; "This is such a line and it's like a spinal cord"; "We got inside and there were nervous impulses"; "Here we see the peripheral nerves and the central nervous system"
	3. Distinguishing the nervous system from other organ systems in the 4D space	"The nervous system is marked red. Aren't they blood vessels? Probably yes"; "I don't know if it's a spinal cord because it doesn't look like a spine"; "Here we have the skeleton, not the nervous system"; "There should be a pituitary gland that contains growth hormone"; "Here is the thyroid secreting thyroxine that affects metabolism and growth"
	4. Discovering unknown objects or concepts of the nervous system in 4D space	"This is some special formation"; "Is that a slug?"; "What is the Broca's area?"; "How do you say it in Slovak?"; "I never heard this term"
2. Mutual learning among students - constructivist approach	1. Mutual learning helps to understand terms and relations	"There is a nervous system around the brain. Isn't that spinal cord? Now my classmate told me it was a spinal cord"; "The nervous system is marked red. Aren't they blood vessels? Probably yes"; "It is the same? You see, it's the same, only here you can switch it; "Now I'm going to zoom in on the object for you to see it better"
	2. Students support each other	"What happened? I don't know, but let's do it"; "Let's try this"; "We've already done this, let's try others"; "Can't you move the picture"

		of brain?"; "Look, if you do it this way, you can see it"
	3. They do not collaborate with each other	"Go to your own group"; "Do I have to know what's inside?"; "What should I write here?"
3. Manipulation activities	1. Improving manipulation ability with the help of AR technology	"You know, when we open it, it's gone"; "It's the same, only here you can switch it"; "We'll Turn It Over"; "Now I switched to AR mode and got inside"; "Turn on VR"
	2. Enthusiasm for AR technology	"Well, it's something new"; "He's pretty handsome"; "Wow, we got into space"; "That brain is so weird, it probably doesn't have energy"; "This is a show"; "This is how I would end our expedition to the brain."
	3. Disinterest of mobile AR technology	"I can't do it at all"; "I can't see it"; "I know it with my thumb, but I can't do it here"; "Ugh, what's that?"; "Why are the muscular people in applications? They look like they came out of bass"

The categories from table 1 referred to constructivist teaching and the students' manipulation activities. Constructivist teaching takes place through didactically considered but conceptually open teaching activities, and through discourse (controlled argumentation, handling facts) in the form of individual as well as group exploration (learning groups), thanks to which common knowledge and understanding is established.

The students correctly identified the nervous and hormonal systems involved in the growth and development of the child. In the 4D space of augmented reality applications, they could easily distinguish the different parts of the nervous system and distinguish them from other organ systems. Within each system, they identified endocrine glands whose hormones contribute to growth and development (Table 1, Category 1, Subcategory 1, 2, 3, and 4). They used applications that offer an illustration of the individual anatomical systems of the human body, so they understand their connection and function. In applications for brain anatomy, students were able to distinguish its parts, but few of them could describe function of brain. Through the transcription of the video-recordings and structured observations, we found that the students frequently helped each other. In most cases, they used the plural form when they talked to each other, which meant that the students did not consider their tasks to be individual ones (Table 1, Category 2, Subcategories 1 and 2). A positive finding is quite clear cooperation between students. During the classes, they explored together, they determined interconnections and helped each other understand anatomical concepts and their functions. The environment supporting constructivist approach significantly helped the students in their work and students' mutual teaching with the help of this approach was efficient.

Another category that we set up was the category of manipulation activities (Table 3, Category 1 and 2). Students enjoyed manipulation activities with AR applications. They often used expressive expressions that confirm a great interest in this type of education. With the help of new technology, students improved the manipulation skills and the cooperation prevailed in their communication. They admitted that this way of teaching is new and extremely entertaining.

Some students showed disinterest in this type of teaching (Table 1, Category 3, Subcategory 3), which was probably due to the choice of some applications that students were not interested or the work with these applications was not easy. For these students, we noticed signs of poor cooperation with other classmates. During the observation, however, we noticed few terms and expressions for poor cooperation (Table 1, Category 2, and Subcategory 3).

The students identified "Anatomy 4D" and "The Brain iExplore" as the simplest and most interesting applications among the applications they could work with during the lesson (Table 2 and Table 3). The "Anatomy 4D" app was the most interesting because they were able to access the information with one click. The application was clear and the features were easy to understand. In addition to the nervous system, this app offers a view of all organ systems. Other applications are specialized only for a certain part of the body. One student says: "This application was easy to work with, there was no problem with it and individual body parts could be approached. You could choose which body parts to display and which did not". The students state two reasons for the easiest work with "The Brain iExplore": 1. the app is easy to load and 2. They have the opportunity to see detailed parts of the brain. They liked the features the app offered and they considered the app fun. Two students described the "Human Brain - Augmented Reality" as an interesting application. As a reason they reported good graphics of app. Students did not like "AR Human Anatomy" and "The Brain App". This may be because both applications had simple and poorly elaborated graphics, making it more difficult to distinguish internal organ parts in these apps.

Table 2: Results of answers to the question "Which application is the easiest for work?"

	N	%
The Brain App	2	14,3
Human Brain – Augmented Reality	2	14,3
AR Human Atlas	2	14,3
Anatomy 4D	4	28,6
The Brain iExplore	4	28,6
Summary	14	100

Table 3: Results of answers to the question "Which application was most interesting to you?"

	N	%
Human Brain – Augmented Reality	2	14,3
AR Human Atlas	2	14,3
Anatomy 4D	6	42,9
The Brain iExplore	4	28,6
Summary	14	100

We also asked which method students would choose to learn human anatomy. The most suitable form of teaching human anatomy was the applications of augmented reality (57.1%). Only 14.3% of students chose the anatomical atlas in book form (Table 4).

Table 4: Results of answers to the question "Which method would you use to learn human anatomy?"

	N	%
Book of human anatomy	2	14,3
3D models	4	28,6
Applications of AR	8	57,1
Summary	14	100

All students liked the activity at the "Somatic Child Development" using the AR apps. It was something new for them. They could have learned in other ways. They were actively involved in teaching. They were not only passive recipients of knowledge. They learned in the form of play, as one student says, "I personally learn more by this form of teaching". They had the opportunity to see the individual organs of the human body from a 4D perspective. As one student says, "It is always better if I can even see something than I only hear it." This answer is interesting because students can see pictures, tables and diagrams even when interpreting the curriculum in powerpoint form. This may be due to the static presentation of images using this method. The second reason may be the fact that if you engage students in an activity, they consider it a game and do not feel that they are actually learning new things.

We used these applications to understand the neurohumoral regulation of child growth and development. The students were to identify the individual parts in the 4D space and determine their function. We were wondering which topic of somatic growth and development the students would like to learn through this teaching method. Some students reported directly the nervous system, which is the most complex of these body systems. What the students lacked in these applications was to depict all parts of the nervous system simultaneously and separately. As one student says, "The application could have a list of individual parts and would display on the human body exactly the part I choose from the list". Students chose the prenatal development of the child as the second topic. They would like to see gradual changes in the 4D space, the various phases of the prenatal period and fetal development, what the fetus looks like and how it gradually changes.

All students admitted that they did not know the augmented reality applications before the lesson of "Somatic Child Development". Nevertheless, everyone agrees to use the AR apps in their future practice. In particular, they stated that they could actively involve pupils in the teaching process. They assume that applications could be interesting and fun for pupils. By using this form of teaching, pupils could be more motivated to deepen their relationship with the subject.

Students had notes to the internet connection. All applications were dependent on wifi internet connection, which was not satisfactory in the classroom where the education was taking place. Some applications did not work ("AR Anatomy 4D +"). At the same time, the students suggested that applications would be accessible on iOS. The larger screen allows better recognition of the structures. According to students, it would be appropriate if the school had better material-technical provision. These forms of teaching realize without problems, because students are interested in this form of teaching.

DISCUSSION

Ubiquitous learning is now becoming a trend. There are many people from various fields speaking about opportunities for learning via ubiquitous means; in the workplace, in education, and in the home (Lee et al., 2012). The simplicity and mobility of the mobile device allows for more effective learning and retainment of knowledge (Balog & Pribeanu, 2010). With use of the AR mobile application features, students should be able to enhance their learning environments and improve their ability to retain information. Our findings confirm most of the students have recognized the mobile technology helped them to repeat the lesson and helped them understand the anatomy. At the same, the environment supporting constructivist approach significantly helped the students in their work and students' mutual teaching with the help of this approach was efficient. However, not all selected AR apps were eligible for the activity. The students identified "Anatomy 4D" and "The Brain iExplore" as the simplest and most interesting applications among the applications they could work with during the lesson. Some applications had simple and poorly elaborated graphics, making it more difficult to distinguish internal organ parts in these apps (e.g. "AR Human Anatomy" and "The Brain App").

The issue of introducing AR technologies into the teaching process is the lack of material and technical provision of the university. During our research, we have experienced wi-fi internet connection problems, which have sometimes made it difficult to load the AR applications, reducing the effectiveness of using tablets and AR applications in biology. In general, researchers in educational technology agree that more motivation studies of AR as a learning method are needed (Lee et al., 2012; Fuchsova & Korenova, 2019; Korenova et al., 2019).

The use of this technology could be very effective in motivating students' learning and nurturing their ability to become passionately involved in their own learning process. The AR application of anatomy (like "The Brain iExplore", "Anatomy 4D") will assist them in learning human anatomy using enhanced materials which stimulate their interest and help them to retain information longer. Based on the study results, we encourage higher education institutions to adopt and implement the AR application as a teaching and learning tool consider imperative in enabling effective and positive learning for the future.

CONCLUSION

In the present study we summarize information to use of augmented reality in education of human biology for university students, which students can use not only to improve their knowledge of the issue, but also in their future teaching practice. We explore how augmented reality technology can contribute to a better understanding of the child's somatic development and how this form of education can increase students' interest in the subject. We also examined students' views on the use of augmented reality technology in biology education. The findings of the research confirmed a higher understanding of the content, better cooperation, as well as increased interest and motivation of students. Education with augmented reality applications was interesting for students. Although most of them have not yet encountered this type of education, they all agreed that they would accept this type of teaching in the future. The disadvantage of using augmented reality applications is their connection to the Internet. Due to the lower material and technological

provision of the faculty, work with augmented reality technologies can be more complex and complicated. Despite minor shortcomings in the use of applications, we consider augmented reality technology to be a suitable method of biology education, and we recommend incorporating it into the education process as a complementary method to classical education methods.

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Ways of Using Social Networking Site Instagram For Educational Purposes

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Abstract

The paper is aimed at using the social networking site Instagram for educational purposes. This easy-to-use social networking site can make instruction more interesting for students. It can spark a student's interest in a topic as they are the ones who create (or participate in creating) the content and then publicly present it. The paper presents the results of research aimed at different ways of using Instagram for educational purposes, focusing on different target groups. Moreover, profiles aimed at educational content and education-related hashtags are also being analyzed. Based on acquired information, teaching models aimed at incorporating Instagram into both formal and informal education were designed, focusing on microlearning as one of the ways to effectively use not only this popular social networking site but also digital technology that the majority of students use every day. The effectiveness of the teaching models introduced in the paper needs to be further analyzed in the future.

Keywords

Instagram. Social Network. Microlearning. Teaching Models. Generation Z.

INTRODUCTION

For the generation of pupils and students entering the school system, social networking sites are an integral part of their everyday lives. The following are some of the terms used to define this generation, which is now being educated in our education system: Generation Z, Generation M (Multitasking), Generation I (Internet). Despite the different terms, this generation can be characterized as connected, using communication and media technology such as the Internet, instant messaging, MP3 players, cellular phones or YouTube. The previous generation (Generation Y) is different from the current one in that its members lived before the advent of digital technology. The current generation does not know what life was like before digital technology. The majority of children grew up with a cellular phone in their hand. For these children, the Internet is the primary source of information and communication. The following table demonstrates some of Generation Z's (Gen Z's) characteristics.

Table 1: Generation Z – Use of Technology

More than half of Generation Z is online more than 10 hours a day. This, among other things, affects how they acquire information and form their opinions.	Media Kix https://mediakix.com/blog/the-generation-z-statistics-you-should-know//#gs.5mus5h
73% of Gen Z-ers use their internet-connected devices for instant messaging and chatting.	IBM https://www.ibm.com/downloads/cas/9PPL5YOX
60% of Gen Z-ers will not use an app or website that takes too long to load.	IBM https://www.ibm.com/downloads/cas/9PPL5YOX
41% of Gen Z-ers say that Instagram is their preferred social media platform.	The Center for Generational Kinetics https://genhq.com/5-ways-gen-z-uses-social-media-that-will-surprise-you/
71% Gen Z-ers watches more than 3 hours of video every day.	: Media Kix https://mediakix.com/blog/the-generation-z-statistics-you-should-know//#gs.5mus5h , Vision Critical https://www.visioncritical.com/blog/generation-z-statistics
Gen Z-ers' attention span is 8 seconds	Forbes https://www.forbes.com/sites/rachelarthur/2016/03/16/generation-z/#1c5216c02909

The aforementioned statistics prove that Gen Z-ers will not give up digital technology easily. However, this does not necessarily have to be negative. It can help modernize the education process and make it more effective, assuming that digital technology is used to motivate students to learn or to make learning more time-efficient. The fact that students will be able to use the same technology they use in their everyday lives can also help motivate them.

However, the teacher must not be afraid to try and learn new things. Aside from technology that is already becoming incorporated in the education process, tools that were not primarily designed for these purposes – social networks and media – can also be used. Besides YouTube, which is often used as an education platform by students, Instagram should also be considered. The following graph proves that Instagram is one of the most popular social media platforms.

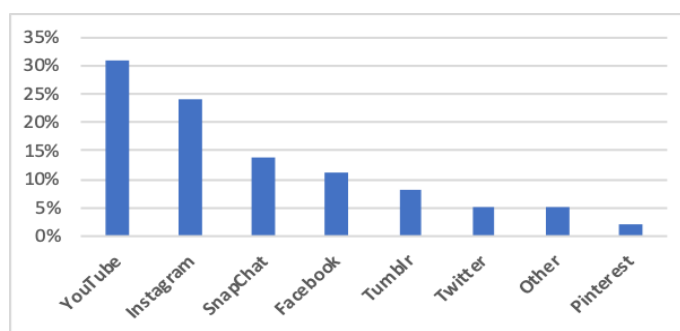


Figure 1: Popularity of Social Networks with Gen Z-ers

The growing popularity of this social network caught the authors' attention, making them want to examine its effectiveness when used for educational purposes. The main question is whether or not the negatives (the dangers of electronic communication; a shortening of attention span) outweigh the positives (making the education process more effective and interesting) (Rosen, 2011).

INSTAGRAM AND EDUCATION

Social networks are often considered to be one of the tools for applying the theory of connectivism. Since Instagram allows users to share only a limited amount of educational content, it appears to be less appropriate than other networks that allow users to share links, longer texts or videos. On closer inspection, however, Instagram offers a number of functions that could be effectively used in education.

There are various studies that examine Instagram-based instruction (thematically diverse), focusing on different target groups. The authors analyzed some of them, with the results being presented in the following table.

Table 2: Summary of previous researches

Erarsian (2019)	A questionnaire survey conducted on 219 university students. Students consider Instagram to be an appropriate tool for sharing materials and an excellent motivational tool. Based on both the students' answers and the result of a pedagogical experiment, Instagram appears to be a useful tool for (English) language learning.
Pilař et al. (2018)	The authors try to determine whether or not education is discussed on Instagram, focusing on gamification. Content uploaded to Instagram (including its purpose) can be examined this way.
Gonual (2019)	This research is aimed at proving that Instagram could be used to assess students' knowledge of a foreign language (mainly English), based on their activity on Instagram – how and with whom they communicate and whether or not they create international content (including hashtags).
Yodhianta a Nuryantini (2018)	The authors used Instagram when assigning tasks to students (future teachers), trying to help them improve their language skills.
Courneya a Cox (2020)	In this study, Instagram was used as a channel for sharing the drawings of medicine students that were supposed to help other students (visual learning).
Manca (2020)	The study focuses on little explored social media and their potential use in education. What is interesting (considering the title of our paper) is that the majority of Instagram-related studies are being conducted in the Middle East and Asia.
Al-Garawi (2016)	A survey conducted on 151 English students proved that Instagram helps improve reading, writing and listening skills, as well as vocabulary.
Handayani (2016)	The authors explore Instagram-based educational activities, defining a number of activities for language learning.

The aforementioned studies prove that Instagram could become more than just as a channel for delivering educational content. They also prove that it is suitable for various target groups, including highly specialized ones (e.g. medicine students).

Selected educational profiles

If we are to explore the possible use of Instagram for educational purposes, we also need to explore studies on existing educational profiles (the table below contains some examples).

Name of Instagram profile	Number of Instagram posts	Number of followers	Description
EWA.ENGLISH	1235	1.8	Using simple infographics, English grammar is presented to users. There are also posts that require feedback (leaving a comment under the post).
INENGLISHWITHLOVE	117	103	Suitable for advanced learners, this profile is aimed at improving English skills.
VOCORDS	821	482	This profile is aimed at correct pronunciation (audio posts). Then there are the so-called feedback posts that require the viewers to comment on the post or answer questions.
NATGEO	21.9	131	A source of information for English speakers – cultural and geographical content (contains pictures). Users who do not speak English can improve their language skills.
WARHISTORY	1063	72.3	A profile aimed at war history. Under each authentic picture, map or drawing, there is a caption describing the situation, war technology or personality.
HANSONSANATOMY	763	50.5	A doctor using original drawings and sketches to explain anatomy. The author provides a link that allows his followers to download his lectures.
INSTRUCTOR_HTML	36	41	A profile suitable for those interested in HTML 5. The user learns how to use various hashtags, including their activity and how they will look on the web.

Considering the number of posts and followers, the aforementioned educational Instagram profiles prove that this social networking site is often (and successfully) used for educational purposes. Based on the nature of the profiles, it can be said that Instagram is mainly used for informal learning. The following part of the paper explores the possibilities of using Instagram in both formal and non-formal education.

#education hashtag analysis (analyzing hashtag-based content)

In order to be able to determine whether or not Instagram is suitable for sharing educational content, the authors decided to analyze the hashtag *education*. This hashtag is used when posting education-related content. The authors used the *displaypurposes.com* tool to analyze the hashtag. Through this tool, the authors learned that the hashtag has

been used in 17,333,925 posts. The hashtag is most used in the following countries: The United States, Poland and the United Kingdom, followed by the aforementioned eastern countries (India, Indonesia, etc.). Most users who use the hashtag in their posts come from Warsaw, London and Dubai. When a user used the hashtag education, they often used the following hashtags as well: motivation, love, science, school, chemistry, passion, onlineeducation and learning. The hashtag is used most by users between the ages of 25 and 44. Users between the ages of 13 and 24 do not use it as much. The hashtag education is used most by women (56.51% of users).

The above statistics and presented profiles show that educational content is already being shared on Instagram. It can be assumed, however, that it is used for informal learning. The following part focuses on how to use Instagram in formal and non-formal education. The authors designed a number of models that might be used in instruction.

MODELS FOR USING INSTAGRAM IN INSTRUCTION

Based on the presented studies, Instagram profiles, Instagram functions and characteristics of Instagram posts and hashtags, the authors designed the following models for using this social network in both formal and non-formal education.

The basic criterion for distinguishing the models from one another is the source of the published content. There are three:

- Teacher
- Student
- Third party (someone other than the teacher or the student)

In a perfect scenario, all the above sources of educational content can influence one another (as can be seen in the following picture).

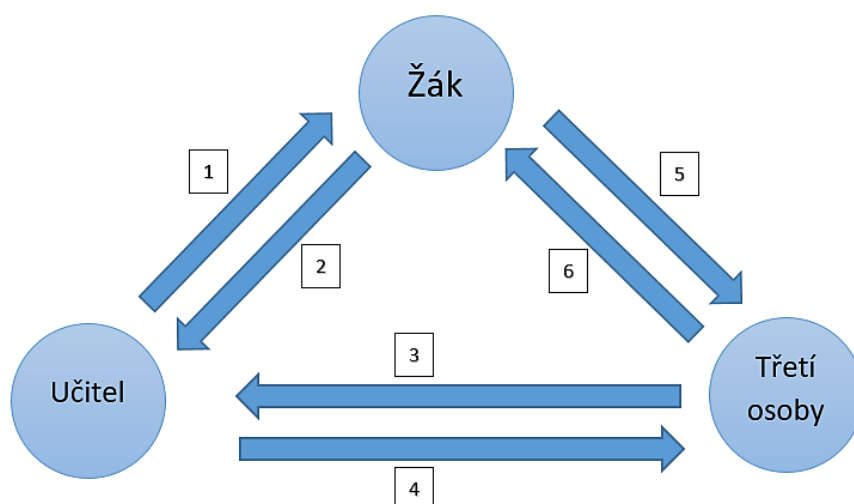


Figure 2: Providing and receiving educational content on Instagram

Teacher the content creator (1,4)

The teacher is the traditional content creator in the education process, and Instagram provides a number of ways to present content to their students.

1. Feed posts

Feed posts allow the teacher to present pictures, schemes, short video (with sound or a simple animation) or drawings to their students. They can also include a caption. This way, the teacher can share pictures taken in class or provide additional information on the current topic. Students can provide feedback either by leaving a comment under the post, or ask the teacher a question (to which, however, other students can respond as well).

2. InstaStories to activate students

InstaStories are a fast way to share time-limited interactive content. This feature allows the teacher to create open ended feedback questions (students provide a verbal evaluation of instruction – they are required to give a full-sentence answer to the question; the student can ask the teacher a question), quizzes, polls or a group chat.

Student the content creator (influencer) (student the influencer) (2,5)

Instagram could easily become a place to create homework, group projects or practical exercises.

1. Photo tagging

The following is an idea for an English vocabulary activity: the student can post a picture (related to the current topic) with English hashtags (Instagram limits users to 30 hashtags per post). The student can either post a picture of their choice, or each student is assigned the same picture. The teacher then checks if the students used hashtags with topic-related vocabulary. Students can also compare the number of likes – a gamification element.

2. Using the same hashtag

The teacher gives the students an assignment to post a topic-related picture (or other content) on Instagram, using a unique hashtag. The hashtag helps the students (and the teacher) to keep track of who posted which picture. The teacher can then comment on the pictures or discuss them with the students in class.

3. Student as the teacher

Instagram enables student networking, allowing students to help one another. Through shared content, any student can inspire not only their classmates, but also students they do not even know.

Using third party content (3,6)

Both the teacher and the students can use third party content on Instagram. The teacher can use it as inspiration (as it might help them discover new teaching methods) or even use some posts in class.

As far as students are concerned, such content is suitable for older students who can use it to expand their knowledge of a particular topic or for personal development.

All the presented models allow teachers to work with gifted students as well as students with learning disabilities by using private messages or sharing content only with selected students.

CONCLUSION

The current generation is often criticized for spending too much time online. In both formal and non-formal education, the role of the teacher should be progressive rather than regressive. They should help their students use online tools in a useful way, making online technology much more than fun (and a waste of time) – making it a useful tool for solving all kinds of problems. Social networks can serve as an example. The majority of teachers criticize them, without realizing their educational potential. It is clear that some social networks are more popular with youngsters than others. The paper explores the possibilities of using Instagram in education. Considering current educational trends, the development of technology and a hectic lifestyle, Instagram can be effectively used in microlearning. Based on international research findings and other methods described in the paper, the authors designed a variety of models for using Instagram in education. In Instagram-based instruction, there are not only the teacher and the student, but also third parties that can provide information and inspiration to students as well as teachers. The designed Instagram-based instruction models could not only become a source of inspiration for teachers, but also provide useful information (when examined in detail). Therefore, in order to determine how effective the models are, and to see if another Instagram-related model presents itself in actual instruction, all the presented models will be tested on different target groups.

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Development of hard SKILLS and soft skills through competitive complex projects using BBC micro:bit

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Abstract

Hard skills competencies that referred to proficiency in any complex task, focused on practical abilities are acquired through education and practice. Soft skills competencies focused on behaviours and personalities are less tangible. The rules for how a programmer creates code is "easy" to teach, but how programmer may communicate effectively to other programmer, manager or customer is much harder to teach. We were interested how to effectively and encouragingly support the hard skills and soft skills teaching at primary and secondary school in computer science class. We decided to attend the competition with the goal to define, design, create, program, describe and promote the complex hardware project using microcontroller micro:bit. We realized that all students were able to find a practical problem that solved such as helping of people with blindness, keeping the water drinking regime under the control or even how to improve the health by playing the movement game. The research show that more than half students like this approach of teaching programming. More than 60% of them like the team work. The promote video creation was considered as the most enjoyable and easy part. The team discussion about the idea was considered as more demanding part even more than programming itself. The most difficult part of the project was the formulation of their results. All competition groups had a unique opportunity to presented their project as a talk or in the form of scientific fair at international conference. They practised the communication and language skills.

Keywords

Hard Skills. Soft Skills. Programming. Project. Microcontroller. Microbit.

INTRODUCTION

Hard skills are learned abilities acquired and enhanced through practice, repetition, and education. Hard skills focus on practical abilities and skills, whereas soft skills focus on behaviours and personalities, such as social and communication skills (Kagan, 2020). Soft skills have been defined as psychological abilities for adaptive and positive behaviour that enable individuals to deal effectively with the demands and challenges of everyday life (Rezgui, 2019) and predictors of not only professional, but also of life self-fulfilment of an individual (Stepanova and Zeer, 2019). 57% of senior leaders say soft skills are more important than hard skills. On the other side of the coin are the hard skills and in 2019 the most wanted ones demanded by the job market mirror the impact of our increasingly digital world, which translates itself into a spike in cloud computing and AI (Jesus, 2019). We need to provide both these skills to our children. So they do not have just a lot of knowledge and do not know what to do with it or how to show it to the world. We were interested how to effectively and encouragingly support the hard skills and soft skills teaching at primary and secondary school in computer science class. This is the main topic of our paper.

Hard Skills and Soft Skills in Computer Science Competitions

Students are expected to be trained with skills and soft skills to be ready for entering the job market (Linh, 2019), but the traditional focus is on academic and technical/hard skills (Foster et al., 2019). The fact is soft skills and hard skills are not isolated concepts and realities. They are two sides of the same coin. They are inevitably intertwined. Hard skills and soft skill in computer science class need to be intertwined too. For example, the rules for how a programmer creates code is “easy” to teach, but how programmer may communicate effectively to other programmer, manager or customer is much harder to teach. Through a meaningful integration of technology in the learning/ teaching experiences, it is viable to promote the development of a hard skills’ set as simultaneously building up a set of soft skills, such as communication, collaboration, problem solving or creativity (Jesus, 2019). These skills can be acquired through complex project in competitions.

A lot of competitions are focused more on the hard skills than soft skills. For example Zenit, Olympiad in Informatics or IT in Nitra, where it is just about single person programming, so it is aiming on just hard skill. But there is more competitions in which students have to use and show more types of skills. During the creations students do not just deepen knowledge in academic or technical skills as the hardware or programming, but also how to use this knowledge to create something original, use their creativity. These competitions can include teamwork, so students can learn how to communicate, solve problems together, divide work and compromise. Plus a lot of students finds this type of competitions motivational and it can improve their self-confidence. To mention few concrete competition there is OfficeArena, where students in final round have to create original project in office, so the knowledge in Office is needed, but also present it in front of commission. FIRST LEGO League is competition, where students in teams have to built and program their own robot and solve some research task. Then they have to present it on the competition. The Tech Challenge is more open competition because they give to students just the problem and students in teams have to find the solution and also construct it. There are three areas, which are judged. First journal, where they have to show how the team made its device and why they made the choices they did. Then during the showcase

interview with judges and device performance. In this article we write about the competition which suits us the most, because students could developed the different type of the 21th century competencies, SpyCup

Spy Cup Competition

Spy Cup is a competition for primary and high school students. The main aim is to create a hardware project and program it. They can use mainly BBC micro:bit, NodeMCU and RaspberryPi; allowed programming languages are block programming, Python and MicroPython. Students can compete individually or in teams of 2-3 students.

The competition was created as a reaction to 4 projects created by high school students in 2018 who were led by Marek Mansell (SPy o.z., 2020). They presented their projects at the international conference PyCon 2018. Since that, civic association We Teach with Hardware organize the Spy Cup competition to promote and motivate students interested in hardware projects.

In the year 2019, categories were only two: primary school and high school. Students could create project with no limitations. Nowadays, it changed and the focus is on social and ecological problems (Figure 1).

Categories	primary school	social problems
		ecological problems
	high school	social problems
		ecological problems

Figure 1: Categories of SPy Cup competition

There are few steps: a teacher registers team to the project. They have 1.5 month for creating the project. If they passed to the finale, they are invited to the international conference PyCon. Finale means the students present their project and winners are announced. In 2019, the winner of high school teams was VA2KRY who created Color Jump. They won a drone.

Micro:bit

BBC Micro: bit was designed for educational purposes by English BBC in 2016 and distributed free of charge to every pupil across the UK (TheSchoolRun, 2020). However, micro:bit is not used just in England (Sentence, 2017), but it is spreading to the world and becoming popular. They are distributed to around 50 countries. It is used in many countries including Slovakia (Mansell, 2019), Czechia (Havířová, 2020), Hungary (Czékman and Kisz, 2018), Netherlands (Gibson and Bradley, 2017). Micro:bit is a small, easy-to-carry device that easily fits in your palm. Directly on the circuit board is an integrated processor similar to that found in mobile devices, memory, 25-LED red display, two programmable buttons, light intensity sensor, temperature sensor, accelerometer, magnetometer, bluetooth antenna, micro USB port, power port and input / output pins. In fact, it is a programmable microcontroller. There is more ways to connect a variety of additional devices that extend the functionality of the motherboard with a number of options. So micro:bit can be used in

complex projects. It is programmable via block language, MicroPython or Javascript (Cápay and Bellayová, 2019).

Spy Cup Competition Projects

We decided to attend the competition Spy Cup with the goal to define, design, create, program, describe and promote the complex hardware project using microcontroller micro:bit. In this section several students proof concept project will be described.

Stairs Measurement: Spy Cup 2020, the primary school, 10-11-year-old students, visual programming language (Figure 2).

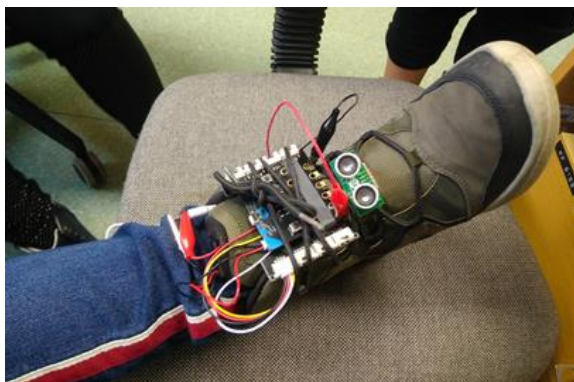


Figure 2: Stairs Measurement

The project focused on blind people and the team wanted to help them to see obstacles like stairs. They can lace the project up and if a stair is closer than 30 cm, it beeps. The students wrote they faced problems with programming because it was their first time they were programming BBC micro:bit.

The Wallet Guard: Spy Cup 2020, the second primary school, 13-year-old students, visual programming language (Figure 3).



Figure 3: Tha wallet guard

The project was created to help blind people not to lose their wallet. In case the wallet falls off, BBC micro:bit notices the fall and the speakers rings. They recommend the project not only to blind people, but also to everyone who usually loses their wallets.

The Watter Buddy: Spy Cup 2020, the high school, 17-year-old students, MicroPython language (Figure 4).

The project was created to help people not to forget to drink water. When the button is pressed the water pump draws one dcl of water, increase the counter showed on 7 segment display and signalized the progress in daily limit using LED ring. The Watter Buddy has an RTC module that synchronize the sound signalization. Students use two micro:bit that communicate using radio transmitter.



Figure 4: The Watter Buddy

Jump Color: Spy Cup 2019, the winners, the high school, 17-year-old students, MicroPython language (Figure 5).



Figure 5: Color Jump

The project was created to help keep peoples health in a good condition by playing the movement game. Micro:bit show lighted up two LED strips at different colour. Player need to jump on the buttons with the same colours which are showed on strips. Reaction time and correctness of the movement is important to reach high level evaluation.

METHOD

As we wrote before we decided to attend the competition with the goal to develop the students hard skills and soft skills competencies. The competition had strict rules about the form of solution. Students need to:

- develop the original idea of the hardware project using micro:bit or arduino,
- create a proof concept of hardware project,
- choose the methods and programming language and create the source code with commentary,
- create the movie that promote the concept of hardware project,

- prepare a project documentation.

The chosen project group, the finalists, has opportunities to present their concept before the teacher audience. All groups presented their solution during the hardware showcase fair.

There were no specific assignment for project problem. Students were free in creation of their proof concept. The project groups consists of at least two students. Students may realised the project during the computer science class. Lot of work was done as afterschool or home activities. Students need to upload the movie on youtube portal and all project files was stored in cloud.

Our research was held in February 2020. We wanted to focus on participants who participated in Spy Cup Competition. Due to the fact, the first year of the competition was in 2019, we defined our sample as all participants who finished and sent their projects for Spy Cup Competition. It means that they are all participants who competed in 2019 and those, who sent their projects in 2020 which were accepted, and they are competing, because the final level of the competition was not held yet. As it turned out, our sampling method is convenience sampling. We decided for this sampling method because participants are selected based on availability and willingness to take part (Barratt, H.; Shantikumar, S., 2018). There were 19 participants who decided to take part in our research. Regarding to the number of participants, we decided for a quantitative research. Our data are primary because we did not find any data of Spy Cup Competition which would involve participants, well, we could not use any secondary data collected from other researchers. We chose a survey from data collection methods. Our convenience sampling based on 19 participants was surveyed in February 2020. They obtained a questionnaire with 20 questions. We focused on the competition as a whole, but also on specific necessary parts of the project. We were interested if and how the students self confidence were influenced by all project steps. Participants filled the online questionnaire to evaluate the pros and cons of all project steps and evaluate their programming confidence. The questionnaire consist of open questions and close likert scale question.

RESULTS

Characteristics of our sample is: 5 primary students, 14 high school students. They are participants of the first or the second year of the competition. We focused on 6 elements which were sorted to hard or soft skills as it is shown in Figure 6.

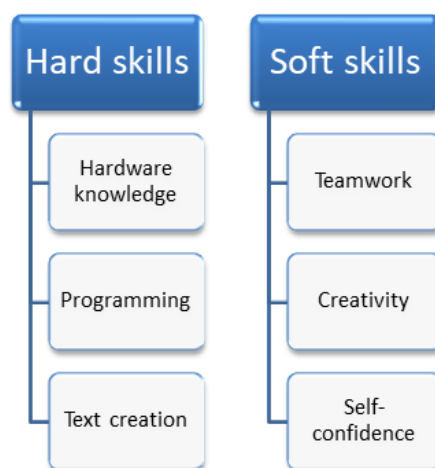


Figure 6: Chosen elements we focused on

The aim of our questionnaire was to measure scale of hard and soft skills. For the measurement we used a 5-point Likert scale with the difficulty response set. The students made their project based on some parts and each part was identified as a hard or soft skill. Hard skills the students needed to work with, were hardware knowledge, programming and text creation.

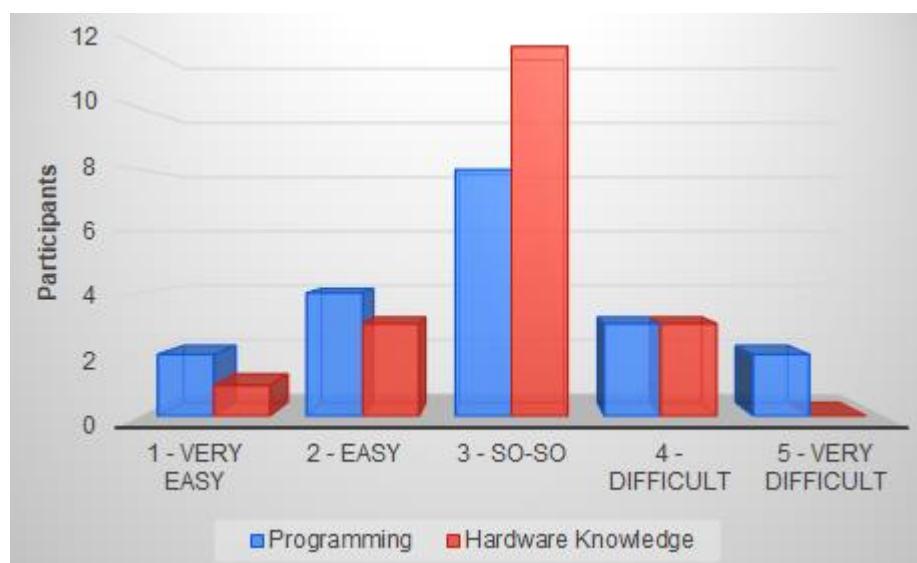


Figure 7: Hard skill - hardware knowledge and programming

Figure 7 shows Hardware knowledge. The original question was „*You needed to make a hardware project. How difficult was this part?*“. We can see it that in average it was not too easy, neither too difficult. Next question focusing on programming showed in Figure x similar data than hardware knowledge. The main aim of the competition is to create a project, what primarily means that primary skills are hardware knowledge and programming. Regarding data, the students could create their project with the prediction of hardware and programming level which were up to them.

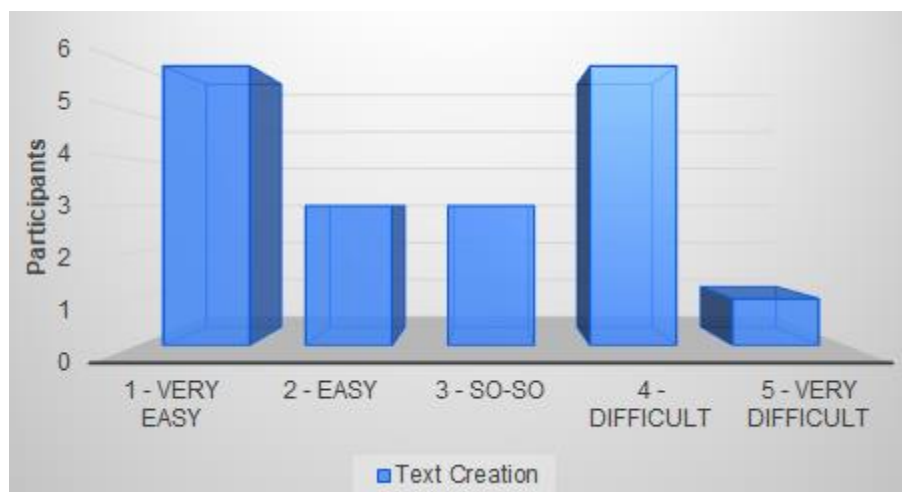


Figure 8: Hard skill - text creation

Text creation as a hard skill in Figure 8 was very easy to those who wrote a text documentation before and they were more experienced. On the other side, the students who were writing the documentation for their first time, evaluated this part as difficult because it was tedious and required a special terminology.

When talking about soft skills in the competition, we mean teamwork, creativity and self-confidence. All measured elements of soft skills are shown in Figure 9.



Figure 9: Soft skills - creativity, self-confidence and teamwork

The students evaluated teamwork as the most difficult soft skill from the measured elements. It is not so common to work in teams in Slovak school and the figure shows that the students are maybe not so experienced. On the other side, some students wrote they liked to be creative, some of them wrote it is difficult to be creative. Self-confidence seems to be a difficult element for them, but it is still less difficult than teamwork.

DISCUSSION

We realized that all students were able to find a practical problem that solved problem in the topic of social needs. The research show that more than half students like this approach of teaching programming. More than 60% of them like the team work. The promote video creation was considered as the most enjoyable and easy part. The team discussion about the idea was considered as more demanding part even more than programming itself. The most difficult part of the project was the formulation of their results. All competition groups had a unique opportunity to presented their project as a talk or in the form of scientific fair at international conference. They practised the communication and language skills. One group decided to extend their work in Scientific students activity.

CONCLUSION

We may conclude that our expectation to the development of hard skills and soft skills among the students that participated in Spy Cup competition was fulfilled. It was proved not only in our research but also during the personal discussion and observation of students motivation. We suggest to support such kind of complex activity realised as a part of computer science curriculum also in the future.

ACKNOWLEDGEMENT

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Use of Interactive Whiteboard and Robot Toys in Kindergarten Teaching

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Abstract

Digital technologies are a completely natural part of children's world. Children use them from an early age and they are a source of knowledge, exploration, communication, expression and development of their logical thinking. Children in kindergartens belong to Generation Z whose thinking is formed from an early age by using technologies in such a way that they no longer perceive their presence and their thought processes are influenced to such extent that they are able to naturally and immediately find the best way to deploy technologies to solve any problem. This is what makes research into the use of digital technologies in pre-primary education so topical. Almost every kindergarten in Slovakia now has its own interactive whiteboard; however, research shows that its potential is not used didactically sufficiently, not even in the area of developing the digital competencies of pre-schoolers. The latest phenomenon that children are interested in is robot toys that children also encounter at home. We have therefore deemed appropriate to combine these two phenomena – interactive whiteboard and robot toys – in socio-cognitive teaching model. In this paper we provide information on the possibilities of combining interactive whiteboard and robot toys to achieve educational goals in pre-primary education. We present pilot qualitative research in the pre-primary education conditions related to the use of digital technologies. We point out the need to change the thinking of kindergarten teachers when creating new educational activity contexts, with an emphasis on the use of interactive whiteboard and robot toys. We conducted the pilot qualitative research in a state-owned kindergarten in Bratislava. The subjects we studied were pre-schoolers and kindergarten teachers. As a research tool, we used a focus group.

Keywords

Qualitative Research. Pre-primary Education. Kindergarten Teacher. Preschooler. Interactive Whiteboard. Robot toys.

INTRODUCTION

Nowadays, digital technologies form part of pre-schoolers' everyday lives. In kindergartens, the emphasis is on the use of digital technologies, including interactive

whiteboard, their integration into the educational activities of children since the age of three, since they contribute to the holistic development of pre-schoolers. Children use them from an early age and they are a source of knowledge, exploration, communication, expression and development of their logical thinking. The current educational discourse in the perception of the possibility of using interactive whiteboard in pre-primary education has shifted qualitatively, however, the didactic practice based on experience lags behind. At present, children are in contact with digital technologies outside of the school environment and school does not use them to a sufficient extent.

Many psychologists and sociologists divide generations of people into “traditionalists” (born between 1939 and 1947), post-war generation – so called “baby boomers” (1948 – 1963), “Generation X” (1964 – 1978), “Generation Y” (1979 – 1991) and “Generation Z” (born after 2000). However, it is clear that Generation Z is quite different from their parents. Technically, this is the brightest generation of all time – children almost as young as toddlers can find anything now on the Internet using YouTube and primary school pupils can now prepare a PowerPoint presentation for lessons and, with the help of their teachers, they can now make their own animated movies. But just like the generations before them, Generation Z, too, has its own positives and negatives. (Sujansky, 2009).

According to Marek Prensky, the biggest question when introducing technologies into schools of the 21st century is not “What does it do?” but rather “How can we use it?”. According to him, there are four steps in the process of introducing technology into schools:

- random experiments (technologies in schools are used without any preparation, plan or vision, on an as-needed-in-the-moment basis)
- old objectives using old methods (e.g. old textbooks in digital form, original teaching materials in digital form, etc.)
- old objectives using new application methods that improve the learning outcome (e.g. animation or video presentation, simulations, modeling, creating virtual worlds, learning games, etc.)
- new objectives using new methods (a digital native is an individual whose thinking is formed from an early age by using technologies in such a way that they no longer perceive their presence and their thought processes are influenced to such extent that they are able to naturally and immediately find the best way to deploy technologies to solve any problem (Prensky, 2005).

Pre-primary education is considered to be key to educating pre-schoolers on how to learn, to making them want to explore and discover information about the world around them on their own. Starting with kindergarten, we prepare them to learn to make critical choices about what is important and what needs to be further verified and to gradually be able to adapt in a flexible way to changes in their surroundings.

TEACHING THROUGH INTERACTIVE WHITEBOARD AND ROBOT TOYS

On the one hand, it might seem that today we no longer need to discuss whether interactive whiteboards are suitable for kindergartens or not. However, we still sometimes encounter negative attitudes towards them, misunderstanding of their role in education, their misuses, inappropriately set learning objectives, unused educational potential.

We often witness interactive whiteboard being used in the teaching process as a static tool that lacks effectivity.

Kindergarten cannot ignore social change, it must help children obtain positive concrete experiences, it must guide them to learn to live in this complex world, to learn e.g. how to use digital and mobile technologies correctly as a tool to explore the world, to communicate, learn and have fun. In order to fulfil this role, kindergarten needs teachers who are digitally literate. Or in other words: A teacher today must be digitally literate in order for him/her to be a good teacher.

Many innovative teachers gradually discover that their own digital literacy is natural, productive and irreplaceable for a modern teacher. That thanks to their digital literacy and own pedagogical erudition, they can use interactive whiteboard and robot toys to benefit the complex development of children. That they already recognize the potential of digital technologies to support their educational goals.

According to (Kostrub, 2012), interactive whiteboard enables learners (including children in pre-primary education) to be actively involved in activities presented on the board. One of the conditions for meaningful teaching using interactive whiteboard is high-quality teaching materials used for the holistic development of pre-schoolers' personalities. However, they do not have to limit themselves to using finished products since those often just update the paradigm of behaviorism and academism in today's digital environment. Teachers can create their own interactive teaching materials according to their own ideas and needs, as well as according to children's suggestions/ideas. Optimally, teachers should create conditions in which learners can be actively engaged as constructors/designers of learning products in the digital interface of the interactive whiteboard. For a child, interactive whiteboard is not a mere digital aid but it can be said that it becomes a toy to play with every day and to master the curriculum in a fun way. According to E. Mujkošová (2011, s. 38–48), interactive whiteboard is an electronic device used for interactive learning and teaching through digital technologies (e.g. via computer, notebook, directly from the interactive whiteboard, by clicking an interactive pen or by touching (finger) the projected image, etc.). Currently, interactive whiteboard can be used in the teaching process as a didactic (digital) aid and/or means. Learners and teachers use various sources of information through interactive whiteboard (e.g. Internet, CD, DVD, etc.); they solve various educational and real-life problems integrated in projects; create presentations of their own individual projects (children in collaboration with teacher); present the acquired knowledge directly onto or from interactive whiteboard, etc. For a child, interactive whiteboard is not a mere digital aid but it can be said that it becomes a toy to play with every day and to master the curriculum in a fun way.

Based on our experiences from practice, interactive whiteboard offers incredible benefits:

- using all sources of information – Internet, CD, DVD etc.,
- children's attention,
- presenting live, everything directly from the board,
- any problem that a child can see, hear, experience and actively solve, will be understood by it better and faster,

- solving tasks with parents at joint events, as well as viewing electronic portfolio of children by parents.

For teachers, interactive whiteboard facilitates their preparation for lessons, communication with children, and basically saves time. It allows children to feel like an even more integral part of the adult world, opening up wider dimensions of mutual communication. It goes without saying that interactive whiteboard must not be the goal but one of the means used in education and teaching. Each teacher should have a clear idea of its use and integration into the educational process. Only a well-thought-out use of interactive whiteboard and robot toys can bring the required outcome.

We emphasize that these children learn extremely effectively when they play with toys and tools so we should also facilitate digital technologies such as robot toys. These robot toys can change important aspects of children's cognitive process because:

- they change educational relationships between children and teachers,
- they offer new ways to create dynamic outcomes, conveying ideas and concepts to children that have so far been outside their content,
- they support the development of learning strategies,
- they open new opportunities for social interactions.

Robot toys, specifically Bee-Bot, Blue-Bot and Code-a-pillar are simple programmable floor toys through which we can develop the knowledge of basic concepts that children encounter in their lives, especially the names of everyday objects, familiar places, people, animals, plants and activities. Children's task is to look for the given term and word (picture) and program the toy to reach the predetermined target on the mat. For children, they are a means to get to know the outside world and for teachers, they are a means to increase the effectiveness of educational activities. They provide fuller, more accurate information about the subject being taught, ensure the acquisition of skills and habits, support the formation of desirable attitudes in children and thus contribute to improving the quality of educational activities. They aid in satisfying and developing children's cognitive interests and abilities, increase the clarity of educational activities, intensify and rationalize activities of teachers and children.

The aim of using robot toys is not only to diversify pre-primary education but also to ensure the comprehensive development of children's digital literacy that affects the holistic development of their personality and creativity, the ability to communicate, cooperate, seek, process and critically analyse information and also the development of higher cognitive processes.

These robot toys perform motivational, informational, training, application, control, feedback and educational functions. Since they contribute to the personality development, they also have a developmental function. They also fulfil ergonomic, aesthetic and technical functions.

DESIGN AND IMPLEMENTATION OF RESEARCH

The main objective of the research was to identify the pedagogical thinking of pre-primary education teachers and pre-schoolers and in particular the influence and contribution of interactive whiteboard and robot toys to the development of:

- children's social competencies,
- children's mathematical competencies,
- children's digital competencies.

The pilot qualitative research aimed to explore the self-conscious and critical use of interactive whiteboard and robot toys and their application in the teaching and learning process. The way the digital competencies of teacher participate in the development of learner's logical and critical thinking. The way they affect the acquisition of knowledge and the development of communication and information skills of teachers and learners.

The aim of the research was to find out whether teachers develop independence, competence and cooperation in children as part of the educational activities, based on the socio-cognitive model of teaching in the teaching process through digital technologies.

Research objectives:

- To implement educational activities focused on the analysis of the use of interactive whiteboard and robot toys in pre-primary education.
- To find out whether children have any experience with actual activities connected with interactive whiteboard and what their experience is.
- To identify the pre-schoolers' thinking regarding the transfer of space onto a surface area.
- To find out children's ability to cooperate in a group on assigned tasks in activities and their reaction to teacher's instructions.
- To identify the causes of underutilization of interactive whiteboard and robot toys in educational activities.
- To analyse the findings of working with interactive whiteboard and robot toys in kindergartens – what children have learned using digital technologies and what they know about them. Where we see the effectiveness of interactive whiteboard in the teaching process.

Research questions:

- What must the process implementation be in order for teachers to be able to use interactive whiteboard and robot toys in a comprehensive, purposeful and conscious way in their teaching based on the socio-cognitive theory?
- What competencies are developed during regular use of interactive whiteboard and robot toys in teaching?
- To what extent has independence increased by learning about reality using interactive whiteboard and robot toys?

Didactic and research tools and methods: interview, focus group, design method, unstructured observation method, method of analysing research material, interpretation of research findings.

Methodology:

The research was based on qualitative methodology. The research tools, methods used were participatory observation (in this part, the researchers along with the children participated in teaching activities), non-participatory observation and indirect observation (the researchers evaluated video recordings using Atlas.ti software). At the end of the activities, the researchers also conducted narrative interview, where children as subjects of the research spoke about their initial experiences with robot toys. Kostrub (2016) discusses these research methods in detail.



Figure 1: Activities of children with Code Pilar robotic toy.

Research sample: pre-primary education teacher, pre-primary education children. Entering the research project – before commencing the research, we had made arrangements for its implementation in a kindergarten with a deputy headmistress and a teacher. We had found out all the important information about the conditions: equipment, organization, personnel. We had studied literature pertaining to didactics, curriculum planning and preparation for pilot qualitative research. We had prepared an organizational outline of the educational activity before we actually commenced the research: a) to acquaint the teacher with socio-cognitive theories of teaching and learning and with the use of interactive whiteboard and robot toys in the teaching process in order to achieve harmony between the teacher and researchers; b) to plan the educational activities together with the teacher. The implementation of educational activities: they were implemented in a kindergarten in a heterogeneous group of children. The implementation took place in the classroom in the morning. As professional researchers, we directly took part in the implementation of educational activities. It was a direct observation of the implementation of teaching activities by the teacher. Indirect observation of subjects and analysing materials – photographs of children and video recordings.

RESULTS OF PILOT RESEARCH

Research results and their interpretation – in the course of direct and indirect observation, we noted the following – we provided children with more space for independence in their interaction with robot toys. Based on questions, they identified how to start up the toys and program them in the space. While actively interacting with robot toys, they identified various functions and options to play with them – programming a path for a robot toy with various sound effects; determining movement up, down, left, right; orientation on the surface area – mat; programming a path on the mat towards a target.

In the course of direct and indirect investigation of children's interaction with interactive whiteboard in the implementation of the performance standard - Based on instructions provided for the movement in the grid, we learned the following:

Despite the fact that the children were not in contact with the surface of the interactive whiteboard, and probably not even with the grid paper, when asked to create the path for the Bee-Bot robot toy based on the information the children provided, i.e. that the Bee-Bot may be moved right, left, up and down, they did create the path on the interactive whiteboard. To further probing questions: "Show me which way is 'up'," four children correctly pointed to where the direction 'up' was on the surface area.

To another question: "Show me which way is 'right'", a little girl in front of the interactive whiteboard automatically extended her hand to the right and in the direction of the line drawn on the interactive whiteboard. None of the other children indicated with their fingers that those were the lines pointing to the area on the right. However, this is not the children's fault. This is related to the understanding of mathematical and logical relationships which at this age in relation to children are natural. We assume that children have not yet been contacted with this transfer from the surface area into the space and from the space onto the surface area. We note that the teacher does not normally conduct such sophisticated dialogues with children in the course of teaching. For example: "Look for an object that is back there at the end of the classroom, on the right-hand side in the cabinet at the bottom," etc. We presume that such surface area – space and space – surface area transfer in children is not yet systematically and purposefully supported.

While observing children interacting in the classroom with the interactive whiteboard as a supporting component, we found that the children regularly only watch a storyline, play, song on the interactive whiteboard or complete missing items according to the teacher's instructions. We can conclude that children are not encouraged to interact with the interactive whiteboard. It is the teacher that is largely dominant in the interaction with the interactive whiteboard.

The inner motivation of children in their play and interaction with robot toys and interactive whiteboard was so strong that they remained actively engaged for a non-standard period of time, as is natural for their age. The motivating factor was the robot toys that made an impact on the inner motivation of children due to the attractiveness of their use. Children expressed curiosity, spontaneous interest, desire and willingness to explore. They examined and experimented with the robot toys and searched for connections between their own experiences and knowledge. They made a volitive effort in their play and overcame learning obstacles. They were delighted with their own results and expressed joy over independently acquired information during their play with robot toys.



Figure 2: Cognitive transfer of children from 2D to 3D

Problematization of the prospective research subject matter based on research findings can be defined as follows:

- In the current pedagogical didactic practice, the support of the holistic development of children's personalities is insufficient given the developmental possibilities of the children who are being educated, taking on the form of performing limited and unambiguous requests, commands, guidelines, where teachers explicitly do not support the learning of children using interactive whiteboard and robot toy in the classroom.
- Interactive whiteboard can be used in the teaching process as a didactic (digital) aid and/or means. Through interactive whiteboard, learners and teachers use various sources of information (e.g. Internet, CD, DVD, etc.); solve various educational and real-life problems incorporated in projects.
- The didactic incorporation of the use of interactive whiteboard and robot toys into the teaching process is not related to only one specific area of an individual's development. In didactic practice, interactive whiteboard and robot toys need to be used responsibly, systematically, and consistently in order to expand information and develop competencies of teachers and learners that also help teachers reduce the negative impact on children.

CONCLUSION

We implemented pilot qualitative research, the results of which we present in this paper. We had the opportunity to see that when we give children more space to be independent we provide them with room for active competence development. The children were given room to act and function independently. The pilot qualitative research confirmed that this is an issue worth addressing and it is interesting to children and teachers, as well as parents.

With the number of robot toys increasing, the question of how to incorporate them in teaching will become more open, and combining interactive whiteboard with robot toys is proving to be one the effective solutions.

Conscious and purposeful teaching and learning with the use of interactive whiteboard and robot toys will attract and stimulate the subjects to new ideas, suggestions and possibilities that correspond with their interests. A perceptive and reflective teacher listens to and accepts children's suggestions and opinions when implementing various topics via the use of digital whiteboard and robot toys.

In the future, we plan to conduct qualitative research in more kindergartens across Slovakia.

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Application of virtual reality in industrial control systems

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Abstract

Application of automation and robotics elements in production industry increases the competitiveness enterprises and development and programming of control systems for industrial automation thus becomes a key competence of the knowledge economy of each country. Education systems should be able to reflect these new social and economic conditions. The main question which the paper deals and which the authors try to answer is how the professional preparation of specialists for development and programming of automation and robotic systems should or could be carried out. An answer to this question the authors see in utilization of virtual reality elements in the training of these specialists. On the one hand this solution can contribute to increase the specialists' competence and professional skills, and on the other hand it can significantly reduce financial demands necessary to ensure material provision of the training. In this context the authors present in their paper a demonstration of the use of virtual reality systems in programmable logic controller (PLC) programming.

Keywords

Industrial automation. Programmable logic controller (PLC). Control system programming. Virtual reality. Development environments for PLC systems. Programming environments. Simulation modes. Education and professional training.

INTRODUCTION

Application of automation and robotics elements in production industry increases the competitiveness of both the enterprise and the entire country within the global economic space. It is no coincidence that companies, that are leaders in industrial automation, have their allocations in developed world economies. Development and programming of control systems for industrial automation thus becomes a key competence of the knowledge economy of each country (Hudedmani et al. 2017; Lashin, 2014; Vosough, S., Vosough, A., 2011). All the more this applies in case of developing economies, which have become a source or environment of "cheap" workforce predestined to operate automatic and robotic

production lines. It is very important education systems of these countries to be able to response personnel requirements of the knowledge economy. However, preparation of specialists for development and programming of automation and robotic systems puts high financial demands on both material and staffing provision of the education process, which is often significantly under-dimensioned in case of the developing economies environment. The latest results in the development of information technology, mainly of the virtual reality elements, could offer a solution to this situation (Yoon Sang, Hak-Man, 2013; Fuchs, Moreau, Guitton, 2011).

SIMULATION MODES OF DEVELOPMENT ENVIRONMENTS FOR PLC SYSTEMS

PLC (Programmable Logic Controller) is an industrial computer system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. One of its advantages is its modularity (Figure 1), what means that different types of input and output devices can be mixed and matched to get the best or most suitable application (EATON, 2019).

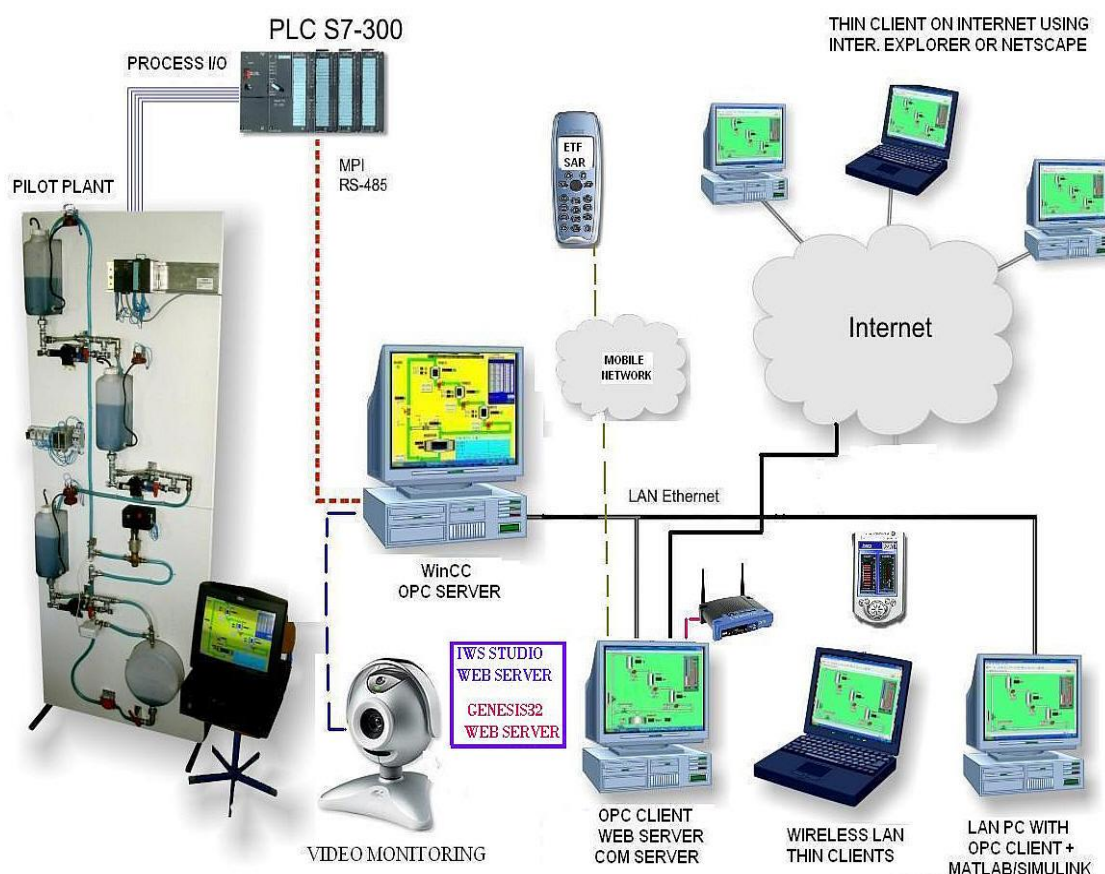


Figure 1: Demonstration of the modularity of the PLC systems.

In industrial automation one can mix and match is overtaken just by the PLC systems (Netto, Bagri, 2013; Voráček at al., 2000). Development of a control program for such a system takes place in specialized development environments that are implemented as applications in common personal. A finished program is then uploaded into the PLC system and is tested on a real automatic or robotic production line, where all sensors and actuators are already accessible for the PLC system.

Development environments for programming PLC systems usually also include a simulation mode in which the behaviour of a control program can be viewed before it runs on a real line.

Figure 2 shows a simulation mode of one of the programming environments and Figure 3. shows how the behaviour of the program can be monitored using the Oscilloscope function (Factory I/O, 2020).

A simple program (Figure 1) responds to two analogue inputs. The first analogue input IA01 records current temperature and the second analogue input represents the desired temperature, which is set e.g. through an HMI panel. Function block CP01 compares these two values and, on the basis of the result, turns on / off the output Q01 – heating or output Q02 - cooling, respectively. In the lower part of the figure there are shown possibilities to set or to change the input values for IA01 and IA02. Specifically, at the input IA01 the value of 2500 is set, what corresponds to the actual temperature of 25.00 °C. At the input IA02 the value of 2700 has been set, which corresponds to the desired value of 27.00 °C. Function block CP01 (Figure 1) compares these values and, since the current temperature is less than the set point ($25.00\text{ °C} < 27.00\text{ °C}$), it switches on the output Q01 - heating (red colour corresponds to the logic value of 1). Of course, the output Q02 - cooling, is switched off in case of the heating (black colour corresponds to the value of log 0). If the actual value is higher than the desired value, the heating is switched off and cooling is switched on. The time course of the values and the behaviour of the program can be monitored using the Oscilloscope function (Figure 2).

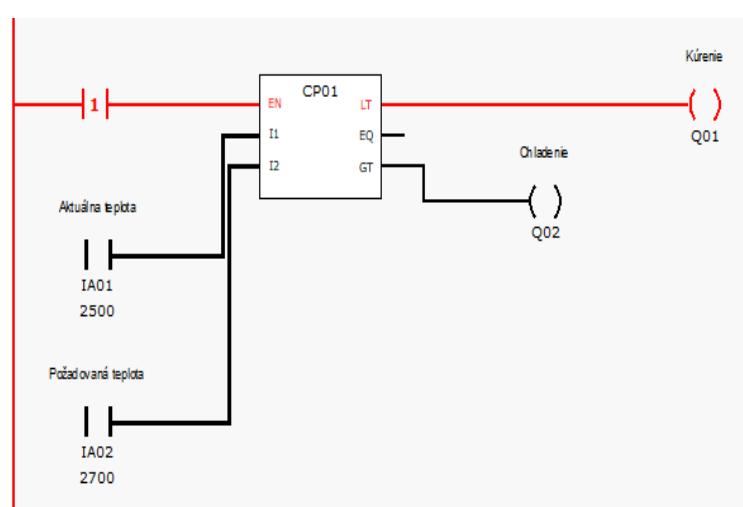


Figure 2: Demonstration of the simulation mode in EATON EasySoft v7 development environment.

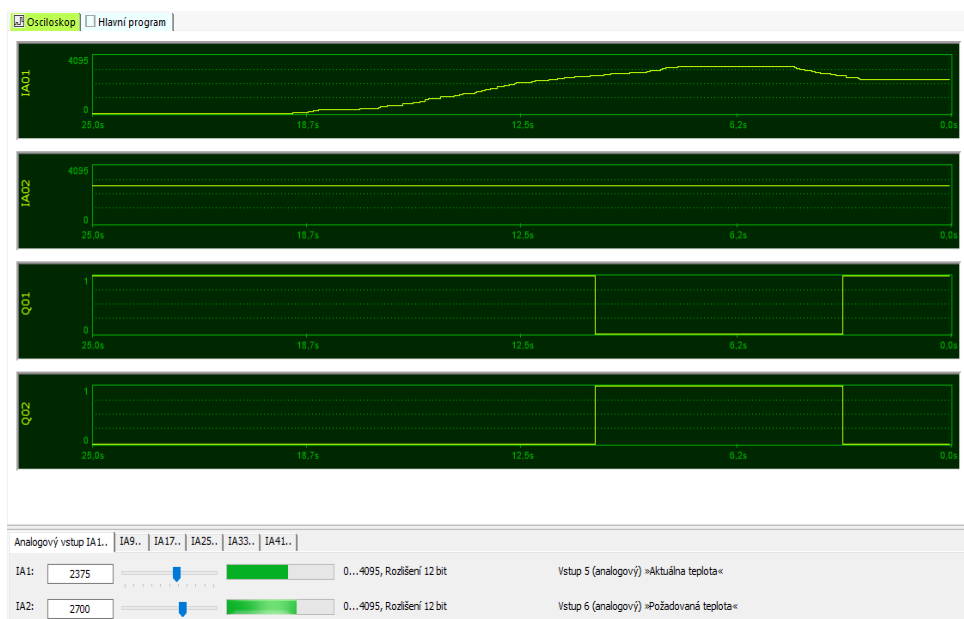


Figure 3: Demonstration of the time course of the monitored values through the Oscilloscope tool in the development environment of EATON EasySoft v7.

Simulation modes in programming environments bring many benefits and are important tools for programmers to develop different applications. Ability of these environments to substitute real systems is a significant contribution, and this regards as well the teaching process, as this offers a possibility to carry out the teaching process without the necessity of having or obtaining real and very expensive systems. In technical practice, they are used as testing environments at creation of the PLC control software. The programmer is able to create and to some extent also to test his program without the need to be physically present by the line. In industrial practice, there are often situations when the program is created simultaneously with the construction of the line. In such situations to test the program in the real operating conditions is possible only in case of the final hardware finalization of the realized project. Despite obvious technical and economic benefits, simulation modes of programming environments have serious shortcomings, which become evident at their setting into the real technical practice:

- PLC system inputs are controlled by a programmer by the means of simulation software. So, the input data cannot simulate specific reactions of the automation system that may be crucial to the behaviour of the control program.
- PLC system outputs in simulation mode are for informational purposes of the programmer only. They are "hermetically" isolated from the actuators of the automation system, which in turn influence the input quantities.

In our example, this means that the values of the inputs IA01 and IA02 are changed manually by the programmer. At the same time, the outputs Q01 and Q02, which switch on the heating and cooling, have not ensured any interaction with the inputs in any way. In practice, this may mean that if the current temperature exceeds a little bit the set point, the heating mode is switched to the cooling mode. However, when the temperature drops

slightly below the desired level, the modes change again. This, of course, repeats itself cyclically continuously. In case the controlled system has a high measure of the response rate and low level of the run down (after switching on the heating the temperature immediately increases and after switching off the heating it stops to increase immediately - the same but in a n opposite direction is applicable also in case of cooling), combined with a high external influence on the regulated system (for example, extremely high or low exterior temperature), then at temperatures near the desired value, the entire control system dangerously wobble itself. This is a common phenomenon and a disadvantage of binary controllers, what is solved in practice by setting the limit values of the control circuit hysteresis. Of course, our example is only indicative and its issue is well known to the professional community. We just wanted to point out that in technical practice there are often occurring key interactions between the outputs and inputs of the regulated system, which may not be reflected in the simulation mode, but may have fatal consequences for the behaviour of the control program. The use of simulation modes in teaching process undoubtedly has its advantages, especially of an economic nature. However, a question arises here, and it is to what extent such teaching can really reflect needs of the industrial practice and how it can prepare a student to solve real technical problems.

USE OF VIRTUAL REALITY SYSTEMS IN PLC PROGRAMMING

Development of information technologies creates new possibilities for their use in virtual simulations in different fields of science and education. For example, at the Department of Geography, Constantine the Philosopher University (CPU) in Nitra its members deal with modelling possibilities (Boltižiar, Biskupič, Barka, 2016) and at the Department of Information Technologies attention is paid, among others, to personalized learning supported just by the means of the newest information technologies and on them based systems of virtual reality (Balogh, Turčáni, Burianová, 2019). However, let's focus on application of these new trends in technical application practice, specifically on new possibilities for PLC control systems development and programming. What is also worth mentioning is the Adobe Flash system, which is used to program interactive web flash presentations and games. One of the workplaces, where the issue of the ways how the simple production processes can be simulated using just this system, is the Georgian Technical University (GTU) in Tbilisi. In frame of the Erasmus+ study stay at the Department of Technology and Information Technologies of CPU the PhD student of GTU (Salome Mukhashavria) has successfully develop a software interface between a real PLC system and interactive Adobe Flash presentations (Figure 4) to a technological process sequence for milk pasteurization.

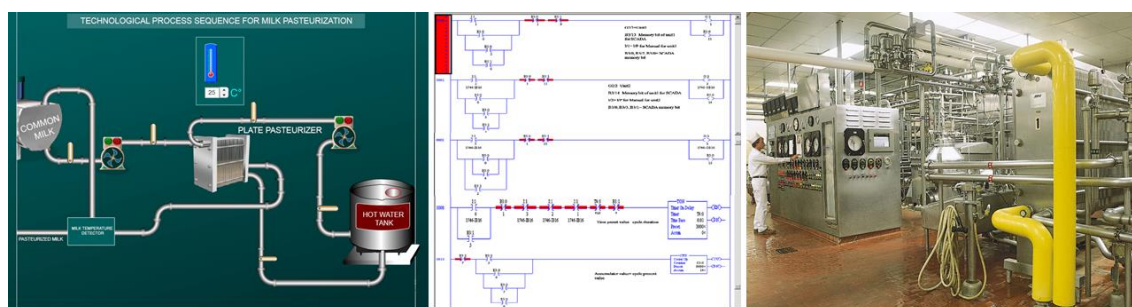


Figure 4: Technological process sequence for milk pasteurization.

Figure 4 shows a view of Adobe Flash application (on left) as an interactive presentation of functionalities of a real technological process (on right), controlled through a PLC control program (in the middle). By means of the software interface PLC responds to the virtual stimuli in the Flash presentation and at the same time by its signals it can influence (control) behaviour of the virtual objects in the presentation. It is clear that such solution has its application mainly in education or teaching. However, current technical application practice requires a powerful tool that would transfer the functional elements of machines (engines, feeders, sensors, etc.) to the virtual environment without the need to program their properties in virtual reality systems. Nowadays, CAx systems with possibilities to simulate operation and verify functionality of the design proposal are used in the design proposals of engineering projects. Robust CAE (Computer Assign Engineering) systems have thus crossed the border of the own support at the technical documentation creation. Virtual 3D models of components and simulations of entire automated lines significantly change the used development processes in automation. So on the one hand we have a functional virtual 3D model of the automated line, where we can verify behaviour of individual hardware components, and on the other hand we have a control program that can be tested in a simulation mode but with the aforementioned limitations. Connecting of these two virtual environments would bring enormous benefits to both schools and applicative industrial practice. A basic element of such interconnection is ensuring of the interaction between the virtual 3D environment of the automated line hardware and the simulation environment of the application in which the PLC program is being developed. One of such solutions is a 3D system called FactoryIO. FactoryIO uses a virtual reality system, in which it is easy to construct a functional unit of an automated line or of a robotic workplace. Elements of such a line act on various virtual objects, which subsequently can be recorded by virtual scanners. A great benefit of this virtual 3D system is its interaction with the PLC control program. In practice, this means that the simulation outputs of the PLC system interfere with the virtual objects operation, e.g. such as starting engines and conveyor drives. The conveyor then acts on various virtual objects (e.g. a box) and these begin to move in the direction of the conveyor movement. Subsequently, virtual sensors can record different processual phenomena (such as the movement of the box) and send information to the PLC simulation inputs.

Figure 5 illustrates a virtual reality space in which it is possible, using available components, to assemble a functional unit of the line together with different virtual objects. Menu of the technical components together with the objects is displayed on the right side of the screen. There are at disposal have more than 80 kinds of components such as Emitter, Remover, Items, Heavy Load Parts, Light Load Parts, Sensors, Operators, Stations, Warning Devices, Walkways.



Figure 5: Environment of the virtual reality of the program FactoryIO.

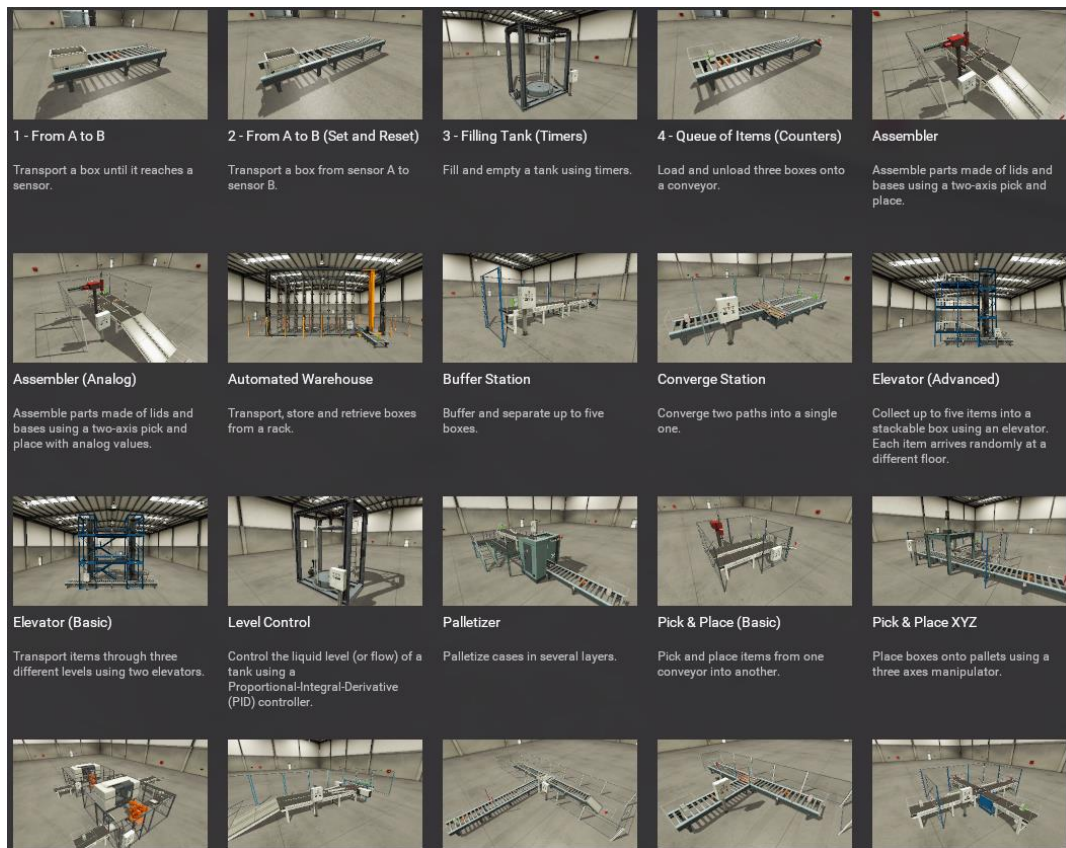


Figure 6: Menu of the already created scenes - automated lines automated line.

So to assemble the virtual line we have a wide range of design options available. However, we can also use 20 created scenes, which are already ready to be used (Figure 6). The greatest benefit of the whole system is the possibility to simulate the PLC program and to monitor the behaviour of the virtual line. The left side of Figure 7 shows the PLC program (SIEMENS Simatic 1200/1500, system TIA Portal), which is switched on in the simulation mode (green colour represents level log 1, black colour represents level log 0). In the

window on the right side of Figure 7 a user can watch, by means of a camera, behaviour of the automated line in the system of the virtual reality. A strength of FactoryIO is also its compatibility with various development environments such as Siemens, Alan-Bradley, Schneider, CodeSys and others.

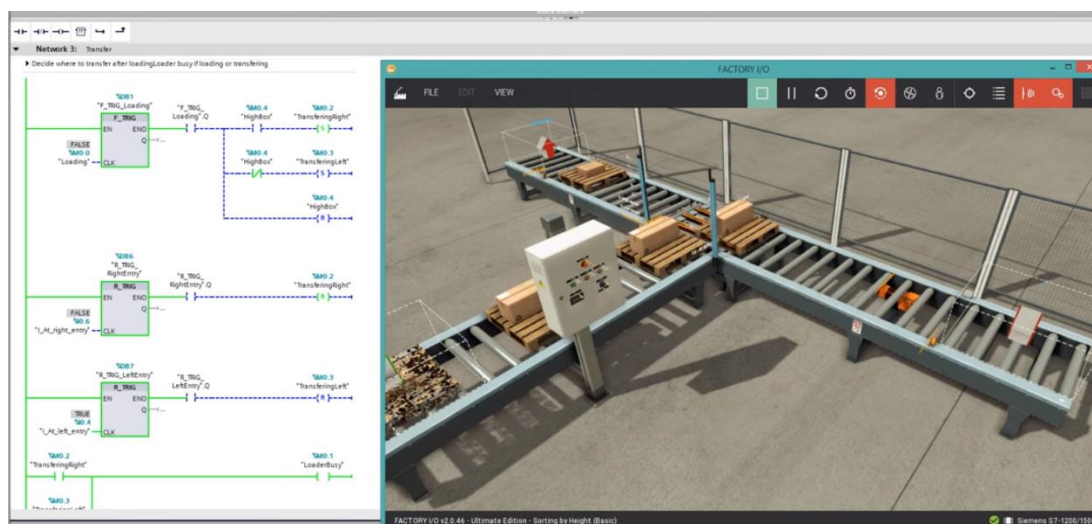


Figure 7: Demonstration of a control program simulation and a line operation in a virtual reality system.

CONCLUSION

PLC programming and automation applications in industrial practice are important parts of the knowledge economy. Material equipment of schools necessary to ensure appropriate quality of the graduates' education in the given field is very expensive. Utilization of virtual reality elements together with simulation environments of development environments brings new possibilities to increase quality level of teaching processes in financially affordable way (Challoner, 2017; Burdea, Coiffet, 2003).

However, application of virtual reality in simulation of industrial automation processes brings many advantages also in technical practice. In our opinion virtual reality systems, primary intended for gaming industry, have a high utility potential for both teaching process as well as project creation in industrial automation.

ACKNOWLEDGEMENT

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Exploring the Usefulness of Mobile Technology in the Teaching/Learning Process a Multidimensional Approach

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Abstract

One can basically assert that technology use in educational practice becomes an inseparable part of educational activity. Both teachers and students are increasingly using mobile technologies in teaching and learning. However, still very little is known and there is very little proof about application effectiveness of these technologies in the teaching/learning process. It is purposeful to responsibly integrate technologies into the educational process and to seek evidence of such integration. In November 2019, pilot research was carried out in two countries – Lithuania and Romania. Natural science and adjacent subject teachers participated in the research (125 – from Romania, 120 – from Lithuania). Research samples were arranged applying a random selection system. Referring to an earlier carried out preliminary research results, a research model was prepared. The research model consists of 4 main dimensions: 1) motivation to learn, 2) better understanding, 3) social learning usefulness, and 4) teaching usefulness. The model has been empirically validated and cross-validated. The prepared research instrument manifests itself in high reliability and can be successfully applied to explore the usefulness of mobile technology in the teaching/learning process.

Keywords

Mobile Technology. Multidimensional Approach. Pilot Study. Science Teachers.

INTRODUCTION

Nowadays, the teaching/learning process, a textbook and exercise book are no longer sufficient. The teacher needs to constantly innovate, change his / her work style, as well as diversify his / her teaching methods and tools. In the lesson, conventional teaching should be replaced by new educational approaches that encourage creativity and efficiency. It is clear that with the increasing flow of information in the educational process and the development of teaching/learning methods and tools, the teaching/learning methods used to date are no longer sufficient. On the other hand, mobile technologies are increasingly used in the teaching process.

This situation demonstrates the teachers' interest in these technologies, the necessity of their application in education, and the need to combine these technologies with conventional methodological tools in the educational process. On the other hand, students are more curious and at the same time very different, and their speed of learning is different, so it is important to choose interesting activities so that the children learn the material more effectively and the result can be better.

Applying teaching based on such technologies, in many cases creation of learning conditions is assured for today's learner, taking into consideration individual pace, time, place, learning possibility and autonomic individualized learning principles (Abromavičienė, Teresevičienė, & Volungevičienė, 2013), at the same time ensuring a good emotional environment/state (Francisti & Balogh, 2019). Research shows that mobile technologies allow to increase teaching process effectiveness, to enrich teaching/learning environment, help to use the newest resources and to integrate various topics, to develop critical thinking abilities and other (Burianova & Turčáni, 2016; Parigi, 2016).

So, mobile technology/devices offer a huge range of options: to learn a variety of things, read e-books, bookmark ideas and notes, collect text, share information, take pictures, draw, and more. Mobile technology/devices is a great tool, you just need to use it properly and effectively, and involve children in the learning process. In addition to the usual psychological and pedagogical knowledge, the future teacher will have to be a good student himself, interested in innovation, quick to learn and able to apply innovation directly to his work. On the other hand, the impact of mobile learning technologies on educational achievement and motivation has not been clearly demonstrated.

BACKGROUND AND CONCEPTUALIZATION

Related Work

Extant literature shows an increasing interest in mobile technology for educational purposes. It is argued that the use of mobile technology not only in computer science lessons but also in other subjects (e.g. science subjects) encourages students' motivation to learn. Research shows that technology's influence on learning is more involving than the usual conventional methods because learning continues virtually outside the classroom, in a real student's everyday life environment (Naismith, et al. 2004). Ciampa (2013) explored how mobile learning technologies were related to motivation peculiarities and established that mobile technology use in learning provided opportunities to experience challenge, stimulated curiosity, provided wider collaboration possibilities. It is obvious that for today's

students it already becomes a usual thing that any information devoted to learning is easily achieved, it can be found on the internet. A research carried out in Lithuania (Gudonienė, 2011) showed that the majority of students use smart mobile phones for internet searching (92.5%), also for logging on at internet cafes, learning environment journals and social networks for learning demand satisfaction (35.5%).

It is obvious, that a great amount of research has been devoted to the analysis of how and why students use mobile technology in their learning process, why mobile technology is used and what it offers or challenges. Fua and Hwangb (2018), conducted systematic research of scientific publications from 2007 to 2016 related to mobile technology-driven education. Mobile technology-based learning has been found to be more effective in cognitive, metacognitive and epistemological terms than internet-based learning (e.g., appropriate tools for learner understanding and concept transformation). Learners are making real progress due to social interaction. They work with a variety of information, communicate with peers and experts to construct and reflect meaningful knowledge. MT-based learning is a potential way of learning to facilitate knowledge acquisition, metacognitive skills, and epistemological beliefs by engaging students in collaborative learning. According to Viberg and Grönlund (2017), students use different mobile technologies for different purposes in their formal and self-directed learning environment. They like to use mobile technologies because of their affordability, flexibility, compatibility, and interactivity. Students often use mobile technology in non-formal education, i.e. finding some time for learning between the activities that are already planned. Agrawal and Parvez (2018) emphasized that mobile technology is a robust package of scientific advancement, compact and convenient. It's flexible, easy to use, compact, inexpensive, multi-functional, user-friendly learning approach.

On the other hand, research also showed a possible negative influence as well. The research carried out by Legkauskas (2013) showed that video games that teenagers play on computers, phones, and game consoles, can have a negative influence on motivation to start any other activity. The research by Ramasauskienė (2014) revealed that frequent use of mobile phones makes it hard to concentrate, shortens the time of live communication with friends, and has a negative impact on educational achievement results. Research also shows that the use of mobile technology causes interpersonal conflicts with teachers, parents, in this way, communication behaviour becomes worse (Phillips, Butt, & Blaszczyński, 2006).

Nevertheless, mobile technology use has a positive influence on teaching/learning. The research by Gray, Ryan, and Coulon (2004) showed that new technologies having occurred both in students' and in teachers' everyday life, make the teachers have IT usage skills, convey them to students and provide them with new knowledge and skills. Some of the research showed that MT use has a positive influence with regard to students who lack motivation because these devices were especially useful creating teacher and students' relationships, which in turn facilitated the learners' involvement in the education process (Ison, Hayes, Robinson, & Jamieson, 2004; Walsh, Lemon, Black, Mangan, & Collin, 2011). In spite of the fact that many of the students can be better prepared in the technology sphere than teachers, it is important to create a suitable teaching/learning environment for the latter, which would allow them to effectively use mobile technologies (Ferry, 2009). The

educational environment factor is significant because this can build trust in the use of mobile technologies (Kim, Kim, D-S., Choi, 2016).

Research Model and Measures

The usefulness of mobile teaching and learning (MTL) has been conceptualized as a second-order factor that loads on four dimensions (first-order constructs): motivation to learn expectancy (ML), better understanding expectancy (UU), social learning usefulness expectancy (UL), and usefulness for teaching (UT). The research model is presented in Figure 1.

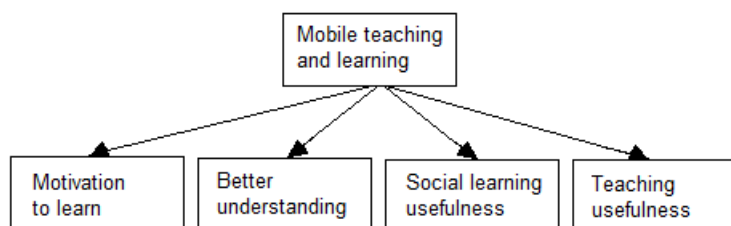


Figure 1: Research model.

The motivation to learn expectancy (ML) is measuring the increased motivation of students as anticipated by teachers. It is expected that by introducing mobile technology in class students will be less stressed and bored. It is also expected that the lessons will be perceived as more interesting and attractive since students will feel in control by using their own devices (Lamanauskas et al., 2019).

A better understanding expectancy (UU) is measuring the anticipated benefits as regards the understanding of concepts (Fua & Hwangb, 2018; Lamanauskas et al., 2019). By using educational applications on their own devices, students will pay more attention and, consequently, will become able to use their knowledge in a creative way.

Social learning expectancy (UL) refers to the opportunities to extend learning in nonformal contexts (such as visits to museums) and learn in a collaborative way. In both cases, mobile technology is expected to favour social learning (Ciampa, 2013; Naismith, et al. 2004).

Usefulness for teaching (UT) is measuring the new opportunities created by mobile technology (Isson et al, 2004). Teachers will be able to prepare more interesting lessons and to find ways to better explain difficult concepts (Lamanauskas et al., 2019). Moreover, teachers may find it easier to give learning tasks to students. The first-order constructs and measures are presented in Table 1.

Table 1: Constructs and measures.

ML	Learning motivation expectancy
ML1	By using mobile technology students may be less bored by the traditional methods
ML2	By using mobile technology students may feel in control to learn with their own devices
ML3	By using mobile technology students may find the lesson more attractive
ML4	By using mobile technology students are less stressed and learning is accepted as a game
ML5	By using mobile technology students may find the lesson more interesting
UU	Better understanding expectancy
UU1	Mobile technology may stimulate students to pay more attention to lessons

UU2	Mobile learning stimulates creativity
UU3	Mobile technology may help to better understand the lesson
UL	Social learning expectancy
UL1	Mobile technology may help to learn outside class
UL2	Mobile technology may help the collaborative learning
UT	Usefulness for teaching
UT1	With mobile technology, I could prepare more interesting lessons
UT2	Mobile technology helps to give learning tasks to students
UT3	With mobile technology, I could better explain difficult concepts
UT4	With mobile technology, I could better stimulate the students to learn
UT5	Mobile technology enables working with simulations and virtual labs
UT6	Mobile technology helps the evaluation process

EMPIRICAL STUDY

Method

The research was quantitative, of a pilot type. The research was carried out in November-December 2019. Before the pilot research, preliminary research was carried out in order to understand the use of mobile technologies in the educational process and to prepare the research questions for the pilot study (Lamanauskas, Slekiene, Gorghiu, & Pribeanu, 2019).

Two samples have been collected: one from Lithuania ($N=120$) and another from Romania ($N=125$). Exploratory factor analysis has been carried on the first sample that confirmed the four-factor solution (extraction method: maximum likelihood, rotation method: Promax). However, the results were unacceptable as regards the item reliability and factor loadings so four items have been eliminated: ML2, UU1, UT5, and UT6.

In order to validate the research model, two models have been specified and tested by using the revised scale: four first-order inter-correlated factors (measurement model) and a second-order factor (structural model). The models are presented in Figure 2. Estimation results have been analysed according to the recommendations from the literature as regards the validation of measurement models, and hierarchical models (Anderson & Gerbing, 1998; Edwards, 2001; Koufteros et al., 2009).

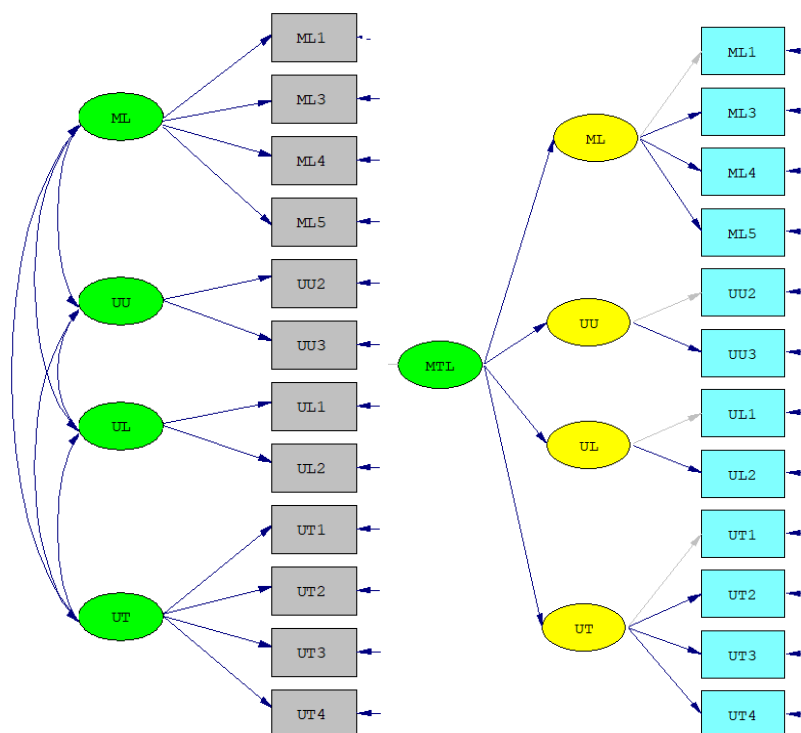


Figure 2: Four-factors model (left) and second-order factor model (right).

Convergent validity has been assessed according to the recommended thresholds from the literature (Fornell & Larcker, 1981; Hair et al., 2010), as regards loadings magnitude (greater than 0.5), construct reliability (composite reliability, CR greater than 0.70), and average variance extracted (AVE, greater than 0.5). Discriminant validity is less important here since the dimensions are expected to be highly correlated (Koufteros et al., 2009).

The model was analysed with Lisrel 9.3 for Windows (Mels, 2006), using a covariance matrix as input and maximum likelihood estimation method.

Model Estimation Results: Lithuanian Sample

Sample

The sample consisted of 120 teachers. The teachers distribution by age was as follows: 3 teachers in 20-29 years group, 14 teachers in 30-39 years group, 29 teachers in 40-49 years group, 50 teachers in 50-59 years group, and 24 teachers over 60 years old. According to qualification: 18 (15%) were teachers, 32 (26.7%) - senior teachers, 56 (46.6%) - teachers methodologists and 14 (11.7%) - teachers experts. From the teachers having participated in the research, 30 teachers work with all age group students, i.e. with the 5th - 12th forms, 23 – with the 7th – 12th forms, 38 – with the 9th – 12th forms, 1- only with the 12th form, 14 – with the 5th - 8th forms, 5 teachers with each 5th -10th forms and 7th -8th forms, and 2 teachers with each 7th -10th forms and 9th -10th forms.

Measurement Model Testing Results

The first-order model has been analysed for unidimensionality, the internal consistency of the scale (Cronbach's alpha), and convergent validity. The descriptive statistics, item loadings, and convergent validity are presented in Table 2. All mean values are over 3.00

(neutral). The highest-rated items are those related to the expectancy for social learning usefulness. With one exception (UT2) all item loadings are over 0.6, thus proving unidimensionality of the first-order factors.

Table 2: Descriptives, loadings, and convergent validity.

Factor	Item	Mean	SD	Loading	Alpha	CR	AVE
ML	ML1	4.13	0.65	0.69	.835	0.852	0.592
	ML3	4.13	0.69	0.82			
	ML4	3.68	0.72	0.68			
	ML5	4.16	0.61	0.87			
UU	UU2	3.58	0.78	0.69	.674	0.683	0.519
	UU3	3.84	0.67	0.75			
UL	UL1	4.30	0.63	0.78	.714	0.720	0.563
	UL2	4.14	0.64	0.73			
UT	UT1	4.24	0.62	0.78	.783	0.786	0.483
	UT2	4.15	0.60	0.56			
	UT3	3.96	0.56	0.68			
	UT4	3.68	0.69	0.74			

The convergent validity is good, since the composite reliability (CR) is varying from 0.683 to 0.852 and the average variance extracted (AVE) from 0.483 to 0.592. The model fit with the data is good, as shown by the goodness-of-fit (GOF) indices: $\chi^2 = 69.83$, $df=48$, $\chi^2/df=1.455$, CFI=0.964, GFI=0.912, RMSEA=0.062, SRMR=0.056.

Structural Model Testing Results

The second-order model was evaluated in order to assess the relationship between the second-order factor and its dimensions (first-order factors).

With one exception, the factor loadings for the second-order model are above the threshold of 0.7, varying from 0.61 to 0.99. The convergent validity of the second-order construct is very good (CR=0.903, AVE=0.704). The second-order factor model explains 66.8% variance in ML, 79.6% variance in UU, 37.4% variance in UL, and 98.3% variance in UT. The model fit with the data is also good, as shown by the GOF indices: $\chi^2 = 72.17$, $df=50$, $\chi^2/df=1.443$, CFI=0.962, GFI=0.908, RMSEA=0.061, SRMR=0.08.

The existence of a second-order factor has been tested with the T-coefficient (Marsh & Hocevar, 1985), which is the ratio between the χ^2 of the first-order factor and the χ^2 of the second-order factor. In this case, $t=0.968$ (greater than the recommended cut-off value 0.80) thus suggesting that the second-order factor explains 96.8% of the relationships between first-order factors.

Model Estimation Results: Romanian Sample

Sample

The sample of 125 teachers consisted of 34 men and 91 women, distributed by age as follows: 15 teachers in 20-29 years group, 27 teachers in 30-39 years group, 29 teachers in 40-49 years group, 43 teachers in 50-59 years age group, and 11 teachers over 60 years old. 93 teachers are active in the urban area and 32 in the rural area. In the research, there were

involved: 81 teachers who have the level 1 certification (64.8%), 22 teachers who have the level 2 certification (17.6%), and 22 teachers having a full-time professional degree (17.6%). From the teachers having participated in the research, 70 are working with lower secondary students (5th - 8th forms) and 55 are involved in upper secondary education (9th - 12th forms)

Measurement Model Testing Results

The first-order model has been analysed for unidimensionality, the internal consistency of the scale (Cronbach's alpha), and convergent validity. The descriptive statistics, item loadings, and convergent validity are presented in Table 3. With one exception, all mean values are over 4.00. The highest-rated items are those related to the expectancy for learning motivation. With two exceptions (ML1 and UT2) all item loadings are over 0.6, thus proving unidimensionality of the first-order factors.

Table 3: Descriptives, loadings, and convergent validity.

Factor	Item	Mean	SD	Loading	Alpha	CR	AVE
ML	ML1	4.05	1.02	0.59	.833	0.845	0.581
	ML3	4.25	0.89	0.79			
	ML4	4.02	0.97	0.77			
	ML5	4.34	0.86	0.87			
UU	UU2	3.84	0.95	0.72	.763	0.784	0.646
	UU3	4.08	0.79	0.88			
UL	UL1	4.10	0.90	0.71	.735	0.740	0.588
	UL2	4.08	0.83	0.82			
UT	UT1	4.26	0.80	0.83	.828	0.834	0.562
	UT2	4.06	0.79	0.57			
	UT3	4.08	0.82	0.80			
	UT4	4.02	0.92	0.77			

The convergent validity is very good since the composite reliability (CR) is varying from 0.740 to 0.845 and the average variance extracted (AVE) from 0.562 to 0.646. The model fit with the data is good, as shown by the goodness-of-fit (GOF) indices: $\chi^2=69.08$, $df=48$, $\chi^2/df=1.439$, CFI=0.971, GFI=0.920, RMSEA=0.059, SRMR=0.042.

Structural Model Testing Results

The factor loadings for the second-order model are all above the threshold of 0.7. The convergent validity of the second-order construct is very good (CR=0.893, AVE=0.678). The second-order factor model explains 58.2% variance in ML, 65.5% variance in UU, 59.4% variance in UL, and 88.0% variance in UT. The model fit with the data is also good, as shown by the GOF indices: $\chi^2=84.15$, $df=50$, $\chi^2/df=1.683$, CFI=0.953, GFI=0.909, RMSEA=0.074, SRMR=0.056.

The *t*-coefficient (Marsh & Hocevar, 1985), is 0.821, (greater than the cut-off value 0.80), thus suggesting that the second-order factor explains 82.1% of the relationships between first-order factors.

DISCUSSION

It is obvious that there exists a demand to have a reliable and valid instrument for any measurement. In this case, a measurement scale is prepared in order to explore the usefulness of mobile technology in the teaching/learning process. The usefulness of mobile technologies for teaching and learning has been measured as a second-order construct that manifests along four dimensions. Three dimensions out of four are related to the expectancy of students' motivation, better understanding, and social learning. One can claim that such approach is appropriate because MT use cannot be evaluated using a single construct or a single-item scale (Lin, Wang, & Li, 2016), though such examples exist (e.g., one dimension and ten variables model constructed by researchers) (Turhangil Erenler, 2018). Seeking to measure MT usefulness and/or effectiveness in the education process, the created instrument has to involve various aspects, only then this will be a useful diagnostic device.

Earlier carried out research shows that the biggest attention was devoted to instruments, measuring mobile technology effectiveness (Hung & Zhang, 2012). Moreover, attention is focused on examples of mobile practices and developments in the educational use of mobile technologies (Valk, Rashid, & Elder, 2010). Fojtik (2014) also accentuated that today's mobile technologies increase learning motivation, create conditions for interactive educational activities. Besides, students' learning achievements improve due to the use of MT. MT creates flexible teaching/learning solutions, and in this way support learning in different situations (Sivakumar, 2014). It is understandable that MT use by itself does not ensure teaching/learning success. However, as research showed, MT supports active learning, increases motivation and satisfaction with activity (Ferreira et al., 2015). Regarding teachers, a serious challenge remains of how to choose and what technology to use, in order to facilitate/make more effective students' learning. It is firstly because MT may be both beneficial and harmful. Nevertheless, despite the rather abundant research of MT use in the sphere of teaching/learning purposes, there is still not much research devoted to evaluating the effectiveness of mobile technologies.

The multidimensional perspective provides higher explanatory power and enables the analysis on two levels. The model estimation results bring evidence for the existence of a second-order factor in both samples.

There are inherent limitations of this pilot study. A limitation is the small number of items for the second and the third first-order factors. Since the data has been collected in both countries in the same period of time, it was not possible to revise the scale after testing it on the first sample. Another limitation is related to the number of dimensions. The elimination of the last two items from the fourth construct suggests that the scale could be further refined.

CONCLUSIONS AND IMPLICATIONS

This pilot study contributes with a multidimensional model measuring the usefulness of mobile technologies for teaching and learning, as perceived by science education teachers from Lithuania and Romania. The model has been empirically validated and cross-validated on a second sample which suggests good reliability and a promising starting point for further studies.

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ICT supported Time management as important competence for learning and life

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Abstract

Today, there is often talk of "digital natives" and "digital immigrants". In this way, ICT competences are differentiated between people of different ages. Depending on the date of birth, generation X (in Poland born between 1960 and 1985), Y (born between 1985 and 2000) and generation Z (born after 2000) are distinguished. Competences regarding the use of ICT are thought to increase from generation X through generation Y to generation Z. Therefore, it was decided to examine whether there is a correlation between belonging to a given generation (X, Y, Z) and the ability to use ICT. The described research is a fragment of a larger part and relates to the ability to use ICT in time planning. Research conducted from April 30, 2017, to February 8, 2020. In summary 833 people took part in them. The research was based on the SAMR model for Technology. Statistical analysis of the results obtained did not confirm the correlation between belonging to the X, Y Z generation and the "depth" of using ICT in time management.

Keywords

Electronic working time organizers, Model SAMR, digital natives, digital immigrants, generations X, Y and Z.

INTRODUCTION

Planning is about thinking about the future tense. It is a process in which we start with a more general look at the whole of our time and then go into details. Proper planning of the use of our time is associated with the question of the purposefulness of our actions. And

although many admit that planning is important, only a few devote enough time to it. People instead of planning immediately take action, which allows reducing the level of tension, but does not bring us closer to the goal. Meanwhile, studies show that it is enough to spend only 1% of the time needed to perform a given work to save one hour a day (Seiwert, 1998; Bradley, McRae, 1994). Both in everyday life and in education (Gil Flores, De Besa Gutierrez, Garzon Umerenkova, 2020), many people delay in completing the task. This situation has a negative impact on both achievements in real life and learning outcomes. The research proves that man's mental health index is his/her ability to self-organization (Savva, Saigushev, Vedeneeva et al., 2016). It is specified that time management, self-organization skills are regarded as a regulated conscious person's activity, which aims at goal setting, time planning, as well as self-control, self-analysis and self-correction of one's actions and behaviour. Time management, self-organization skills secure timeliness and succession of student's life cycle changes. Also, research conducted by (Eldeleklioglu, Yilmaz, Gultekin, 2010) showed that a positive relationship was found between psychological well-being and time planning. The research revealed that the realization of long term projects can be sometimes problematic students. The problems derive from inappropriate project management, especially time management (Balogh, Klimes, Turcani, 2011; Balogh, Turcani, Magdin, 2015; Baprowska, Bilek, 2017; Balogh, Kuchárik, 2019). The planning skills of older students are also moderate (Tanriogen, Iscan, 2009). It seems that currently in the era of access to various types of calendars, including online, planning your activities should not be difficult. We always have even the simplest calendar on our phone.

It was decided to check how Generation Y (Millennials - the generation of people born in the 1980s and 1990s) and Generation Z (Post-Millennials - a generation of people born after 2000) uses on-line time planning tools. Because, unlike the previous generation, referred to as generation X, generation Y "tamed" technological innovations and actively use digital media and digital technologies and are considered a bold generation, open to new challenges. Recently, young employees from generation X and Y are often called generation C - from the adjective "connected" as people constantly connected to the internet and using social media for private and professional communication every day. Generation Z (multitasking generation) are people for whom technology is the main tool for expanding knowledge. Therefore, it was assumed as a research hypothesis that people belonging to Generation Y or Z will fully use on-line time planning tools (Becton, Walker, Jones-Farmer, 2014). It was decided to examine whether and how online tools for time planning are used. The research was based on the SAMR model for Technology Integration created by Puentedura (2009). In this model, he defined several levels of technology integration in the process of education or everyday life. In each subsequent level, we immerse ourselves deeper and deeper in technology and use it more fully. Definitions of subsequent levels and examples of the use of the same tools at subsequent levels are shown in the figure below.

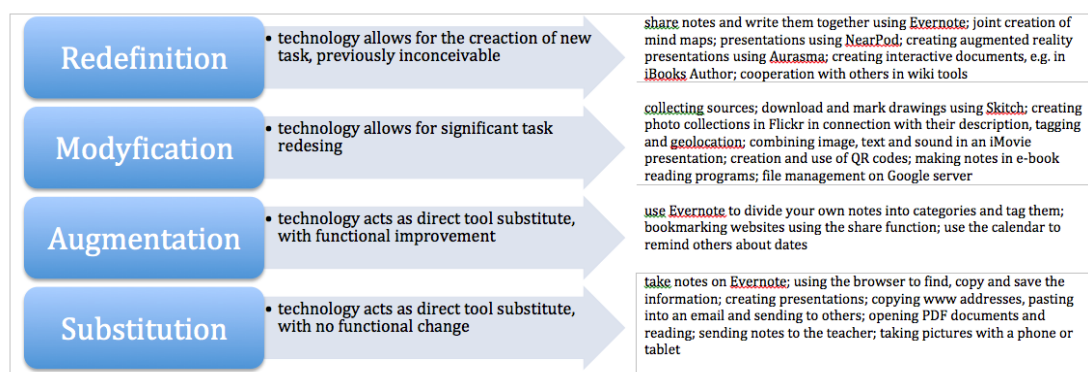


Figure 1: Definition of levels in the SAMR model and assigning sample activities to individual levels (modified from original by Puentedura, 2018)

Research conducted by Zhai, Zhang, Li et al. (2019) showed that the Augmentation level from SAMR model of use was positively correlated with the learning outcome, but the Substitution level of use was not. Also, research conducted by Sanchez, Mendieta, Lainez et al. (2018) have also shown that the integration of mobile educational technology with a ubiquitous approach favours the results of learning mathematics. The positive impact of the application of the SAMR model in mixed teaching has been demonstrated by research conducted by Albeanu, and Popentiu-Vladicescu (2019). This applies to both teaching/learning effectiveness and increasing student motivation. Research of Onyango and Gitonga (2016) shows how the use of the SAMR model allows the use of ICT for lesson planning. In turn, research of Tsybulsky and Levin (2017) concerned transformations of practices associated with microcomputer-based laboratories (MBLs). It is shown that the Redefinition level reflects the fundamental transformations of our society in the Digital Age. The proposed SAMR model demonstrates the deep interpenetration of science and technology. Also, the use of the SAMR model to use ICT in education brings positive effects (Connie, 2015). Unfortunately, higher levels (M and R) in the SAMR model are often not used and users use technologies - only in the first stage - S - substitution (Tsybulsky, Levin, 2016).

METHOD

Research on the use of time organizers for life planning and learning was part of our larger research on the use of ICT in life and science. The research lasted from April 30, 2017, to February 8, 2020. In summary 833 people took part in them. Research sample included 68.7% women and 31.3% men. The largest group of respondents were undergraduate students (35.8%), followed by post-graduate students in M.A. level (33.1%) and high school students (19.8%). Other respondents were post-graduate students in Ph.D. level (3.1%), students of elementary schools (3.1%), junior high schools (3.6%), and servants of the University of the Third Age (1.5%).

The respondents' task was to answer the question of whether they use any time planning tools. And if they use it at what level of SAMR model they use them.

For the needs of the study, subsequent levels SAMR of on-line calendars using were defined:

Level (S) Substitution An online calendar is used to perform the same tasks that were performed before computers appeared. The calendar contains data, dates of meetings, dates of birth and name of the family. In this situation, there is no functional change. Although in some situations, substitution makes some sense, but in fact, there is no profit from using ICT here.

Level (A) Augmentation At this level, computer technology is used as an effective tool to solve basic problems (tasks). For example, the calendar sends us notifications (e-mail, SMS) about upcoming dates. We can share calendars - that is, we know when our colleagues have free time and when busy. We can automatically mark non-working days in different countries - which is important in the globalization of the labour market. The calendar will show us any time zones - because more and more people are working outside of local time zones.

Level (M) Modification The calendar significantly expands its capabilities. We can create events to which other users can be invited. We can give the event location, a map of the place in the calendar. The calendar will help us achieve our main goals and resolutions - if we set goals and define the frequency of operation, the desired time and the optimal time for us - the calendar will search for appropriate gaps in our schedule, which with our permission will fill the selected activities (at level S and A we can do it yourself but if something important falls to us during this time, the calendar will not plan this activity in other free time).

Level (R) Redefinition - the last stage of the SAMR model is Redefinition and represents the pinnacle of how technology can transform a student's experience. In the calendar, we can assign tasks to our colleagues to monitor their progress. Add photos, notes, and film materials to your dates. We can use it as a communicator and create video conferences.

The respondents' task was to indicate at which level of the SAMR model they use the online calendar. It was enough to use one of the elements of a given level to be able to indicate this level.

RESULTS

The most numerous group among the respondents are people who do not use electronic time organizers at all - it is as many as 294 people (which is 35.3% of the group). The least numerous group are people who use organizers at the highest level of Redefinition. There are only 41 such people, which accounts for 4.9% of respondents. The number of responses in individual groups along with error lines and the trend line is shown in Figure 2.

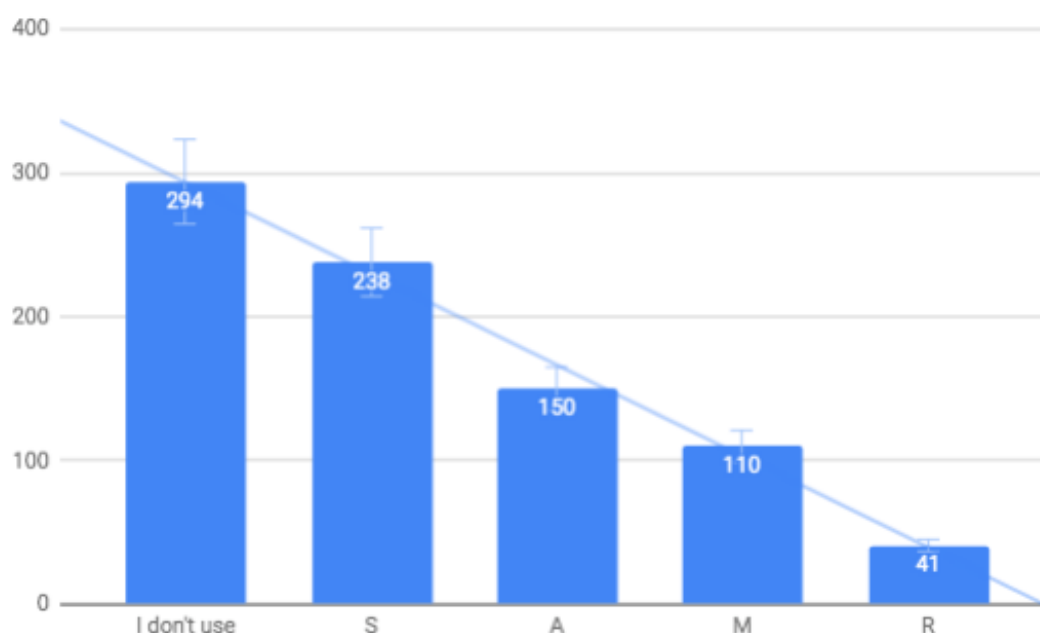


Figure 2: Respondents' answers to the question: At what level of SAMR model do you use electronic organizers?

Almost a third of respondents (238 people, 28.6%) use electronic organizers - just like regular calendars. It means only for saving important information. It does not use any of the online features available. Even sending SMS or emails with event reminders. Other people (301, 36.1%) use organizers at higher levels. However, with each successive degree the number of respondents decreases (A-150, 18.0%; M-110, 13.2%; R-41, 4.9%).

In the introductory part of the survey, participants were asked about gender, age, level of education, and "How much are you interested in new technologies?" and "How much do you like to learn?" A correlation was expected between the age of study participants (X, Y, Z generation) and the level of use of the electronic calendar, and a correlation between interest in new technologies and the level of use of the electronic calendar.

No correlation was found between the level of organizer's use and:

- gender (Spearman correlation coefficient $r = 0.05$),
- level of education ($r = 0.02$),
- age of the respondents ($r = -0.02$),
- ICT interest ($r = 0.19$),
- willingness to learn ($r = 0.16$).

In our research the correlation between gender and ICT interest was weak positive correlation ($r = 0.21$). However, in the research the correlation between the level of education and ICT interest turned out to be average ($r = 0.50$).

DISCUSSION AND CONCLUSION

The main purpose of the research was to confirm or refute the hypothesis that the Y and Z generations use computer technologies (in this case electronic calendars) at higher SAMR levels than the X generation. By the way, other correlations were also examined.

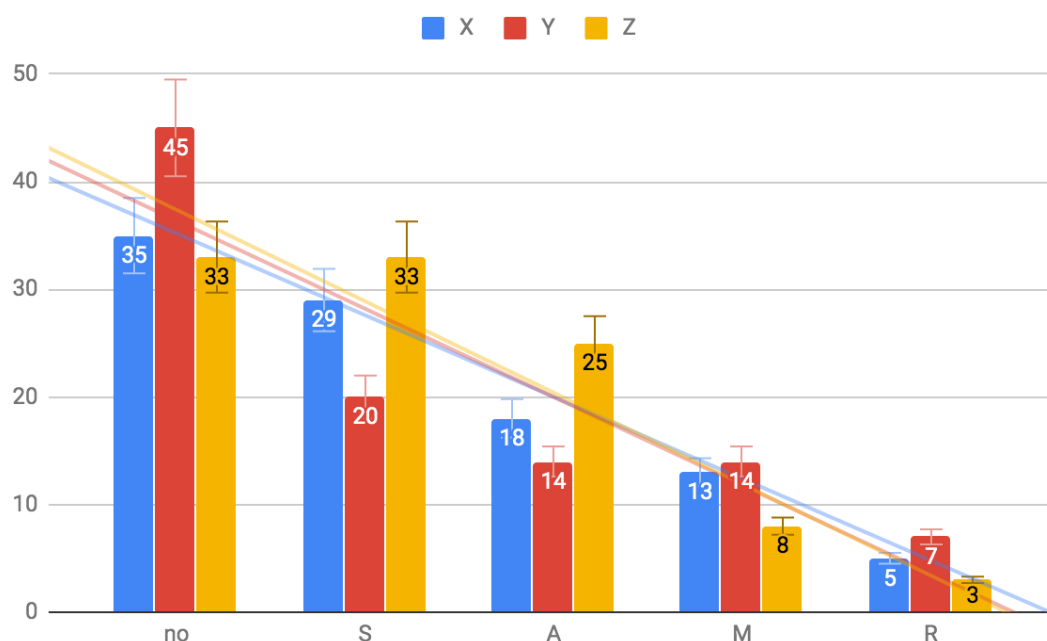


Figure 3 Comparison of Y and Z generation and X generation respondents' answers to the question: At what level of SAMR model do you use electronic organizers?

The weak positive correlation between gender and ICT interests ($r = 0.21$) means that men, slightly more often than women, are interested in new technologies. The average positive correlation (0.50) between age and education level is obvious.

The very weak correlation ($r = 0.19$) between the interest in ICT and the SAMR level of the use of the time organizer is puzzling.

The conducted tests did not confirm the expected correlations, especially between age (i.e. belong to the X, Y, Z generation) and SAMR level of use the electronic organizer.

The lack of correlation between age (i.e. belonging to the X, Y, Z generation) and the use of electronic calendars can be explained in several ways.

The first of the explanatory theories results directly from research. The research hypothesis that belonging to the generation affects the level of use of more advanced functions of the organizer has been refuted - so perhaps the generations Y and Z use ICT more often, but their ability to use more complicated functions of the organizer does not differ from the skills of generation X (see Figure 3).

The second theory refers directly to the e-skills of individual generations. Assuming that in fact Y, Z generations use ICT more fully, it can be concluded that instead of using the Redefinition level in the organizer, they use tools dedicated to given tasks. So instead of add photos, notes, and film materials to your dates or use it as a communicator and create video

conferences - they use Photoshop, messengers, and Skype. Perhaps instead of delving into the next possibilities of one program - people from generation Y, I will use many different programs at lower levels (S and A).

The third theory concerns personal time management skills regardless of the tools used. As many as 1/3 of respondents do not use organizers at all - it proves the lack of ability to manage themselves in time. It can be assumed that the remaining 2/3 of respondents try to manage their time, but we do not know if they have competence in this field. And at what level are these competences. Scientists studying human time management skills (Covey et al., 1994; Lakeina, 1973; Macan, 1994) distinguish three levels of time management:

1. The first step consists only in creating to-do lists and keeping notes (without using a calendar). It is an attitude more adapting to emerging tasks than creating reality.
2. The second stage occurs when the scheduler adds task planning and calendar preparation to the task list.
3. The third level complements the previous two with a reflection on the values and priorities in life, there is also a definition of a long and short-term goal.

Perhaps the level of organizing your time affects the SAMR level of using an organizer. And because we acquire this skill with age, generation X prevails over this generation over generations Y and Z. Which disturbs the possibility of assessing the impact of the age of respondents on the level of SAMR of organizer application.

In order to be able to conclude that belonging to the generation does not affect the SAMR level of ICT use, further research should be carried out. It seems that further research should determine the level of time management skills (third theory) and check if generation X actually uses fewer programs than Y and Z (second theory).

In this moment we can say that no correlation was found between the age of respondents (belonging to the X, Y, Z generations) and the SAMR level of the use of time organizers.

ACKNOWLEDGEMENT

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Design of Wiki Application in Microlearning in Terms of Attendance and Course Utilisation by Students

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Abstract

The article focuses on the possibilities of further development and enrichment of the e-Learning and MicroLearning (ML) concepts in the framework of university education. After creating an ML course and having it used by students in their classes, we discovered that they study in bursts, especially shortly before the final test. One solution may be the inclusion of continuous testing during the semester. However, we prefer the creation of texts related to the course content. We are exploring the option of involving students in a project-based wiki creation, which could be a possible solution to encourage better attendance of the course and to improve the utilisation of its content. For this reason, we are focusing on how the wiki could be used in teaching and how it is already being applied in research. We mention our concept of ML, and the framework for integrating wiki creation into an existing ML course. In the results, we present the findings of the analysis of the attendance and utilisation of our current ML concept by students in the course "Computer Architecture and Operating System Basics". As log records analysis results show, students attended the course in an irregular and fitful manner, where the attendance is the highest just before the test date. There are also significant differences between the attitudes and approaches of individual students, and from a statistical point of view, those who attended the course more often and spent more time in the course achieved a higher score in the test.

Keywords

Wiki, MicroLearning, e-Learning, LMS, student engagement.

INTRODUCTION

Seeing as e-Learning has become a relatively common thing today, the research is turning towards its improvement, enrichment and further development. In addition to mobile learning (Blilat and Ibriz, 2020; Crompton and Burke, 2018; Kumar, Goundar and Chand, 2020), MicroLearning (ML) is also being currently developed (Hesse et al., 2019; Jahnke et al., 2019; Skalka and Drlík, 2018).

As part of the author's research to date, we have focused on ML, designed a concept and converted the traditional e-Learning course into an ML course. During the verification of the e-Learning courses created in such a way, we have found that some undergraduate

students (groups of students) of the teaching fields attend the e-Learning courses on a sudden and fitful basis (see Results below). Especially at the beginning and end of the semester. In teaching, this can be solved by including continuous testing during the term, where students are forced to regularly attend the e-Learning course in addition to the knowledge gained in full-time teaching in order to prepare for the tests. According to preliminary findings from the winter term 2019/2020, we have shown that this approach could produce corresponding results.

However, since we do not consider the (largely) negative motivation (avoiding bad grades) approach to be the most appropriate approach, we decided to find a path that would motivate the students and engage them to utilise the course and its content without testing in classes. As a possible solution to this problem we consider using the wiki in teaching and learning, focusing on students' work with study materials in the ML course and creating their own summaries and notes in collaboration and cooperation. In addition, the work and familiarisation with the wiki will be beneficial for undergraduate students of teaching fields and their subsequent practice. So far, they have not commonly encountered this instrument in their studies.

MicroLearning and its benefits

Since 2004, MicroLearning is no longer a completely unexplored area of research into e-Learning. Small, relatively independent blocks in accessible form (Almazova, Rogovaya and Gavrilova, 2018), granularity and division of larger curriculum into smaller parts (Bruck, Motiwalla and Foerster, 2012) are mentioned in connection with it. In many implementations, it is a mobile learning concept focusing on asking questions and choosing the appropriate answers (Bruck et al., 2015; Göschlberger and Bruck, 2017; Zhaparov Meirambek K, Aitchanov Bekmurza H and Nussipbekov Abai, 2012). The results of the research indicate that when it is used, the students achieve better factual knowledge (Matthews, Hin and Choo, 2014; Rehatschek and Smolle, 2018; Polasek and Javorcik, 2019).

Wiki and its use

Nowadays, wikis are quite commonplace on the Internet. However, their origins date back to 1994 (Leuf and Cunningham, 2001), when the first website of this kind was launched. Although today the concept of co-creating and editing content on the web by visitors (Web 2.0) seems obvious, before the advent of Cunningham's WikiWikiWeb, it was not obvious at all; collaboration was only possible using e-mail Exchange (mailing lists), shared folders / file access and only later through Interactive pages (Leuf and Cunningham, 2001).

In practice, wikis are used in multiple applications, such as classic web pages (wiki serves as CMS), or in particular as a knowledge base or knowledge management system (Pellet, 2012; Wagner, 2004; Willmes et al., 2018), but they can also serve as personal knowledge management systems (Hsiao and Huang, 2019). The best known wiki application is the Wikipedia encyclopaedia, which suffers from some issues caused by its large number of authors (editors); one of such issues is editing vandalism, known as "edit wars" (Alfonseca et al., 2013; Giles, 2005; Tramullas, Garrido-Picazo and Sánchez-Casabón, 2016). These issues, together with the varying knowledge and competences of the contributors, can affect the quality of Wikipedia's individual articles. On the other hand, it needs to be said that it did not turn out at all bad even when compared to encyclopaedia Britannica (Giles, 2005).

Use of Wiki in education

Possibilities of wikis and their utilisation in teaching become apparent shortly after their creation. Initially, the focus was on what the wikis can offer and how to use them in class (Augar, Raitman and Zho, 2004), but technical aspects were also considered. The main thing mentioned in discussions about the way wikis are used is the collaborative community (Ruth and Houghton, 2009), where newcomers work together with experts. Considering its application in education, Ruth sees wikis as a tool of discovering knowledge (Ruth and Houghton, 2009). Recently, research into the use of wikis in education has focused on problematic (DeWitt et al., 2017; Ioannou, Brown and Artino, 2015) and project-based (Chu et al., 2017) teaching, the aspects of writing and engaging students (Alghasab, Hardman and Handley, 2019; Cho and Lim, 2017; Hadjerrouit, 2014) in collaborative learning (Hadjerrouit, 2014; Su et al., 2019), and teacher-student interaction (Alghasab, Hardman and Handley, 2019). Wikis are used in teaching programming (Lin, Wu and Chiu, 2018) or even as a system for creating some form of a knowledge base (Lin and Reigeluth, 2019, 2016).

If we use a wiki to involve students in writing, we cannot always count on them to have an active approach. It is advisable to implement supporting activities and set certain goals (Cho and Lim, 2017). Scaffolding is a way to involve students when using a wiki (Huang, 2019; Lin and Reigeluth, 2016, 2019), as it leads the learner through steps towards knowledge.

Our concept of ML

In creating the existing e-Learning course, we used the LMS Moodle environment and supplemented it with the educational units created according to MicroLearning principles (Hug, 2005). We created these MicroLearning units (MCUs) using the H5P platform and integrated them into a traditional LMS environment. Individual MCUs were created with the principle of easy “consumption” by students, where the limiting factor was the length of one MCU of about 5-7 minutes, respectively 5-7 concepts/ideas. Each of these units had a short quiz (at the end or on one of the slides). MCUs contained text as well as photographs of individual computer components, peripherals, connectors and interfaces.

Our concept of using wikis – a proposal to integrate Wiki with MicroLearning

Regarding the classification of the concepts for using wikis in learning (Page and Reynolds, 2015), our design concept corresponds to “Group authoring & learning”, where students create their own form of a learning aid, which is related to already created MicroLearning units (MCU). It is a form of writing and creating a knowledge base with a link to a specific MCU with the possibility of adding any other resources and materials on the Internet that the students can use as additional materials. We intend to divide the students into groups, each of which would be tasked with elaborating one area of related concepts. Within these groups, each student chooses one keyword (a page) to elaborate, but the group as a whole is responsible for the whole area of related concepts. The aim is to encourage students to create (write), as well as edit and collaborate in the creation of a given section of a wiki page and to achieve appropriate quality for all wiki articles created.

Contrary to the previous concept of ML, where we used MCUs within the LMS, this time wiki has been chosen as the environment for their presentation. It does not provide the support of pre-prepared structures for inserting individual MCUs. However, this can also be an advantage, seeing as the course creator (teacher) can create a quite different ML course,

for example, with a much greater emphasis on using hyperlinks for interconnecting the wiki and individual MCUs.

ML is sometimes criticised for the fragmentation of information (Hug, 2012), leading to a mere accumulation of isolated facts. We want to counter this by using the ability to link individual MCUs within the wiki. In the case of LMS Moodle, the possibilities of using hyperlinks for linking individual learning units are not usable in practice (the course and unit URLs will change when they are imported).

The aim is to use the ML course as a curriculum presented in a decomposed form, which the student is forced to use and get familiar with during the creation of articles and links in wiki. Until now, students had to prepare a seminar paper on a given topic and present it in the classroom. In order to enhance the students' motivation to create and improve the wiki, there is an opportunity to let the students choose the topic for presentation from the wiki articles they will create within the wiki working group.

METHODS

As part of the "Computer Architecture and Operating System Basics" course in the winter semester of the 2019/2020 school year (23 October to 20 December 2019), the students had access to an e-Learning course designed according to the above ML concept in LMS. Nineteen students enrolled in the course, one student did not participate in the course at all; seeing as he also did not attend any of the classes, we excluded him from the analyses. Another 3 students had already discussed the subject in detail at secondary school (they thus attended the e-Learning course only minimally) and other 2 students did not finish the whole course (did not write the final test), which we also excluded from the analysis. In total, records of ML course use by 13 students ($N = 13$) were included in the analysis.

At the beginning of the semester, a test of entry knowledge (pre-test) was submitted to the students, which was followed by a credit test (post-test) at the end of the semester. During the semester, students had access to an e-Learning course, and no other study materials were provided. The course consists of ten topics and contains a total of 120 MCUs. Furthermore, in the framework of learning and teaching, each student was assigned one of the topics covering a part of the curriculum and had the task of elaborating it as a seminar paper and presenting the result in teaching.

The Matomo analyst system (www.matomo.org) was used to monitor attendance and student access to the course. Due to the lack of reliability of the attendance measurement and the possibility of identifying individual visitors using Matomo analytic data (they were compared with the LMS logs), we used only the LMS Moodle logs in the subsequent analysis.

Logs of actions performed by students in LMS Moodle were imported into MySQL database for further editing and analysis. Subsequently, a custom script was created in the PHP scripting language for further aggregation and data analysis. In analysing the data, we focused on the number of visits and fetches by semester weeks, even for individual students, calculating the total time spent in the course for each student, and the number of times a student visited on a given day. We used a 30-minute inactivity threshold for each day to distinguish between individual "next visits". To refine the tracking to only monitor the activities where students were learning in the course, we included in the statistics only

the logs that were associated with the following Moodle components: H5P, File, Page, Basic System.

RESULTS

One of the basic indicators of how the current ML course was used by students is the attendance and individual fetches (loading) of ML course pages. Table 1 provides an overview of attendance and fetches. While the number of visits did not change so dramatically – although an increase can be seen at the beginning of the semester (week 2) and at the end of the semester (weeks 12 and 13). This corresponds to the date the students participated in the final test (16 December 2019, at the very beginning of week 13). In addition to the increase in visits, the number of pageviews increased (see Figure 1). The behaviour of time spent in the course (Table 1) *de facto* copies the number of page loads.

Table 1: Overview of attendance, fetches of course pages by students (pageviews) and time spent in the course in each week

Week	2	3	4	5	6	7	8	9	10	11	12	13
Pageviews	6	148	192	82	30	46	29	39	83	144	1021	158
Visits	2	56	49	26	14	24	20	13	26	26	59	52
Pageviews per visit	3.0	2.6	3.9	3.2	2.1	1.9	1.5	3.0	3.2	5.5	17.3	3.0
Minutes in course	5	360	227	125	7	31	30	64	153	208	1142	149

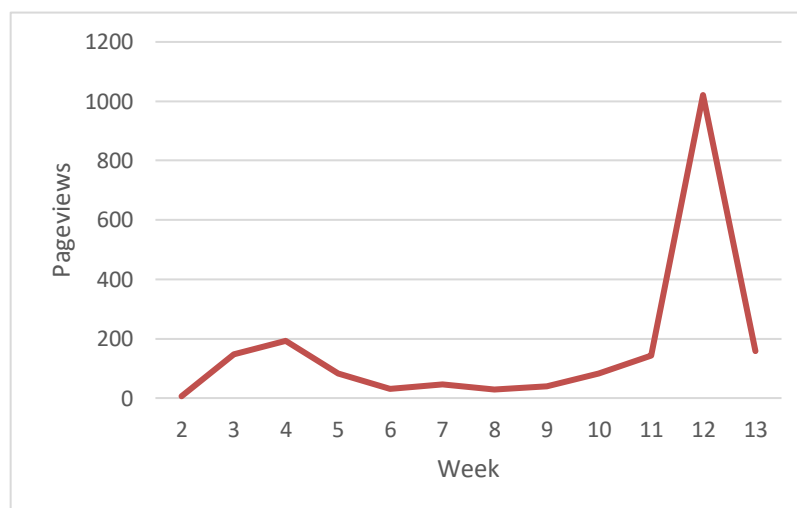


Figure 1: Number of course page loads in each semester week

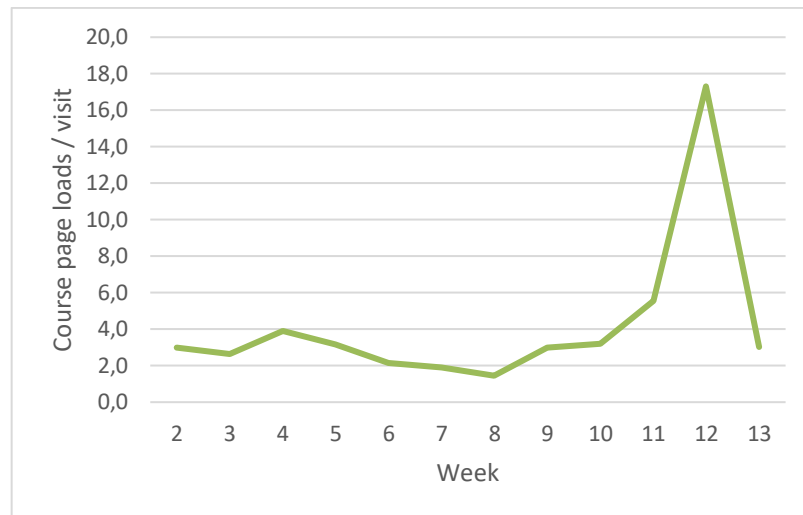


Figure 2: The number of times a course page was loaded per visit in each week

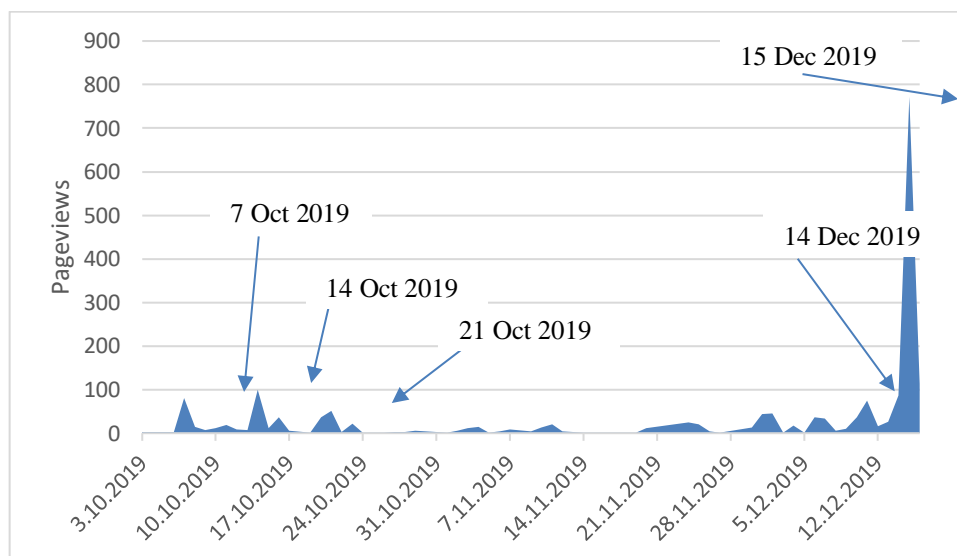


Figure 3: The number of course pageviews on each day

The behaviour of the number of course content loads is shown in Figure 3. The culmination occurred on 15 December 2019 /week 12/, on the eve of the test date, when there were 772 pageviews (at Mean 30.2, std. dev. 97.46, Median 8.5). Other days when the number of fetches was higher were 7 October 2019 (81 pageviews) /week 3/, 14 October 2019 (100) /week 4/, 14 December 2019 (86) /two days before the test; week 12/.

Table 2: Visits and fetches, the duration of the ML course, and the number of visits and fetches for the first sessions and subsequent sessions for individual students, and comparing the correlations of these parameters to grade in the test

Student No					1st visits of the day		2nd and next visits of the day		(Max. 28)
	Visits	Pageviews	Pageviews per visit	Time in course (mins)	Visits	Pageviews	Visits	Pageviews	Test grade
1	31	490	15.8	750	20	202	11	288	24.83
2	17	41	2.4	12	11	18	6	23	17.43
3	29	108	3.7	241	22	89	7	19	17.38
4	25	52	2.1	33	19	36	6	16	13.13
5	14	44	3.1	58	11	29	3	15	15.09
6	24	158	6.6	164	17	69	7	89	14.96
7	18	325	18.1	356	14	205	4	120	23.43
8	33	263	8.0	344	18	189	15	74	24.33
9	2	5	2.5	32	2	5	0	0	13.98
10	29	105	3.6	78	21	64	8	41	18.51
11	22	103	4.7	105	15	57	7	46	24.62
12	28	61	2.2	48	21	49	7	12	13.43
13	9	61	6.8	102	9	61	0	0	12.84
correlation to grade	0.449	0.75	0.7	0.69	0.27	0.76	0.62	0.66	
p value	0.12	0.002*	0.01*	0.008*	0.36	0.002*	0.02*	0.01*	

As can be seen from Table 2, there are not so many differences in the total number of visits between students (Mean 21.6, std. dev. 9.22, Median 22), also the correlation to the final grade is less significant for this variable (0.45). In the case of the course pages fetches (and thus educational units fetches), the differences between individual students are greater (Mean 139.6, std. dev. 139.4, Median 103). Students who achieved the best grades also fetched some of the content (MCU) of the course most often. The correlation between the number of fetches of some course content and the final grade is also significant at 0.75. Similarly, the number of minutes of studying the course for each student shows a 0.69 correlation to grade.

To further analyse the students' behaviour in the course, we focused on their repeated visits within one day. The number of visits per day ranged from 1 to 5 visits. The number of only one visit per day was the largest (200 visits) and the number of second and subsequent visits was 81 in total. That was one of the reasons why we only considered the first visits per day and all the others on that day combined when processing the data. Only pageviews of first visits per day have a significant correlation (0.76) to the final grade, as their number decided how the student approaches the study. The number of first visits per day has only a low correlation to the grade, because even those students who did not spend so much effort made the first visits. Conversely, in the case of second and subsequent visits per day, we can find a more significant correlation to the resulting grade – a correlation of 0.62 for visits and 0.66 for pageviews.

DISCUSSION

The results of the analysis of visits and the use of the created ML course “Computer Architecture and Operating System Basics” show that students attended it in a sudden and fitful manner. Their attendance, or the number of course page fetches (MCUs) culminated in week 12, just before the test. The highest number of fetches was recorded on 15 December 2019 (with an overlap into the morning of 16 December 2019), with 16 December 2019 being the date of the credit test. This is not ideally suited to the distribution of study throughout the semester, reducing the amount of knowledge that students learn through the course as a result of sudden and fitful learning.

Another aspect is the different approach of students to the number of fetches of the course content (in total and per visit). Students with the highest number of fetches (Students 1, 7, 8) achieved one of the highest scores in the test (24.83, 23.43, and 24.33 out of the total 28 points). Only Student 11 with “only” above-average number of course content fetches achieved a similarly high score (24.6). Similarly, we can identify the link between the time spent in the course (studying) and the points gained in the test.

For these reasons, it seems appropriate to modify the current concept of the course so that students attend the course more often and spend more time in it during the semester. In addition to the possibility of introducing continuous mini tests in lessons, we consider it more appropriate to involve students in the creation of wiki articles that are linked to the MCU course. Regarding this approach, the literature mentions the reluctance of students to write articles for the wiki. A suitable measure is the mentioned scaffolding (Huang, 2019; Lin and Reigeluth, 2016, 2019) and the division of students into groups. This also shows better results for content-creation and writing (Bikowski and Vithanage, 2016). Regarding the division into groups and their size, it is recommended to limit the number of members to four (Kessler and Bikowski, 2010), which was successfully applied to younger students (Mak and Coniam, 2008). Therefore, we expect the wiki utilisation to be adapted accordingly to students’ approach to the course.

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Using the Geographic Information System in the technological development and manufacture of insulators

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Abstract

One of the main criteria of any technology for the production of insulators is to ensure the most homogeneous mixture of material used in their manufacture. In the case of increased heterogeneity of ceramic blanks, the fired insulators made therefrom are characterized by an increased number of cracks on their surface, lower mechanical quality, which means reduced production quality and efficiency. This represents a loss of material and financial resources for

the manufacturer. In this paper is proposed a method of measuring the homogeneity of dielectrics in the manufacture of very high voltage insulators, using the voltages on the surface of the sample placed between the electrodes, together with a demonstration of their quality evaluation using geographic information systems. As an example, the results from the measurement of the homogeneity of ceramic blanks are presented. For the evaluation of the homogeneity of the measured environment was used a) expression in the form of a shape index, which expresses the deviation of the measured equipotential level of voltage from the ideal homogeneous state; b) display of functional dependence of voltage on distance; and c) 3D visualization of measured voltage in the sample. Geographic information systems have proved to be a suitable means of evaluating and visualizing the results of the measurement quality in homogeneity of blanks by the method of measuring the voltage on the sample surface. The proposed method of measurement and evaluation is also applicable to other materials and has its application in the didactics of electrotechnical materials.

Keywords

VHV insulator. Geographic information system. Texture measurement. Ceramic blank.

INTRODUCTION

In the production of very high voltage (VHV) insulators, one of the important factor for achieving high quality and production efficiency is the homogeneity of the blanks from which the raw insulators are made and after firing the product as a result is a ceramic insulator. Preparation of ceramic blanks on a vacuum press is the technological operation in which the internal arrangement of the individual components of the ceramic mixture is formed. The homogeneity of the arrangement of the individual components of the ceramic mixture is dependent on the orientation of the individual particles of the raw material components of the ceramic mixture, especially clays and kaolins, and is dependent on the rational composition of the ceramic mixture, its granulometric composition, the amount of water present in the mixture and its properties. The formation of a homogeneous arrangement of the mixture particles in the blank volume during vacuum pressing also depends on the technical state of the press (vacuum chamber state, technical state of the extruder screw and the level of the mixture descaling before pressing), from technological conditions of pressing (humidity of the mixture, speed of extrusion of the mixture in the press, temperature of the blank) and from the conditions of preparation of the semi-finished ceramic product to be pressed (such as the conditions of preparation of the preforms and their storage prior to the pressing itself).

It is important that the manufacturing technologist has information on the homogeneity of the ceramic blank which will enable him to use the knowledge of the technological texture in the technological process of insulator production.

A requirement of the technology production of large-size ceramic blanks and the VHV insulators made therefrom is that the method used to measure of the technological texture and the procedure for evaluating the results is characterized by:

- technical simplicity, speed of sample preparation, unassuming measurement and evaluation of results,

- simple application in practice, undemanding measurement preparation, simple collection and manipulation of the blank sample during measurement,
- the simplicity of the technical principle of measurement, supported by the theoretical justification of the method used to measure homogeneity,
- a simple and transparent approach to assessing the results obtained.

Production technology expects that measurement results would provide technologists:

- a clear and rapid possibility to decide on the level of homogeneity of the blank produced;
- assessing the possible impacts on the quality of production and making a qualified decision on technological adjustments in the production process (impact of the shape of the insulator, suitability of composition and granulometry of the mixture and determination of technological conditions in other processing processes).

Various theoretical solutions of texture measurement can be found, for example, in works (Kozík et al., 2019a, 2019b; Kozík and Minárik, 2013), which also include other methods for determining the texture of ceramic blanks. However, these methods do not meet the above technological and operational conditions for texture determination.

With regard to the above-mentioned requirements of the technology of the insulator production and based on the study of the scientific literature as well as the actual technological practice, the paper proposed a method of determining the homogeneity of ceramic blanks (technological texture of moldings), by measuring the differences in electrical voltage on the surface of a specimen formed from a ceramic blank inserted between electrodes with a constant electrical voltage and evaluated using Geographic Information Systems (GIS).

Geographic information systems belong to relatively dynamically developing information systems whose primary goal is to process and work with spatial (mostly geographic) data. Although GISs are mainly associated with geosciences, it is broadly interdisciplinary in nature and can be used in a variety of sectors and activities (e.g. forensic science, economics, didactics, archaeology or health care).

METHODS

From a technical point of view, to achieve the desired results, an experimental device has been designed and implemented to measure the potential difference at any point on the sample surface located between the voltage electrodes. Setting of the measuring point on the sample is solved using three bipolar stepper motors. Motors through mechanical gears, ensure sample rotation, movement of the measuring head with the probe and its pressure on the sample surface are controlled by an adjustable program in the PC, which is a part of the device (fig. 1). The scanning of voltage differences in the measuring points with the probe is logged and evaluated in the PC via parallel port. Voltage difference measurement is fully automated according to the selected program. (Kozik and Noga, 2015).

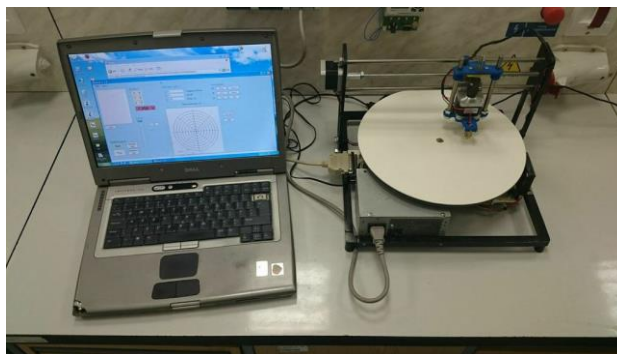


Figure 1: A view on the experimental device for measuring electrical voltage on the sample surface

Experimental Ceramic Mixture Used in Measurement

The measurement of the homogeneity of the ceramic blank by the method of measuring the voltage difference on the sample surface was performed on blank samples made on a Netsch vacuum press.

The pressed corundum ceramic mixture was prepared under operational production conditions and had a raw material composition: 30% of kaolin, 15% of clay, 30% of feldspar and 25% of corundum. The extrusion temperature during extrusion did not exceed a temperature of 21 - 22 °C.

Preparation of Measurement

Based on the possibilities and principle of measuring the voltage differences on the surface of a ceramic sample (a dielectric inserted between electrodes with a constant voltage connection), this experimental apparatus allows two ways of positioning the electrodes in:

- a) axial direction - perpendicular to the direction of the specimen axis (fig. 2a),
- b) radial direction - parallel to the axis of the (blank) compact (fig. 2b).

For making samples from the blank, a tool of its own construction for cutting was used, which allowed to cut samples from a larger blank part with a thickness from 1 mm up to several centimetres. Prepared blanks were characterized by the same thickness in the entire volume.

On such prepared samples from the blank, after their insertion into the apparatus for measuring voltage differences and setting the measurement program, the voltage differences on their surface could be measured.

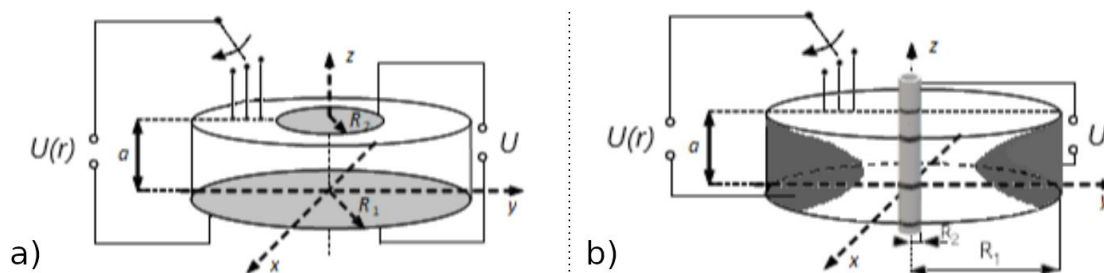


Figure 2: Principle of texture measurement arrangement in: a) axial and b) radial direction

In the experiment, the electrode arrangement of fig. 2b. was used. Connected voltage to electrodes 3.5 V, sample thickness 23 mm, external sample diameter (also electrode) 295 mm, internal voltage electrode diameter 3 mm, first measured point from sample center 10 mm.

The output of the experimental measurement of the individual voltages at the points on the sample surface is a table display of the measured values. The movement of the probe during measurement is from the center of the sample to its edge in the specified direction and at a specified distance between the individual measurement points.

GIS Evaluation

The GRASS (Geographic Resources Analysis Support System) GIS program was used to evaluate the measured results. It is a open-source geographic information system enabling work with spatial data on many platforms, both using the graphical user interface and especially the command line (GRASS Development Team, 2019).

Since these systems require information on their geographical location, these non-spatial data tables had to be projected into a coordinate system (CRS) before they can be used again. For our purpose, the global Cartesian coordinate system WGS84 Pseudo-Mercator was used, where the X coordinate of the sensor serves as the longitude, the Y as the latitude and the voltage differences themselves as the height information (Z).

Since the measured and transformed data obtained are in the form of 3D vector points, it is important to interpolate the missing values between measurements in order to accurately represent the differences in the local properties of the experimental material.

From the wide range of interpolation methods offered by GRASS GIS, due to the nature of our data, we have chosen the RST (regularized spline with tension) method. It is a method of estimating values using mathematical functions, where the selected function passes through the measured points with minimal curvature. The result is a smooth dependency surface that respects entry points, with each part of the surface represented by a separate polynomial function derived from local values. The method itself is considerably flexible and allows several parameterization options. The most important parameters are tension and smooth. In our case, the value of the tension parameter 40 and the value of the smooth parameter 0.8 have proven to be the most successful, thus providing a flexible, smoothed surface. The output is a digital model of voltage differences for a given material in raster format. To ensure the best possible ratio of output quality, calculation speed and resulting layer size, we have chosen the resolution (edge length of one cell) of the digital model 0.2 m.

RESULTS

In measuring the technological texture of ceramic blanks by the proposed method, we determine the voltage difference $U(r) = f(r)$ at the points on the surface of the sample from the blank in the direction from the axis of the molding. The experimental measurement voltage values are shown in Table 1.

Table 1: Measured values of voltages on the surface of ceramic blank, where the rows represent the axes / directions of measurement and the columns their steps / distances from the centre of the sample

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
I	2,30	2,17	2,07	2,00	1,94	1,89	1,85	1,81	1,69	1,72	1,70	1,68	1,65	1,62
II	2,22	2,15	2,06	2,00	1,94	1,86	1,85	1,81	1,73	1,73	1,70	1,66	1,64	1,60
III	2,22	2,13	2,05	1,99	1,93	1,87	1,84	1,81	1,77	1,73	1,69	1,64	1,62	1,59
IV	2,22	2,15	2,06	2,00	1,94	1,89	1,85	1,80	1,78	1,74	1,71	1,66	1,64	1,61
V	2,3	2,16	2,07	2,00	1,95	1,90	1,86	1,82	1,79	1,75	1,72	1,68	1,64	1,64
VI	2,24	2,16	2,06	2,00	1,95	1,90	1,86	1,81	1,79	1,75	1,73	1,69	1,67	1,66
VII	2,18	2,15	2,05	1,99	1,94	1,90	1,86	1,82	1,79	1,76	1,74	1,71	1,69	1,67
VIII	2,18	2,13	2,05	1,99	1,94	1,86	1,85	1,82	1,79	1,76	1,74	1,72	1,70	1,68
IX	----	2,12	2,05	1,98	1,94	1,83	1,83	1,82	1,79	1,76	1,74	1,72	1,70	1,68
X	----	2,14	2,06	2,00	1,95	1,87	1,84	1,83	1,81	1,78	1,75	1,74	1,70	1,69
XI	----	2,16	2,07	2,01	1,95	1,90	1,84	1,84	1,82	1,80	1,75	1,75	1,73	1,72
XII	----	2,15	2,07	2,00	1,94	1,90	1,85	1,84	1,81	1,78	1,75	1,74	1,72	1,71
XIII	2,28	2,15	2,06	1,99	1,93	1,89	1,86	1,83	1,79	1,77	1,74	1,72	1,70	1,69
XIV	2,23	2,13	2,05	1,98	1,93	1,86	1,84	1,81	1,77	1,69	1,69	1,67	1,65	1,62
XV	2,19	2,11	2,03	1,97	1,92	1,84	1,82	1,79	1,75	1,61	1,65	1,63	1,60	1,55
XVI	2,24	2,14	2,05	1,99	1,93	1,86	1,84	1,80	1,72	1,67	1,67	1,65	1,63	1,59

Measured results on the sample surface under specified measurement conditions using GIS can be expressed in three ways:

- 1) graphical representation of equipotential voltages for specified voltage values,
- 2) display of functional dependence of voltage differences $U(r) = f(r)$,
- 3) 3D visualization of the interpolated surface of the measured voltage differences.

The aim of the paper, regarding the application of the results of measurement of the technological texture, which is qualitative determination of the technological texture of the balk, it is important to show which expression of the three imaging options is most suitable for the technologist. In technology of insulator production, possibly in education in the field of material properties. Thus, which expression of the above options most accurately characterizes the changes in the technological texture.

1) Display of equipotential levels on the surface of a blank

The first possibility of evaluation is to display the isocurves of equipotential voltage levels of the interpolated model surface obtained from their measured values (fig. 3).

In case of an ideal homogeneous blank the continuous lines formed for a given potential voltage difference $U(r)$ and the specified distance (r) should be symmetrical circles or curves very similar to circles with a centre in the middle of the blank. This means that in case of deviations from the given symmetry, these deviations represent changes in the technological texture of the blank, thus the changes in configuration of the spatially oriented elements of the ceramic mixture in the blank. Due to the shape and position of the calculated isocurves, slight differences between the ideal and the measured state can be seen. However, the deviations are not so significant, which indicates the relative homogeneity of the blank.

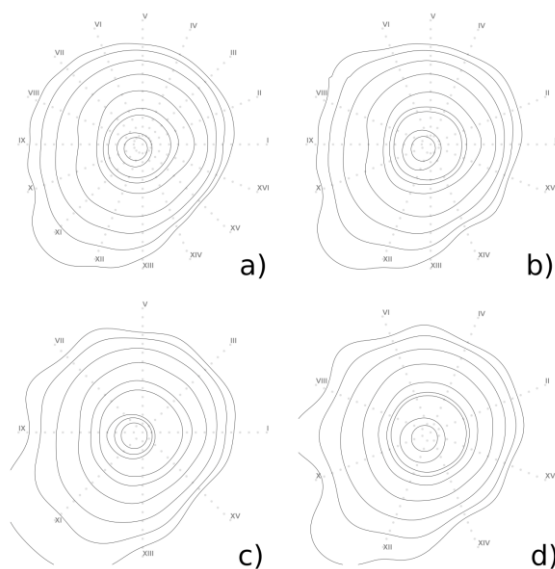


Figure 3: Display of the equipotential levels of the measured voltage by using: a) 16, b) 12, c) 8 (uneven), d) 8 (even) measuring directions

This deviation of the real shape of equipotential level from the ideal circle shape can be quantified by using a simple shape index, determined by:

$$\text{Shape index} = \frac{P_{\text{real}} \times 100}{P_{\text{calc}}} - 100 = \frac{P_{\text{real}} \times 100}{2 \times \sqrt{\pi \times A_{\text{real}}}} - 100$$

where P_{real} is a perimeter of the formed isocurve, A_{real} is a surface of the formed isocurve and P_{calc} is a calculated theoretical value of the circumference of a given isocurve in the case of an ideal circle with an area A_{real} .

This difference in equipotentials is better seen by direct records of the values of shape index into the area of displayed equipotential levels. Homogeneity is expressed as a value close to zero (fig. 4).

This method of evaluating the technological texture represents a qualitative expression of the variations in homogeneity of the blank, thus deviating the structure of the particles of the ceramic mixture components from their uniform and regular structure in the blank. Differences in the blank homogeneity negatively affect the final product quality and the efficiency of the entire technological process.

From the figure 4b, we can see a considerable advantage of this method as a simple and fast tool for identifying and localization the points of inhomogeneity in the blank.

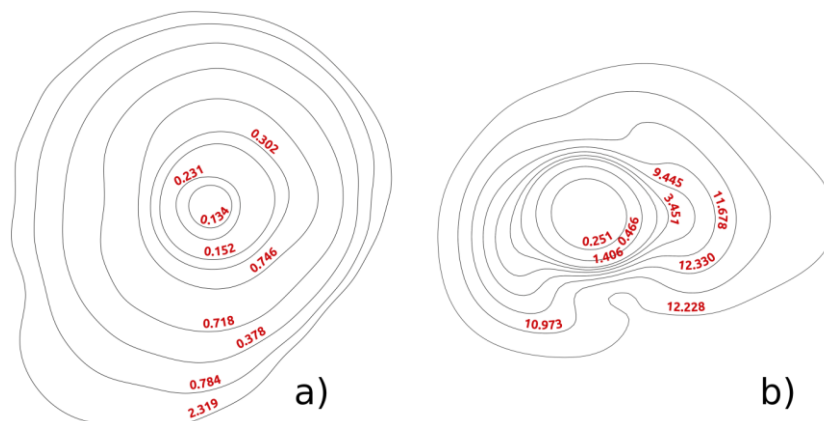


Figure 4: Display of equipotential levels of the measured voltage, at 16 measurement directions, together with shape index values for each isocurve a) example of a homogeneous blank from the table 1; b) example of an inhomogeneous blank according to Kozík et al., 2019b

2) Display of measured values in functional dependence of the voltage $U(r) = f(r)$

Homogeneity or deviations from homogeneity of the blank may be expressed also as a graphical expression of the dependence $U(r) = f(r)$. This dependence is determined by the theoretical relationship for the electrode circuit location (Fig. 2b) presented in (Kozík et al., 2019b).

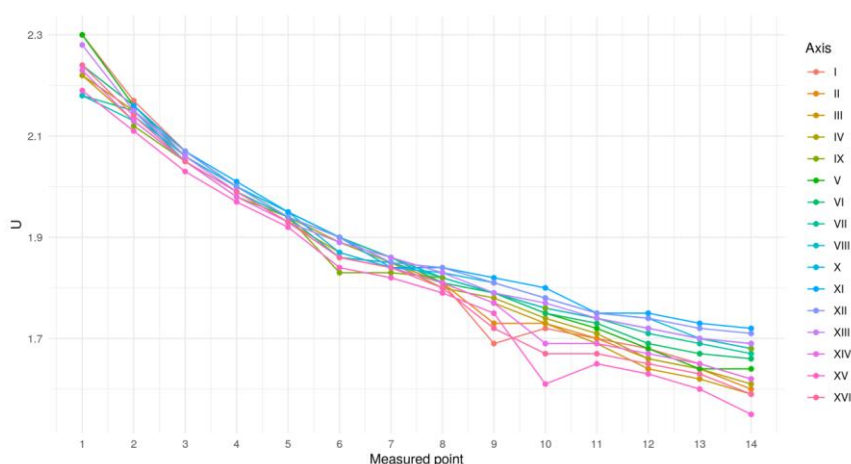


Figure 5: The functional dependence of the voltage (U) from the distance of the centre ($U(r) = f(r)$)

Graphic display of measured dependencies $U(r)$ on the surface of the blank has the nature of a theoretically predetermined course. In case of homogenous blank the courses of each curve in different directions have to show compliance. The deviation means an inhomogeneity in given direction and given place.

As seen from the development of dependencies (fig. 5) in each of the measured directions, the deviations in dependencies are minimal. The blank shows a noticeable homogeneity. From the point of view of imagination about the localisation of deviations from homogeneity, the above display of homogeneity $U(r) = f(r)$ is less visual in comparison with the view of equipotential levels.

3) 3D visualization of interpolated surface of measured voltage differences

GRASS GIS also allows 3D visualization of measured values of the voltage differences (fig. 6). The visual three-dimensional expression of homogeneity of the blank is a convenient means of expression of the equipotential levels on the surface of the blank. The program allows to shoot views and thus to create an idea about places of inhomogeneities in the blank. It is an advantage to use the 3D projection in case of inhomogeneities in the blank and to find out the origin of their occurrence.

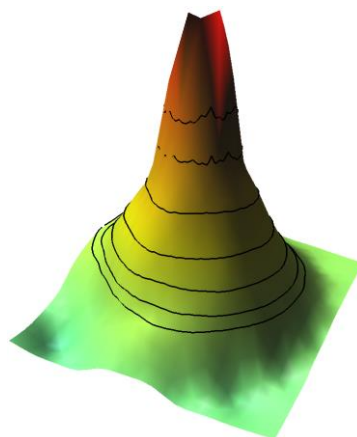


Figure 6: 3D visualization of interpolated surface of the measured voltage differences

DISCUSSION

From the measured values and the use of GIS for evaluation with regard to the shape of the future product (the blank from which this will be made) and the technological conditions of processing the molding to the final product (forming the shape of the insulator, drying, glazing, firing and mechanical tests after firing), we know to determine with high objectivity the places in the volume of blank and hence on the final product - high voltage insulator, which will have a high probability of damage by cracks of different intensity.

Professional knowledge, results of the theoretical solution of the problem, as well as our own experience gained during the gradual improvement of the proposed method of measurement and evaluation of dielectric properties allow us to suggest several opinions and recommendations for future use of this method, either in pedagogical or technological practice:

- for thin samples of the blank a higher attention has to be taken while handling the samples to avoid their local damage which appears as an undesirable deviation in voltage values when measuring voltages. Such an anomaly should be considered when evaluating measurement results,
- considering already published theoretical solutions of electrical conditions in dielectrics between electrodes (Kozík et al., 2019a, 2019b; Kozík and Minárik, 2013), we can conclude that at the axial connection of electrodes (fig. 2a) the voltage value on the blank surface is dependent on the thickness of the dielectrics (blank). Measurement accuracy requires a minimum sample thickness that can be taken from the blank while observing its integrity and non-damaging when placing it into the measuring apparatus between the electrodes,

- in the second case of placing the blank sample between the electrodes (fig. 2b), the voltage measured on the sample surface is independent of the sample thickness. The set of measurements showed that it is appropriate to work with this circuit location of the electrode system for technological purposes,
- the magnitude of the measured voltage on the sample surface at a given location also depends on the geometric shape of the contact measuring electrode. When using the same shape of the contact electrode and its contact pressure on the sample in measuring, the obtained values show the same measurement error and are fully usable in manufacturing technology. For the theoretical analysis it is necessary to select the shape of the contact electrode and its effect on the surface of the measured sample properly,
- WGS84 Pseudo-Mercator CRS was used for data processing. Although GRASS GIS does not necessarily require a coordinate system to be defined, some tools may require it to be functioning properly. In the case the coordinates of the measured points start from zero, we recommend using the coordinate systems that contain zero within their natural range. It is also appropriate to select CRS with metric units, it means one of the global Cartesian CRS,
- although the parameters of the used interpolation RST method as well as the selected spatial distinction have been proven successful in several evaluations, these are only recommended values and not fixed settings. Their change may affect the final evaluation, but in some extreme situations this change may be necessary,
- the choice of values used to describe equipotential levels should cover the full range of interpolated data. The decimal percentiles of all values were used, and they are recommended for their detection,
- figure 3 shows a slight displacement of isocurves from the geometric centre of the measurements. Such a displacement may be caused by several factors (e.g. measurement error or outlier presence). In our case, it is caused by four missing measurement values (table 1), which were not recorded correctly. It is also possible to see the influence of decreasing number of the used directions in measurement, thereby also the density of spots used in interpolation resulting in an increasing inaccuracy, especially with isocurves farther from the centre. A more serious problem, however, is the inconsistency of the results with respect to the measurement of rotation (figs. 3c and 3d), which in some cases may also mean an incorrect identification of the blank quality. Therefore, we recommend using 12 or more measurement directions at least,
- from the point of view of simplicity and speed, intuition and objectivity it is the best to use the shape index (fig. 4) to display equipotential levels on the blank surface from the used possibilities of evaluating the homogeneity of the blanks.

CONCLUSION

In the article, the theoretical substantiation of the used method, the designed and created measuring apparatus and the determined measuring procedure were derived by the gradual development of the proposed method of measurement of dielectric homogeneity. Together with geographic information systems, a computerised system for

measuring and evaluating the homogeneity of dielectric materials has been created. For the experimental measurement, a dielectric of ceramic material with a radial location of the electrode system has been used (fig. 2b).

Although the application of GIS in technological research is not common at all, it has made the evaluation of homogeneity results much more effective. For practical purposes, it is appropriate to evaluate the homogeneity of the material by expressing the equipotential voltage levels on the surface of the sample $U(r)$ and to express it quantitatively with the shape index. The shape index expresses the deviation of the equipotential voltages level from the ideal angular characteristics of the compared voltage. If the shape index approaches 0, the sample is homogeneous in the given area. The 3D image suitably complements the findings from the homogeneity evaluation expressed by equipotential stress levels on the sample surface. An assessment of homogeneity from the characteristics $U(r)=f(r)$ is the least appropriate.

The proposed method of measuring the homogeneity of dielectrics can be used in a suitable way in practice and in didactics of electrical engineering materials (dielectrics) as well.

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Mobile Application for Supporting the Development of Communication Skills

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Abstract

The paper deals with mobile applications, which appear to be potentially suitable for supporting the development of student's communication skills. The article draws from a partial solution described in the dissertation thesis of the main author. Within this phase of the solution, a retrieval of potential mobile applications is carried out and suitable applications that can support the development of an individual's communication skills are selected. These will be then used for the purposes of the main research. Firstly, the paper gives an overview of the basic theoretical background. Secondly, it describes the process of selecting and testing the suitable mobile applications and thirdly it gives a detailed analysis of the selected applications. To select the suitable mobile applications, the authors determined specific factors which are described in detail further in the paper. The authors analyze selected applications, illustrate their nature and their possibilities of use during the development of the desired communication skills. The paper presents the parameters of application selection and subsequently discusses the results of the retrieval. Then the paper deals with the analysis of the selected mobile applications. The outputs of this paper will serve for further research purposes.

Keywords

Mobile application. Communication skills. Primary education.

INTRODUCTION

Communication skills are one of the key factors to an individual's successful career and integration into society. We encounter communication between people every day as it is an integral part of people's lives. Not only for these reasons are communicative competencies listed as one of the key core competencies of many countries (for example the Czech Republic, Great Britain, New Zealand or Ireland). As a part of the dissertation thesis, the author tries to find a simpler and more efficient way of developing these skills, i.e using mobile technologies. The author focuses on mobile technologies influencing communication skills as a targeted effect in the classroom. The research focuses mainly on the ability to formulate and express ideas and opinions, and to express them in a logical sequence, either orally or in a written form. The student should be able to express himself/herself in a concise, coherent and sophisticated way, both in his written and oral expression (Kocourková, 2011).

This paper represents only a section of the whole research. In the current phase of the research the authors focus on the choice of mobile applications that seem to be suitable for developing the above mentioned communication skills. The selected applications will be used in the main research, with the main purpose of assessing whether the mobile technologies pose an influence on the development of communication skills of an individual. The authors want to design, develop and verify a learning model that integrates mobile touch devices into the classroom and develops communicative competencies through this technology. As a part of the retrieval of potential mobile applications the authors pose two questions: Do applications that possess the potential to support students' communication skills exist? What kind of applications are they?

Communicative competencies

At the beginning of the paper, it is necessary to define the main area of the research, that is, the key competencies. The focus of this paper is exclusively on communicative competencies. These are one of the essential components of educational concepts of many countries. A survey conducted in 2011 shows, that communication skills are conceived as one of the key competencies in countries such as England, Ireland and New Zealand (Kocourková, 2011).

In the Czech Republic, key competencies are defined by a national document called the Framework Educational Programme for Primary Education. This document outlines the activities that a student should be able to master by the end of his/her primary school education. These activities are defined as follows (Rámcový vzdělávací program pro základní vzdělávání, 2017):

- *Formulates and expresses his or her ideas and opinions in a logical sequence; his or her oral or written expression is apt, coherent and cultivated.*
- *Listens to other people's utterances; understands them and responds to them adequately; participates effectively in debates; defends his or her opinion and uses appropriate arguments.*
- *Comprehends various types of text, record, visual material, commonly used gestures, sounds and other information and means of communication, considers them, responds to them and makes creative use of them for his or her own development and active engagement in social events.*
- *Uses information and means of communication and technologies for high-quality efficient communication with the outside world.*
- *Uses his or her acquired communication skills to form relations necessary for fullfledged coexistence and quality cooperation with others.*

The authors do not focus on all the communication skills mentioned above, but instead a single selected one. Among all the listed activities, the authors have singled out the first one, where the student is able to *"formulate and express his or her ideas and opinions in a logical sequence; his or her oral or written expression is concise, coherent and cultivated"* (Rámcový vzdělávací program pro základní vzdělávání, 2017).

This paper focuses on the process of finding and analyzing mobile applications that possess the potential to support the development of the above mentioned single activity.

Mobile technologies in education

The authors are also involved in another large field of interest, that is mobile technologies in education. Their main research tries to assess whether mobile technologies pose an influence on the development of communicative competencies of primary school students. This tool will play an important role in the research.

It is necessary to define a second large field of research – mobile learning. The principle of mobile learning is to use mobile or wireless devices for learning purposes. Often, it can involve learning while traveling. Such devices include smartphones, tablets, handheld computers, palmtops, but also laptops or personal players (Kukulska-Hulme, 2005). Mobile learning offers unique attributes that have a positive impact on students' learning. Pea and Maldonado summarized the features that mobile learning offers in their publication. These features include (Pea, 2006):

- portability,
- small screen size – easier handling,
- performance,
- diverse communication networks,
- a wide range of mobile applications,
- data synchronization with computers or other devices,
- input device – stylus.

However, can mobile technologies be an appropriate means of developing a student's communication skills? The researchers have asked this very question. In the current phase of the research, the authors deal with the selection of mobile applications that may have the potential to support the development of an individual's communicative competencies.

A study published in 2018 partly addresses the issue of the development of communication skills through mobile devices. The study focuses mainly on learning a language using mobile technologies and collaborative learning. The study outlines the use of the "Videos for Speaking app" to improve the oral presentation of Spanish or Belgian students in the English language (Kukulska-Hulme, 2018).

METHODOLOGY

The main part of the survey was to search and retrieve mobile applications from a mobile app store. The research will be carried out using Apple devices, therefore the official application store of this manufacturer has been researched. The authors have focused on three types of applications:

- applications that target 13-15 year olds (main research target group),
- educational applications,
- applications, which the authors themselves have an experience using, especially for educational purposes.

During the retrieval, keywords such as "*communication*", "*education*", "*school*" and "*talking*" were used. Subsequently, applications and games that ranked high on popularity were reviewed.

All of the applications meeting the above mentioned criteria were subjected to a selection process, but only those which were suitable for the purposes of the main research remained at the end of this process. The selection process consisted of several phases:

1. Searching the App Store.
2. Studying the description, screenshots and user reviews of a specific application. The authors questioned the application's potential as a means for development of communicative competencies. If the application seemed appropriate, it continued through the process.
3. The specific application was installed on a device and was tested and analyzed in detail. The authors tried to understand its functioning principles. If the application continued to appear as a suitable means, it proceeded further.
4. Searching the Internet resources (teacher blogs, RVP.cz portal, social networks) to assess whether any educational material using the specific application exists.
5. The application has either been selected as a suitable means for the main research or has been removed from the list.

During the application analysis the application was tested in detail on the iPad. While testing, the authors have probed all the available features of the application and tried to understand its functioning principles. Subsequently, for each individual application the authors have considered these questions:

- Does the application pose a potential to develop communicative competencies?
- What kind of application is it (repetitive, game, testing, presentation, creative, etc.)?
- What senses does the user need to receive information from the application (images, sound, etc.)?
- What senses does the user need to send information into the application? (touch, sound, etc.)
- Will the application be used in the upcoming research?

Based on the mentioned parameters and procedures, applications that seem suitable for the purposes of the main research were chosen. Such applications are covered in the following text. The application retrieval will continue until the lessons based on main research are proposed. The following chapters present ongoing research results, an analysis of selected applications and their impact on the communication abilities of an individual.

RESULTS

In the following paragraphs the focus is on the current results of the survey and analysis of the selected mobile applications. A total of 63 applications were examined according to the above mentioned procedure. Of these applications, 26 were selected (based on the app description, screenshots and user reviews) and installed on a mobile device and tested. For the purposes of the main research 5 applications were selected. These are then discussed in detail further below.

Table 1: The amount of examined and tested applications.

Total examined	63 applications
Practically tested – installed on a device	26 applications
Suitable for main research	5 applications

iMovie

The first application is used mainly for working with video. A user can edit videos, add audio tracks, opening or closing subtitles and use other similar features. The application can simply be described as a video editor. It is mainly a “creative” application where the user has relative freedom working with the application and thus the creativity of students is greatly supported. The user can upload video recordings, images or written text into the application. The outputs are then complete videos. The screenshot below shows the basic navigation in the application. The green wave represents the audio track (recorded audio commentary).

This application can serve as a tool to support communication skills, especially due to the feature of recording audio tracks. The combination of iMovie and so-called “silent videos” (videos without sound track) seems to be suitable for the research purposes. As such it could be presented to students as an activity including a pre-recorded video, where the students are to add a spoken commentary based on the content of the video. The topic of the video can be for example a serious social problem. The students will be able to voice their opinion and their attitude towards it (Kristinsdóttir, 2019).

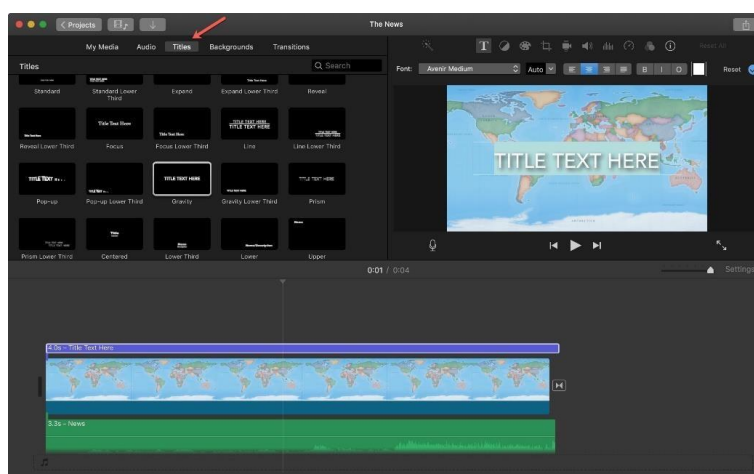


Figure 1: Navigation in the iMovie application (How to add and edit movie titles in iMovie on Mac and iOS)

ChatterPix

The ChatterPix application is used for creating simple animated images that are accompanied by an audio commentary. The application works mainly with sound. The user uploads any desired image to the application, then indicates the mouth area of the character and uploads the narration. The character in the picture then moves its mouth in the

indicated spot based on the narrated comment. This application seems to be both motivating and interesting for students. The enclosed screenshot of the application shows the basic and simple navigation within the application.



Figure 2: Navigation the ChatterPix application

A teacher has an opportunity to prepare a wide range of various activities with this application. Students can express their opinions and ideas on a presented topic, create animations on current social topics or create spoken presentations. Such activities will support the expression of the student's thoughts and opinions, especially in oral speech.

Nearpod

The third selected application is intended for presentation of the curriculum. This application is of an educational nature and is primarily intended to support frontal teaching, moreover it is also an effective tool for getting feedback from the students. The application is widely used in education and is utilized by many teachers as a frontal teaching support (Nearpod).

At first glance, this is not an application that would act directly on the communication skills of students, however, when used correctly, the application can be used to develop communication skills of an individual. The application can be for example used to present the students with certain topic or a message, which will be followed by a discussion about the subject. Another way of using the application is to support the development of written expression of the students by making them write an essay as a part of the feedback activity. For the purposes of the main research, the application will serve as a means for developing correct formulation and expression in writing.

Chanty

The Chanty application is a communication tool. It is used for communication purposes when working on group projects. The application works primarily with text, that is, mainly written communication is supported. Despite the fact that this application is primarily used in businesses, it can also be used during teamwork in the classroom. Students can communicate with their co-solvers using this application. However, it is also necessary to take into an account that much of today's communication takes place in a virtual environment and Chanty is no exception (Chanty).

The authors see the potential of this application in facilitating teamwork among students. During such communication the students can learn to formulate their problem correctly and express their thoughts and ideas. Another important factor is also supporting the development of proper ethical behavior during virtual communication.

Speech Blubs

The last analyzed application is Speech Blubs. This application was designed especially for children with speech impediments. It facilitates the development of correct articulation and correct speech habits. The application was created in cooperation with speech therapists and speech pathologists. Nevertheless, it can also be used for students without any speech impediments. The application offers a variety of videos, speech modules and activities.

The authors find that this application is the most applicable for students' independent work. This can be, for example, an individual task during a lesson or while doing homework. However, the application is commercial which is its biggest disadvantage. Therefore, its inclusion in the main research is still to be determined.

The above mentioned applications have the potential to develop students' communication skills and will most likely be utilized in the main research. The analysis of the other 21 tested applications showed that these applications are not suitable for the purposes of the intended research. These applications include, among others, Kahoot, Classkick or HP Reveal. The remaining 37 applications were completely unsatisfactory for the purposes of the research and therefore were not even tested.

The search for mobile applications will continue. The mobile applications market is fairly vast and therefore the search will continue until the specific lessons of the main research are proposed.

DISCUSSION

Communication skills are important for both social and professional life of a person. The development of these skills is already emphasized in primary education not only in the Czech Republic but also in many other countries as well. This paper is a partial step in the whole scope of the authors' main research. In this phase of the research, attention was given to the choice of mobile applications that possess the potential to develop communicative competencies of students, and thus are suitable for the main research.

The survey results show that only a small proportion of applications are potentially suitable for developing communication skills of an individual, and far fewer applications are suitable for the main research. Those that appear to be suitable for the main research are analyzed above. These applications will be used in the main research, that is, in the experimental group that will attend lessons with the support of mobile technologies. The risk of this survey represents a situation where the authors have not searched through a sufficient number of applications and some suitable ones may have been overlooked. Another risk may be the undergoing changes and updates of many applications. The latest version of the application may not be compatible with the device or the version of its operating system. The producers of the applications often radically change the way applications work and in the future the application may work in a

completely different way or its new version may not be suitable for developing communicative competencies in students.

The main question for further research is whether mobile technologies have an impact on the development of communication skills (whether negative or positive) of an individual. In case of a positive impact, how would it be appropriate to use mobile technologies to support the development of students' communication skills. Would this technology make it easier for students to develop such competence? It is these questions that the main author will try to answer in his further research.

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“The Robot is Not so Scary as it is Painted!” – A Project Report

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Abstract

The authors describe the origin and current status of "An engineering approach in education" as a didactic and educational strategy. Next, the authors present an educational project referred to as "The robot is not so scary as it is painted!", implemented in the 2017/2018 school year by the "WOM" Regional In-Service Teacher Training Center in Bielsko-Biała and its Partners. Teachers participating in the project were introduced to the strategy in the context of conducting robotics classes in primary schools. Finally, 37 teachers (including school head teachers and deputy school head teachers) were trained during the first and second editions of the project. Robotics workshops were attended by 150 primary and lower secondary school students. Moreover, this article discusses the results of research accompanying the project: initial quantitative research applied to all project participants before the start of the classes included in the project, and qualitative research (action research) conducted both during the project and after its completion. It was the change of the researcher's role (change of the degree of the researcher's intervention) that had decisive impact on the choice of different research paths at the individual stages of the project.

Keywords

Constructivism. Engineering Approach. Didactic and Educational Strategy. Robotics.

INTRODUCTION

"An engineering approach in education" ("Podejście inżynierskie w edukacji") is a strategy of working with students during classes conducted in the areas referred to in the English acronym STEM (STEAM) - Science, Technology, Engineering, Mathematics (Science, Technology, Engineering, Art, Mathematics).

The need to apply in education - especially in primary school - the strategy discussed in this article stems from the main (primary - according to the authors) educational goal, which is to educate creative thinkers and creators.

ENGINEERING APPROACH IN EDUCATION

Usage of robotic kits for development of technical skills of pupils in primary and secondary schools was described by Oujezdský and Nagyová (2015). The aspects of learning with educational robotics through co-creative methodologies were presented by Siouli, Dratsiou, Antoniou and Bamidis (2019). Applying mechatronic sets to enhancing students class attendance in higher education was described by Pinter, Maravić Čisar, Balogh and Manojlovic (2020).

The collaboration of the authors of the article (both during the project and earlier) focused mainly on the place of robotics classes in contemporary didactics of Polish schools as well as in other countries (Smyrnova-Trybulska, Morze, Kommers, Zuziak and Gladun, 2016; Zuziak and Smyrnova-Trybulska, 2017).

The scope of the authors' joint research interests covered four areas: (1) formal and legal, (2) scientific and methodical, (3) technical and technological as well as (4) psychological and pedagogical.

The formal and legal area provided a framework for the authors' research search: a framework for the list of key competences and a framework for general education in Polish schools.

Issues in the area of science and methodology were related to the problem of organizing student teams' work during IT, infotechnical or robotic classes. The authors drew attention to the agile methodologies used by programmer teams in self-organization of their work. Particular attention was paid to an agile methodology called "Scrum".

Teamwork: lively, creative and often spontaneous, forced to look at the role of mistakes in the creative process, or more broadly: the role of mistakes in teaching. The authors distinguish a mistake from error in the sense proposed by Michele Pellerey, an Italian mathematics educator: "We make an error when we do not apply the rule or the already known theory correctly (...); we make a mistake when we are looking for a new theory. Consequently, those exposed to the risk of mistakes are those who deal with discoveries; and those at risk of errors are those who are not to discover anything, but should apply the theory. In other words, a mistake is closely related to imagination and creativity; an error is the fruit of poor memory or insufficient attention. (...) The best school will obviously be the one that will allow you to make more mistakes than errors." (Pellerey, 1989, p.137).

The technical and technological area was another area of the authors' mutual interest. Here, one had to look at ICT tools used when working with students - both hardware and software. They quickly turned to visual programming languages (graphical environments) adapted to the young creators' age, needs and capabilities.

In the psychological and pedagogical area – when analyzing young programmers' work - the authors had to deal with issues related to the recognition of a colleague's authorship. For this purpose, the idea of a remix of a programming project as understood by Mitchel Resnick (MIT, USA) (Zuziak, 2015), the utility of the student's work during classes and the utility of products created during classes and/or product documentation were analyzed.

The changes introduced in Polish education since 2017 have resulted in the need to return to the formal and legal area, in the context of the requirements of the new core curriculum (general education basis).

These four areas of interest, own research and conducting robotics classes with students and teachers allowed us to identify seven fundamental features of the proposed approach, called "engineering".

Today we can treat the "An engineering approach in education" as a strategy for conducting classes, which is characterized by: (1) clarity of goals - the student knows from the beginning of the course what the expected end product is; (2) freedom of access to information sources - the Internet is a source of inspiration for students: we transfer ideas, not ready solutions; (3) variety of possible solutions to the problem posed - there is more than one correct solution ("open endings"); (4) openness to mistakes - because we treat the mistake and understanding its causes as a signpost leading to the goal; (5) responsiveness - the need for quick response to changing conditions - the teacher is the organizer of the class, but must respond quickly to the changes proposed by students; (6) teamwork - the best results are achieved when working in teams of 2 or 3 students; (7) product usability - the team's work ends with documenting the stages of creating the robot (photos, videos or 3D instructions); others may use this documentation in the future.

Full use of the proposed didactic and educational strategy assumes the creation of new knowledge by students (based on the conclusions of their own research) and sharing it with others. This approach is in line with the principles of constructivism. In constructivist pedagogy we deal with new interpretations of well-known concepts. And thus: "education is understood as an introduction to responsible self-management, (...) learning as understanding differences, teaching as a staging of productive perturbations, knowledge as a significant, meaningful, vital experience" (Berner, 2015, p.243).

The proposed strategy supports the creativity of the student and develops their independence, also in the context of responsibility for themselves and the effect of their work. Moreover involves the transfer of knowledge not only from the teacher, but also from peers. Working with students using the proposed strategy changes the current role of the teacher in the teaching/learning process. Here the teacher - Sage on the Stage - becomes the Guide on the Side (Morbiter, 2010).

Using the proposed strategy during robotics classes also fosters development of students' competences. Special emphasis is placed on shaping mathematical competences, competences in technology and engineering, and digital and social competences.

In the 2017/2018 school year, the authors implemented the educational project "The robot is not so scary as it is painted!" ("Nie taki robot straszny!"). It was planned and implemented in such a way that teachers participating in the project had the opportunity to "learn in action" the described strategy in the context of conducting robotics classes in primary schools.

PROJECT "THE ROBOT IS NOT SO SCARY AS IT IS PAINTED!"

The project was a unique form of popularizing robotics classes in contemporary school didactics on a national scale. It was directed to primary schools that plan to introduce robotics classes to their educational offer (based on LEGO® Education brick sets) or have recently done so.

The project's scientific supervisor was dr hab. Eugenia Smyrnova-Trybulska, associate professor at the Institute of Education Sciences at the Faculty of Ethnology and Education Sciences in Cieszyn at the University of Silesia in Katowice. Project coordinator - mgr Wojciech Jan Zuziak, teacher-consultant at the "WOM" Regional In-Service Teacher Training Center in Bielsko-Biała.

According to the assumptions - the project "The robot is not so scary as it is painted!" was: (1) an incentive to use an engineering approach in education; (2) comprehensive support for primary schools submitted to the project at the stage of selection and commencement of work with LEGO® Education sets (10 teaching hours for each school submitted to the project); (3) an opportunity to exchange experiences, share knowledge and skills; (4) an opportunity to present project Partners' activities.

The project was co-created by Partners and primary schools invited to participate. The partners included: (1) "WOM" Regional In-Service Teacher Training Center in Bielsko-Biała; (2) AKCES Edukacja Kurzyca, Piasecki sp.j., Przeźmierowo (near Poznań) - official representative of LEGO® Education in Poland; (3) Primary School No. 10 of the M. Rej School Society in Bielsko-Biała - in the first edition and (4) "Akademia Żaków" Private Primary School in Bielsko-Biała - in the second edition.

In the 2017/2018 school year, 14 primary schools were invited to participate in the project: 9 in the first edition (start: September 2017) and 5 in the second edition (start: January 2018). The stages of the project were planned as: (1) conference and workshops for directors and teachers; (2) observation practice; (3) active practice; (4) consultations with teachers in schools.

As part of the project were organised: 2 conferences combined with teacher workshops led by LEGO® Education Academy trainer (10 teaching hours); 14 observations and discussion of classes in 2 partner primary schools (28 teaching hours); 14 workshops for students, during which teachers participating in the project conducted robotics classes with the help of teacher-consultants (42 teaching hours).

In the conference part, participants familiarised themselves with the principles of the engineering approach, and in the workshop part they worked with a LEGO® Education Academy certified trainer.

Each school participating in the project had its own (drawn) month in which 2 events were organized specially for it: the practice of observing and discussing classes at the school that was a Partner in the project and the active practice - workshop classes in robotics at the Regional In-Service Teacher Training Center "WOM" in Bielsko-Biała, which were conducted by teachers from schools submitted to the project, with the support of two teachers-consultants from the Center.

The last stage of the project was optional: consultations with teachers in the schools participating in the project.

During the project, 37 teachers (including school head teachers and deputy school head teachers) were trained. Robotics workshops were attended by 150 primary and lower secondary school students in primary schools.

Our educational project was accompanied by educational research. The authors decided to follow two research paths:

- initial quantitative research – using the diagnostic survey method – carried out in respect of all project participants before the project activities were commenced;
- qualitative research (action research) conducted while the educational project continued (participant observation method) and after it was completed (problem-centred interview method).

The authors do not consider the above research paths to be contrary to each other. "Both have their disadvantages and advantages, yet each of them, when used, allows for discerning different aspects of the phenomenon being studied, and despite their different natures, both contribute to the development of our educational knowledge" (Pilch and Bauman, 2010, p.269).

The main reason for changing the educational path at subsequent project stages was the change of the role (change of the degree of intervention) of the researcher: starting from an objective and independent researcher, situated outside the group before the start of the project - and ending up with an individual functioning openly inside the group being studied; an individual aware of "their subjectivity in reception and assessment of the situation, their impact on the contents and course of action" (Pilch and Bauman, 2010, p.285).

Therefore it was decided to adopt the principle of complementarity of quantitative and qualitative research and follow this principle in describing the course and results of the project.

RESULTS OF THE RESEARCH

Stage #1. A survey of teachers - participants of the first edition of the "The robot is not so scary as it is painted!" project was conducted in September 2017 and a survey of teachers - participants of the second edition of the project - in January 2018.

An electronic questionnaire was prepared, which was made available to N1 = 25 people (principals and teachers) from schools submitted to the first edition of the project and N2 = 12 people (principals and teachers) from schools submitted to the second edition of the project.

To the question: "Do you think children can enjoy learning and playing with building blocks and robot programming kits?" - as many as 88% of respondents in the first edition and 83% in the second - answered "Yes"; the other people chose the answer "Rather yes".

Teachers who took part in the project were convinced of the possibility of making children interested in robotics classes.

The next question was: Why do you think children can enjoy learning and playing with robots? What determines this? Here the respondents could choose several answers. Table 1 presents teacher responses.

Table 1: Answers of the respondents to the question: Why do you think children can enjoy learning and playing with robots? What determines this?

Id	Answers	Number of answers (Share)	
		N1 = 25	N2 = 12
A	the ability to build your own models (creative work)	24 (96%)	9 (75%)
B	the ability to give commands to the robot, control it, program its behavior	19 (76%)	11 (92%)
C	the opportunity to imitate real life situations and looking for ways to solve real problems	7 (28%)	3 (25%)
D	the ability to simulate unusual situations	8 (32%)	3 (25%)
E	entering a specific and attractive play environment	18 (72%)	8 (67%)
F	other	0 (0%)	0 (0%)

The respondents most often (33 times out of 37 answers; 89%) pointed to creative work - the possibility of constructing their own models (A). Then they indicated (30; 81%) the possibility of controlling the robot and programming its behavior (B). Slightly fewer (26; 70%) paid attention to entering a specific and attractive play environment (E).

The following question concerned the emotions accompanying robotics classes: "What positive emotions can - in your opinion - trigger children's activities (learning, playing) with robots?" In this question, the respondents could also choose several answers. Table 2 presents the responses of the surveyed teachers.

Table 2: Answers of the respondents to the question: What positive emotions can - in your opinion - cause children to learn (learn, play) with robots?

Id	Answers	Number of answers (Share)	
		N1 = 25	N2 = 12
A	satisfaction with the completed project - the robot built (my robot works!)	23 (92%)	11 (92%)
B	satisfaction with acquired new knowledge (I know more!)	12 (48%)	5 (42%)
C	pride of a job well done, willingness to show the effect of work to others - photos, videos (see what I can do!)	19 (76%)	10 (83%)
D	joy of having fun (learning) with a friend (we are a great team!)	19 (76%)	8 (67%)
E	certainty of acquired skills (I can - I did it!)	13 (52%)	8 (67%)
F	curiosity, how else you can modify the robot you just built (this will be a robot!)	18 (72%)	7 (58%)
G	other	0 (0%)	0 (0%)

As many as 34 out of 37 (92%) of the respondents indicated satisfaction with the work done (A), 29 of the respondents (78%) chose the pride of a job well done (C), and 27 teachers (73%) - the joy of teamwork (D). In addition, 25 out of 37 (almost 68%) respondents pointed out the possibility of getting children interested in modifications of the base model of the robot (F).

In the next question, we asked to indicate what could decide - according to teachers - about the usefulness of robot classes and an engineering approach in teaching (learning). The respondents could also choose several answers. The results are summarized in Table 3.

Table 3: Answers of the respondents to the question: What can decide - in your opinion - about the usefulness of robot classes and engineering approach in teaching (learning)?

Id	Answer	Number of answers (Share)	
		N1 = 25	N2 =12
A	clarity of goals - build and program the robot (at the end of the classes the robot should work!)	20 (80%)	11 (92%)
B	free access to information sources - seeking inspiration in the world and on the Web	10 (40%)	4 (33%)
C	variety of possible solutions	15 (60%)	5 (42%)
D	the possibility of making mistakes, making corrections in the construction and program of the robot	17 (68%)	9 (75%)
E	the need to react quickly by changing the robot's design or program to new circumstances arising during the testing phase	9 (36%)	6 (50%)
F	teamwork	18 (72%)	8 (67%)
G	usability of the resulting product: you can document the stages of creating a robot (photos or 3D instructions), which others may use in the future	10 (40%)	2 (17%)
H	other	0 (0%)	0 (0%)

The three most frequently chosen answers are: clarity of goals (A) - 31 out of 37 respondents (84%), team work (F) and the possibility of making mistakes, making corrections in the design and program of the robot (D) - 26 (70%).

The smallest number of people - 12 out of 37 (32%) - pointed to the usefulness of the resulting product (G) as a decisive feature of the usefulness of robotics classes and an engineering approach in teaching (learning). Not many more - 14 (38%) - chose free access to information sources (B).

Stage #2. During the project, teachers from individual schools were invited to observe robotics classes in the schools that were project Partners.

A researcher (a teacher-consultant) was present during classes being observed by the teachers participating in the project. The teachers knew the researcher and were aware of the researcher's role. The same was true of the teachers who taught the classes being observed. The researcher was a participant who was doing the observing. On the other hand, the pupils perceived the researcher as a stranger (as an outsider) who emphasized the capacity he acted in. From the pupils' perspective, the researcher was more of an observer than a participant (Pilch and Bauman, 2010, p.319).

The teachers (project participants) were seen to participate in class observation in the following ways: (1) a passive observer; (2) an active observer - would approach the pupil teams and ask them questions, was interested in individual stages of the work on the project; (3) a teacher assuming the role of a participant - paired with another teacher (project participant), works with a robotics kit; (4) a teacher assuming the role of a supporting teacher - paired with a pupil, works with a robotics kit.

The Table 4 sets forth the teachers' (project participants') main needs and concerns reported after observations, as well as activities intended for implementation as part of the project that were to be responses to the needs and concerns.

Table 4: Main needs and concerns reported by teachers after classes observed by them.

A problem - a need or a concern reported	A remedy - an activity planned for implementation in the project
Need to familiarize oneself with a robotics kit before a given class period with pupils which is scheduled as a subsequent project stage.	An opportunity was provided to lend a robotics kit to teachers so that they can prepare for their first robotics class with their pupils.
Concern regarding the degree of engagement during upcoming project classes on the part of pupils from the school where a given teacher (project participant) works. (For many pupils that was to be the first time they would work with robotics kits)	During post-observation discussions, both the teachers who taught the classes and the teacher-consultants answered questions from teachers (project participants), providing extensive explanations on the stages of a typical robotics class.
Need for additional support from an experienced teacher during the first robotics class.	As part of the project provision was made for the presence of teacher-consultants during the first class the teachers participating in the project would teach to their pupils.
Concern regarding lack of ideas on how to run robotics classes.	Providing teachers with software and ready-to-use ideas for lessons as well as information on sources of inspirations for robotics classes.

Stage #3. After the project had been completed, a problem-centred interview was conducted with three teachers who taught the classes that were observed by project participants. Tables 5, 6 and 7 contain their selected comments in the form of a matrix of attributes on which the interview was concentrated. The teachers' comments have the descriptions of importance (in relation to each teacher's beliefs before the project started).

Table 5: Selected factors determining that children like learning and playing with robots.

Attribute	Teacher #1	Teacher #2	Teacher #3
(C) Opportunity to imitate real life situations and looking for ways to solve real problems	When working with pupils from younger grades, we use simulations of real events.	Younger children not always enjoy real-life simulations and problem solving.	The pupils focussed more on performing the construction tasks in accordance with the instructions.
Change of importance	Equally important	Is not as important	Is not as important
(D) Ability to simulate unusual situations	That was especially evident in situations where a pupil was able to see what would happen if he or she added a part that normally is not in the structure.	Discovering or verifying something that is less common is more fun than real-life simulations.	An experiment is one of the core principles of working with children.
Change of importance	Significantly more important	Equally important	Equally important

Interpretation of teachers' opinions: attribute (C) - decrease in importance, attribute (D) - slightly increase in importance.

Table 6: Selected positive emotions which can be elicited in children by activities with robots?

Attribute	Teacher #1	Teacher #2	Teacher #3
(E) Certainty of acquired skills (I can - I did it!)	With time, they gradually became more and more confident in their abilities, they were able to share tasks within their teams (constructing, programming).	The pupil is not so much aware of having acquired new abilities as is happy that the robot is working, and this is what stimulates her/him to further experiments.	After the project was completed, my opinions and beliefs were further confirmed.
Change of importance	Equally important	Equally important	Equally important
(F) Curiosity, how else you can modify the robot you just built (this will be a robot!)	[The pupils] would often move by themselves on to the next stage which the teacher had planned. Their curiosity was so intense that they would not wait for further instructions.	I never expected curiosity could drive pupils to action so powerfully.	Pupils who are fascinated by the topic want more.
Change of importance	Significantly more important	Significantly more important	Always of key importance

Interpretation of teachers' opinions: attribute (E) - importance is retained, attribute (F) - significant increase in importance.

Table 7: Selected factors determining the usefulness of engineering approach in education

Attribute	Teacher #1	Teacher #2	Teacher #3
(A) Clarity of goals - build and program the robot (at the end of the classes the robot should work!)	The pupils have to know what we want to accomplish.	A large proportion of pupils like to know what goal they are expected to achieve. Still, they like to decide for themselves what [path] to take when working towards the goal.	A clearly set goal allows pupils to focus on action. In addition, a time limit stimulates greater commitment and motivates pupils to complete the task.
Change of importance	Equally important	Equally important	Significantly more important
(C) Variety of possible solutions	This is well demonstrated in activities where LEGO blocks are used, and is also used in other fields - there is no single "right" path.	I never thought that it was so important for pupils to come up with something different than their schoolmates have.	Initially [pupils] did not understand that various solutions might be developed and each of them would be correct.
Change of importance	Always of key importance	Significantly more important	Significantly more important

Interpretation of teachers' opinions: attribute (A) - slightly increase in importance, attribute (C) - significant increase in importance.

SUMMARY

The proposed proprietary strategy referred to as "An engineering approach in education" is designed to assist in finding evidence of the usefulness, in everyday life, of knowledge as well as mathematical, technical and digital skills acquired at school. It also changes the teacher's current role in the teaching/learning process. This is determined by the specific features of the described strategy - such as: the clarity of goals, freedom of access to information sources, a variety of possible solutions of the problems, openness to mistakes, responsiveness, teamwork and usability of the resulting product.

The research carried out in respect of the teachers participating in the project and teachers assisting with it demonstrates that they notice and appreciate both the educational potential of the described strategy and the "didactic attractiveness" of the proposed topics of classes.

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New Modern Application for Gamified Memorizing Paired Facts by More Fun form of Memory Game with the Possibility of Own Content Development

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Abstract

The article deals with the technique of memorizing a larger number of pairs of related facts (e.g. words in mother tongue and foreign language) using the flashcard method transformed into the classic card Memory Game. For this purpose, the new authoring mobile application Own Memory is introduced, whose major advantage is support for creating custom card sets, complemented by many original useful options. In addition to images, the application adds support for text and sound cards that can be used both separately and combined. These features make it easier to creating of sets with an effective educational component that allows to learn paired facts with the long-time proven flashcard method, but in a much more fun form than the classic version. This learning with the game can be enjoyed separately, against the artificial intelligence of the selected level, or with friends or family even on devices with a larger screen. Thanks to the open format of cards sets, it can be prepared outside of this application in any favourite software. The development of the application Own Memory continues, but already in its current release it has proven to be a quality and useful tool for a modern way of effective learning, where it is important to store a larger number of different paired facts into the long-term memory.

Keywords

Memory Game. Application. Smart phones. Gamification. Memorizing. Drill. Flashcards. VARK.

INTRODUCTION

The *Memory Game* (also known as *Pexeso*, *Pelmanism*, *Shinkei-suijaku*, *Pairs*, *Concentration game*, ...) is a classic cardboard game that helps train short-term memory. The game requires an even number of cards that are all the same on the reverse and form pairs (i.e. two cards) with the same face on the obverse. The cards are spread on the table with face at downside and two or more players trying to find these pairs. Each player can turn only two cards per turn, and all players can see their content. If they are the same, the player earns a point, otherwise the cards are turned back to face down. (Kuběna, 2010)

Players must remember the position and the image of each card to reveal it when they hit the other card in the pair. If the graphic representation of the pictures on the cards is aimed at children, for example in the form of characters from the popular children's

animated serials, they usually like to play the game (see Fig. 1), and they unconsciously practicing their memory from an early age (Wilson, et al., 2011; Hubálovská, 2015; Hubálovská, et al., 2015; Hubálovská and Hubálovský, 2016).



Figure 1: One-year child playing the memory game on the tablet.



Figure 2: Seven-year schoolgirl trains fruit and vegetable names and classification with memory game.

This game can have another educational benefit if the appropriate content on the face side of the cards is selected. In order for a player to remember of the previously turned cards as much as possible, they must somehow memorize their contents. The image itself can be a significant information that is for players desirable to retain in long-term memory for other than only game reasons. The picture can also be accompanied by a description that identifies it for the players and puts it into the right context (viz Fig. 3).

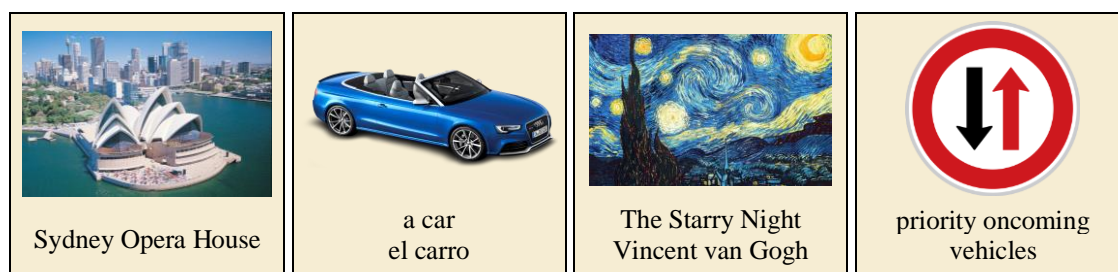


Figure 3: Sample cards with beneficial educational information

The player thus stores into the memory the word indication and graphic representation on the card, which can be transferred from the short-term memory to the long-term memory when playing the same set of cards repeatedly (Barondes and Cohen, 1968). Positive for this memorization is also to say the name on the card aloud, respectively the sound perception of the information, which also increases the enjoyment of the game.

Flashcard and The Memory Game

Another way to increase the educational impact of this game is to use different but related content on two paired cards, whose both versions and the relationship between them need to be remembered (e.g. split the picture and its description on Fig. 3). This approach is based on the so-called *flashcard* method (Wissman, et al., 2012), where on one side of the card is written a fact, a title or a task and on the other side is a solution or related

fact (e.g. English and Spanish word, mathematical example and its result, historical event name and its year, chemical symbol and an element name, etc.). In some cases, one or both of these data can also be represented graphically as an image (e.g. a geometric figure and a mathematical formula to calculate its surface or content, images and their authors, road signs and their meaning, blind maps and names of countries/cities/rivers etc.; see Fig. 2).

Learning through flashcards, sometimes also called as memorizing or drill (Palombella and Johnson, 2005), an individual performs by looking at one side of the card, trying to imagine or say out loud the content of the other side, then see if he answered correctly and remember the right answer if necessary. Right solved cards, for which we have to sure of the answer, can be put aside, and incorrectly answered cards are return back to try it again later. With the appropriate delay between attempts and the correct number of repetitions of each of them, by so-called the *spaced repetition* method (Settles and Meeder, 2016), this form of learning is very effective (Kornell, 2009). Many of computer programs exist to calculate the right and most efficient parameters (e.g. number of repetitions and delays between them), such as *SuperMemo* (Wozniak, 1990), *Anki* (Hanson and Brown, 2019), *Memostation* (Cakula, et al., 2013) etc. (Voborník and Němec, 2019; Němec, et al., 2016a; Němec, 2017)

Transforming *flashcards* into the *Memory Game*, i.e. dividing a two-sided card into two pair cards, which are needed to be found and identified, can be beneficial in several cases. First, it allows, or rather requires, joint learning in more than one person. It can also keep players' attention longer if they enjoy playing more than just memorizing facts. Knowing the relationship between two cards in a pair is motivated especially because of that the player could succeed in the game at all.

METHODS

The methods implemented in *Own Memory* multimedia application to streamline the educational components (Milková, 2012) of the game include *flashcard* method (Kornell, 2009), a modified version of Ebbinghaus's curve of forgetting (Ebbinghaus, 1885) for simulating artificial intelligence for automatic opponents and the method using multiple perception channels to effectively memorize related data (Kim and Gilman, 2008; Němec, 2019), so partly also the VARK method (Othman and Amiruddin, 2010).

The development of the *Own Memory* application has been implemented by means of the multi-platform technology of Xamarin.Forms (Hermes, 2015). It allows a common code in language C#, respectively the XAML design definition, to compile into a native application for operating systems of Android, iOS and Windows 10 (UWP – Universal Windows Platform). (Voborník, 2019)

RESULTS

*Own Memory*¹ application in the first stage was created as this classic game (Borkovec, et al., 2013) for finding two identical images that gamers could import themselves from their

¹ Official website of the *Own Memory* application is www.own-memory.com. The app is available on Google Play and the Microsoft Store.

own photo gallery on a mobile device or computer (see Fig. 4). Gradually the app was extended to include all the above-mentioned educational possibilities, plus some others. Emphasis was also placed on the overall openness and versatility of the solution, providing the possibility of using third parties.



Figure 4: Own Memory game in classic mode.

The set of cards for the game is therefore basically only a few image files, each used twice. These sets can be created directly in the application environment (see Fig. 12). All imported images are automatically cut to a square aspect ratio, shrink to 512x512 pixels and saving as a JPG image with 80% quality. However, in order to create or edit sets without these limits outside of *Own Memory* app, a classic ZIP archive was used as the format for storing these sets, that only has changed file extension from ZIP to OMS (*Own Memory Set*) for file type resolution. All you have to do is select images on your computer or mobile phone in any browser, wrap them in a ZIP archive, change the extension to OMS, and the memory card set is ready for import into the application.

Picture cards

However, if is needed to take advantage of the advanced capabilities of the application, especially in the field of education, then just rename the image files in the set. For creating of a pair which has different pictures on both cards, a wavy line character (~) is using. The beginning of the name (prefix) of the cards files in the pair must be identical, different is in the part after the separating character of the wavy line (postfix). For example, files in a pair can be named *card2~a.jpg* and *card2~b.jpg*, or *car~en.png* and *car~es.png*. The files with pictures in the set can be named arbitrarily, but if this notation is followed (even if only on some of files in the set), the principle of different pictures in one pair will be used.

If there are more than two image files with the same name prefix, two of them are randomly selected and used when shuffling cards. The other variants can then be selected in the next game. It works similarly with the total number of cards. If there are more cards than is needed for the game, only the selected number of cards/files/pictures in a pair is randomly selected from the whole set at the start of each game.

If the set contains any localization items, such as tab text in different languages, just add another parameter to the file name. From more language versions is selected just one by the national settings of the operating system where the application is running. Dot before file extension can be used for separation of the culture code (two chars ISO 639-1; Morey, et al., 2013) at the end of file name. E.g. if there are *card3.en.jpg*, *card3.es.jpg* and *card3.jpg* files, the first image will be shown only for English localization, second only for Spanish and the third for every other language.

Text cards

If the picture on the card should be only text, it would be unnecessarily laborious to create such a picture manually, the picture would be unnecessarily data-intensive, and the text would be blurred due to rasterization. The same applies to any descriptions below the pictures. For this reason, XML card support has been added. An XML card is a text file with an extension and format of XML (Bray, et al., 2008). Its structure is shown by the following code. Not all of elements and attributes are required.

```
<?xml version="1.0" encoding="utf-8"?>
<card background="#FFAAFFAA" textColor="#FF000000">
  <text>carrot</text>
  <label>vegetable</label>
  <info>The carrot is a root vegetable...</info>
</card>
```

Fig. 5 shows how this XML card definition is edited in the application. The text on the card (element *text*), if defined, is shown in the centre over its entire card's surface. The card label (element *bottom*) is the text on the bottom of the card. Additional information (element *info*) is displayed in the dialog by clicking on the rotated card, and this text can be longer and multiline. If the image is to be combined with the text and it is too dark, the text color on the card (attribute *textColor*) can also be changed to make it readable, and/or the background color of the card (attribute *background*) around the image, respectively below its completely or partly transparent pixels, or instead of whole image. Both colors can be defined including the alpha channel value, i.e. the degree of transparency.

Figure 5: Form for editing XML card details.



Figure 6: Example of rendered card without picture and in combination with picture.

Figure 7: Form for editing set information.

As shown in Fig. 6, the text and the picture on the card can be combined. For this variant is necessary to name both files (with image and XML) the same so that only their extensions differ (e.g. *card4.jpg* and *card4.xml*). This allows to define only the label of the card and this text appears as additional information below the image without the need to edit the image itself.

Sound cards

The images and texts provide the visual side of the cards. However, some people better remember sound perceptions and everybody a combination of both (Kim and Gilman, 2008; Němec, et al., 2016b; Němec, et al., 2016c). Especially when learning foreign languages, listening to the pronunciation of vocabulary words is very important (Yeh and Wang, 2003). For this reason, support for audio files has been added to *Own Memory* app.

The same rules apply for file names as for picture and XML cards. If the audio file name is unique, then the contents of the card will be empty, but its sound will be played when the card is rotated from back to front side. The sound can also be played again by clicking on the already rotated card. If an image (or even text) is present with the same file name in the set, everything for that card will be combined together.

File naming system in the set

Supported extensions of the files for specific card types are:

- **Images:** JPG, JPEG, PNG
- **Audio files:** MP3, WAV
- **Text data:** XML

Any other file types in the set are ignored. In future versions is also planned a support of vector images SVG and GIF animations.

There may also be several special files in the set with specific reserved names that begin with an underscore (_). These add more information about the set as a whole or set the implicit default content (colors, texts, images or sounds) for all cards that are used only when some cards do not explicitly (individually) define them.

- **_info.*** (data) – information about set (name, description, author, license, URL and color settings of the play board; see Fig. 7)
- **_back.*** (image/data) – image and/or text data for back of cards of the whole set (if absents, default background image from the app will be used)
- **_theme.*** (image) – image that is used in the sets list (see Fig. 11)
- **_default.*** (image/data/audio) – image, audio and/or text data used for cards without image, audio or text data (at least one of these file types must exists for card identification, other may be defaults); if this name has a suffix (e.g. “~a” or “~b”, i.e. there are files *_default~a.jpg* and *_default~b.jpg*) then these default images (or data or audio) will be linked with all cards with the same suffix
- **_turn-card.*** (audio) – a default sound for turn a card
- **_pair.*** (audio) – a default sound when the whole pair is turned
- **_pair~yes.*** (audio) – a sound when the pair of the same cards is founded
- **_pair~no.*** (audio) – a sound when the pair of a different cards is turned
- **_end.*** (audio) – a default sound for the end of the game
- **_end~human.*** (audio) – a default sound for the end of the game when human wins over computer
- **_end~computer.*** (audio) – a default sound for the end of the game when computer wins over man
- **_end~both.*** (audio) – a default sound for the end of the game when computer and man has the same score or when plays computers only

Thus, the definition of default files (*_default* for images, sounds, and texts) can be individually replaced by specific cards if their file variant is present. Default values can be also specified specially for different cards in a one specific pair (files with wavy lines in the name). Simply name them with a common base from the file name (part before the tilde). For example, if the cards in the pair are to have the same image and sound when rotated but different labels, these files should be inserted into the set: *card5~a.xml*, *card5~b.xml*, *card5.jpg* and *card5.mp3*.

This optional system of gradual settings properties can minimize the need to repeat the same files in the set (see Fig. 8).



Figure 8: Example of hierarchical validity of properties and cards content settings from the most general (left) to the most specific (right) for the *card~x*.

Game options

The conditions under which the game will run can be also set in the *Own Memory* app (see Fig. 9). The timing of the pauses between moves can be specified, and thus the time to remember the cards turned in the current turn. Default sound effects of cards rotating (not explicitly defined audio files in a set) can also be deactivated to avoid distracting. It is also possible to set whether the same player should continue or not with playing after finding a pair of cards, which both variants are valid in different versions of the Memory Game rules.

Defined can also be the transparency of found pairs of cards, so that they do not disturb the rest of the game but remain available in case they display additional information or play audio when clicked. However, when the visibility is set to 0%, found cards disappears completely from the board. Some other settings can also change the whole game mode.

When this option *Show all cards at the beginning* is enabled, all playing cards will face up for the selected time interval as soon as a new game begins. Players can then try to remember the content and location of as many of them as possible and after their turn to back to quickly find these pairs again. This variant is another interesting alternative for memory training, especially suitable for a single player game.

Option *Auto start a new game when a previous ends* displays a table with a summary of each player's score after the end of the game, but the *Play again* button launch a 10-second countdown and after it a new game automatically starts with the same settings. While this option may seem unimportant for classic gaming, it allows the application to be used for presentation purposes. This option, along with the setting to play a computer for all players, would allow the game to run in an endless fully automatic loop. For example, if some firm created a set of images of their products (goods, school campus photos, travel agency photos of destinations ...), thanks to this function, it can be projected on an unattended screen or projector to attract potential customers at an exhibition, at doors open days or at shop window as an interesting form of presentation.

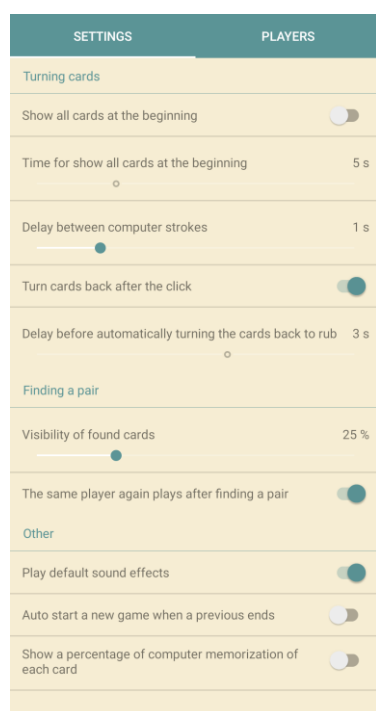


Figure 9: Game settings.

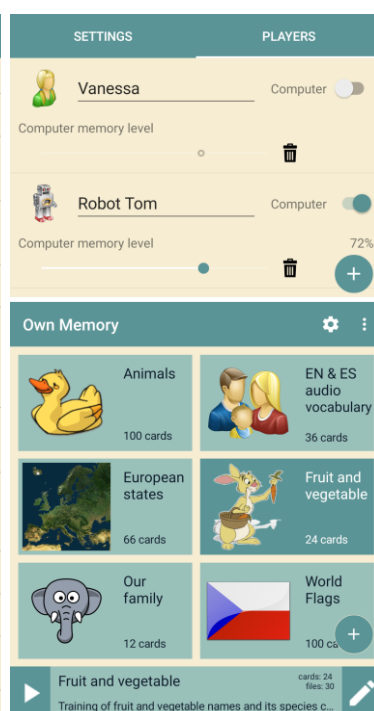


Figure 10 (top): Players settings.



Figure 12: Cards (files) in the set.

Figure 11 (bottom): Sets list.

Presentation sets should also be assisted by the upcoming feature to start playing a new set in the application directly via a special URL². The application would start and immediately start playing with this external set of cards only by clicking on such this URL link in the browser (Milková and Ambrožová, 2018). The teacher could thus prepare a set of cards suitable for the current subject matter and provide it to the pupils simply by publishing its link, for example, through an e-learning environment (Hubálovský, 2013; Hubálovský, et al., 2019).

When the computer player plays then activated option *Show a percentage of computer memorization of each card* will display a percentage at the right-bottom corner on the back of all non-turned cards on the board, that indicating the degree of assurance of the content of this card for the automatic player. The game can be played not only by one player itself or with any number of human opponents (on one device), but also with any number of players controlled by the computer. Players settings is on the second tab (see Fig. 10) and their number may be increased or decreased at will except the last one. The option *computer* can be activated to each of them and set their memory level too.

Artificial intelligence of an inhuman player

A model of artificial intelligence for players marked as *computer* was included into the application in order to increase variability, enjoyment of playing by one person and at the same time motivation to play more often and, in case of suitable educational sets, a learning (Hubálovský and Šedivý, 2013).

² E.g. "own-memory://www.some-copany.com/marketing/main-products.oms"

This model was inspired by the *Ebbinghaus forgetting curve* (Ebbinghaus, 1885) adapted for the *Re-wise* method (LANGMaster, 2012), which has already been used, for example, in the *Universal Testing Environment* (Voborník, 2012) for intelligently mixing test questions (Voborník, 2016). However, in this case, this is not a simulation of long-term memory, but only a short-term memory. Thus, cannot be counted in days, but only in game rounds.

In this modified model, the *computer* player would halve his knowledge of the content of previously rotated card in each round. If he encountered on the second card in a pair he would have a 50% chance to reveal the right card in the next round, after two rounds only 25%, then 12.5% etc. (see Fig. 13).

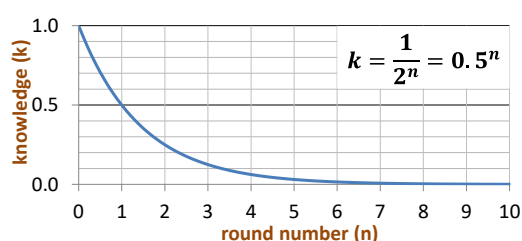


Figure 13: Forgetting curve according to the *Re-wise* method.

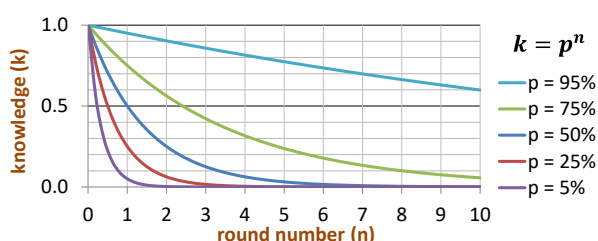


Figure 14: Modification of the forgetting curve for simulation of AI in the memory game.

However, such a decrease is too fast for short-term memory. At the same time, it was necessary to give the users the ability to adjust the level of automatic opponents to best match of their current individual abilities. For this reason, the parameter p has been added to the original equation instead of $\frac{1}{2}$ (50%), which can be set in a percentage scale of 0–100%, i.e. in the range $\langle 0, 1 \rangle$, to define the degree of memory quality, respectively the ability of the automatic player to keep the card in memory (see Fig. 14). The knowledge of the content of the card k can then be determined by the equation for the given round n at the level of the automatic player p (1).

$$k = p^n \quad (1)$$

When adjusting the level of an automatic player, it can be intuitively assumed that 50% will be average level, but this does not correspond to half the loss of knowledge in each round. By experiments and simulation tables have found that to the average player corresponds the value $p \approx 75\%$, meaning that the knowledge level of the previously viewed card is reduced by only a quarter (25%) in each round, i.e. to 75% of the previous round (100%, 75%, 56.25%). It was also necessary to mitigate too slowly changing thresholds ($x \rightarrow 0^+ \vee x \rightarrow 1^-$). For example, 10% (i.e. 90% loss of knowledge in each round) is also a more unusable value than would be expected and more corresponding is value $p \approx 25\%$ for this level. On the other hand, at 90% the level of knowledge decreases too quickly and a smaller decrease of around 3% (i.e. $p \approx 97\%$) would be more appropriate. The user-defined percentage level (x) should therefore be adjusted ($p = f(x)$) before being used in the selected model of forgetting.

A function that would convert user-selected percentages to percentages with expected properties should be concave, symmetrically curved to upward, passing at the beginning of

$[0, 0]$ and 100% at $[1, 1]$, which would also be the limit for its use. Logically, the $y = \sqrt{x}$ function is offered in the range of $\langle 0, 1 \rangle$. But this function is not symmetrical at both ends of the usage limits (see Fig. 15). The left upper quarter of the unit circle shifted by its radius to the right provides symmetry, correct shape and range. Basic equation of the circle taking into account this shift is $(x - r)^2 + y^2 = r^2$, and expressed for y it is $y = \sqrt{r^2 - (x - r)^2}$. However, the circle with radius $r = 1$ is too concave (see Fig. 15) and the input value x would be transformed by $y = f(x)$ to beyond the expected values.

The concavity of a circle decreases as its radius increases ($r > 1$) in the 1x1 viewport (see Fig. 17). Thus, by determining the appropriate radius could meet all the requirements for this function. For this purpose, it was necessary to correctly shift the viewport 1x1, resp. calculate the coordinates of its lower left corner $[x_s, y_s]$ (viz Fig. 16).

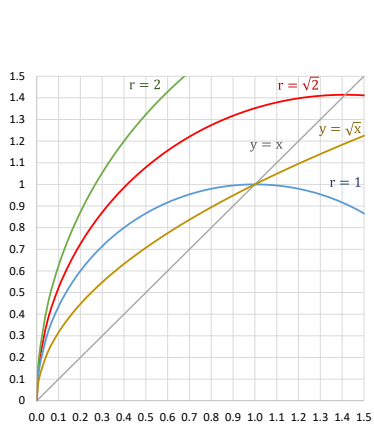


Figure 15: Candidates for transformation function of selected level to parameter p .

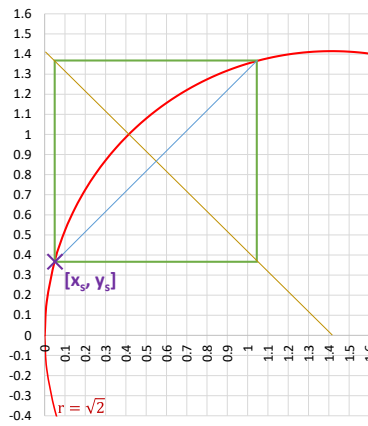


Figure 16: Representation of the 1x1 cutout the required part of the circle.

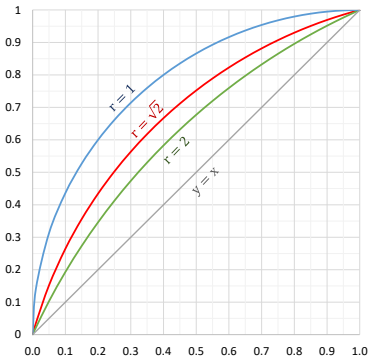


Figure 17: Comparison of the concavity of cutouts of circles of different radii.

After appropriate adjustments of the equation of the circle and the line between points $[0, r]$ and $[r, 0]$, when was searched x for such y where the horizontal distance of the point on the circle from this line was exactly 1, the following equations (2) of shift coordinates for the unit viewport x_s and y_s was derived.

$$x_s = \frac{2r - 1 - \sqrt{2r^2 - 1}}{2} \quad (2)$$

$$y_s = r - (x_s + 1)$$

After calculating the shift coordinates for the selected radius and substituting into the original equation of a circle, we get the resulting function (3) that in the range of $\langle 0, 1 \rangle$ converts the selected level of the automatic player (x) to the value expected (y , resp. p) for the calculation in the equation (1).

$$y = \sqrt{r^2 - (x + x_s - r)^2} - y_s \quad (3)$$

As the ideal radius of the circle for the transformation function, the value of $r = \sqrt{2}$ was empirically determined, which was closest to all selected coordinates of the expected values.

In the case of repeated turning of the same card in different rounds, the knowledge is summed by the same way as the predicted knowledge of the questions in UTE (see (Voborník, 2016) including the derivation of the function), as shown by the function rule (4), where k_x indicates the remaining knowledge of the card in any of its x turns.

$$\begin{aligned}f(x) &= k_x + (1 - k_x) \cdot f(x - 1) \\f(0) &= 0\end{aligned}\tag{4}$$

Whether the automatic player turns the right card or not is decided by chance, respectively a randomly generated number in the range of $\langle 0, 1 \rangle$, which if less than the overall knowledge of the card's contents, the player reverses it, if not, randomly selects from all non-turned cards for which he does not remember their contents by this way. Similarly, he also tries to remember the position of both cards in a pair before the first one of them is turned.

CONCLUSION

Own Memory application at first glance brings another variation on the classic board Memory Game in a new modern design. From this point of view, it is certainly interesting to create your own card sets from gallery on a mobile device, where nothing prevents players from using their favourite pictures or family photos and enjoy the game separately, against the artificial intelligence of the chosen level, or with friends or family even to larger screen devices (support for Xbox One console is planned). Thanks to the open format of OMS sets, which is essentially a classic ZIP archive, sets can be prepared outside of this application in any favourite software. Finished sets can then be used not only by the author, but can also be sent to pupils or classmates, or even shared publicly as a full-fledged teaching tool.

However, *Own Memory* app does not stay with just pictures when it comes to creating custom sets but extends the capabilities with text and audio information that can be used both separately and combined. These features make it easier to creating of sets with an effective educational component that allows to learn paired facts with the long-time proven *flashcard* method, but in a much more fun form than the classic version.

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Enhancing Geoinformation Skills of Geography Students Through Field Geocoding

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Abstract

One of the requirements of today's society is to quickly and accurately determine the location and description of the object in space and time. In this sense, mobile geoinformation technologies (e.g. PDA/GNSS device) represent useful technologies which integrate multiple components in order to define the object based on geographic coordinates and describe its properties. Geocoding of address point plays an important role in everyday life. It is a process of locating and describing objects in the field, which can be approached to students of geography through field exercises. Such field exercises enable students to develop geoinformation skills and offer many possibilities how to practically use geoinformation technologies. The aim of the paper is to point out the potential of using geoinformation technologies in teaching university students of geography on the example of geocoding of address points. Nowadays, geography students should not only understand the theoretical framework of geoinformation technologies, but also practically master them. Although students are more or less able to handle smartphones and their various applications, working with professional (mobile) geoinformation technologies and acquiring accurate field measurements brings new practical skills that they can use in their future practice.

Keywords

Geoinformation technologies. Mobile GIS. Field geocoding. Geography. Education.

INTRODUCTION

The development of information technologies is constantly moving forward offering new possibilities for their practical use. Geoinformation technologies also take part in this information revolution. Exact localization of objects in space and time is one of the main requirements of today's society (Vojtek et al., 2016a). Car navigation systems, tourist navigation devices as well as mobile phones and tablets contain GNSS (Global Navigation Satellite System) receivers for localization purposes in space and time (Hofmann-Wellenhof et al., 2001; Bhatta, 2011). GNSS is part of geoinformation technologies, which also include geographic information systems (GIS) and remote sensing (RS) (Hofierka et al., 2014). Their interconnection with GNSS allows not only to define an object on the basis of geographical coordinates, but also to describe and analyze its properties (Kennedy, 2009). Using GIS, such

spatially localized information can then be placed on a map, which nowadays takes the digital form, often presented via the Internet (Longley et al., 2010).

Mobile geoinformation technologies work with spatial dimension and can gather information anywhere and anytime (Lemmens, 2011). They integrate the following (Rapant, 2006): small laptops such as PDA or tablet, software for geoinformation systems, geodata, wireless communication technologies, GNSS, Internet, geoweb. In case of using highly precise mobile geoinformation technologies, professional and very accurate field data can be obtained and subsequently analyzed and assessed in computer environment (McCoy, 2005; Ghilani and Wolf, 2012).

Geocoding of address point is widely used in practice and plays an important role in everyday life (Kusendová, 2018). It is a process of locating and describing objects in the field, which can be approached to students of geography through field exercises. Such field exercises enable students to develop skills in working with mobile geoinformation technologies (GIS, RS and GNSS), which interconnection offers many possibilities how to practically use them.

The aim of this paper is to point out the potential of using geoinformation technologies in teaching university students of geography on the example of geocoding of address points. Nowadays, geography students should not only understand the theoretical framework of geoinformation technologies, but also practically master them. Although students are more or less able to handle smartphones and their various applications, working with professional (mobile) geoinformation technologies and acquiring accurate field measurements brings new practical skills that they can use in their future practice.

BASIC PRINCIPLES OF GEOCODING

Geocoding refers to the process of assigning geographic coordinates to records that are placed directly on the map as a point representing a particular address. If objects in GIS environment are not defined by an explicit geographic reference (geographic coordinates), they must include an implicit reference such as address, postal code, road number, etc. These are data from which we can identify the geographic location of an object. Converting explicit references to implicit and vice versa is ensured by the geocoding process.

Generally, there are three levels of geocoding accuracy:

1. Address point – this is the most accurate localization where the geographic coordinates are assigned to a point that represents a particular building.
2. Street definition point – this is a less accurate location where the geographic coordinates are assigned to the center of a particular street and thus all the buildings on that street are assigned one geographic coordinates.
3. Definition point of the municipality – geographical coordinates are assigned to the center of a part of the municipality or to the center of the whole municipality and, therefore, all the buildings in that municipality or its part are assigned one geographic coordinates.

The aim of geocoding of address points in practice is to create digital point layers with records containing address data on buildings within the given territorial unit.

HARDWARE AND SOFTWARE FOR FIELD GEOCODING

Field geocoding cannot be realized without mobile geoinformation technologies enabling accurate localization, i.e. direct definition of geographic coordinates to records (points) that represent a building with its address information. Mobile geoinformation technologies are means that integrate main geoinformation technologies (GIS, RS and GNSS) or telematics and are designed to acquire geodata and to communicate it to mobile users (Rapant, 2002).

Mobile units are represented by the combination and integration of a mobile phone or PDA (personal digital assistant), the Internet, GIS software, GNSS receivers and geodata (Rapant, 2006). Use of PDA mobile device and integrated GNSS is one of the options applicable to field exercises in geography. For example, the Trimble Juno 3B PDA/GNSS device has the following hardware parameters (Figure 1): high resistance IP54 to harsh conditions, 2 GB internal memory, 256 MB RAM, highly sensitive integrated GNSS receiver or 5 Mpix camera with flash. Trimble Juno 3B, as a control unit, can be used in combination with GNSS receiver, e.g. Trimble Pathfinder Pro 6H, in order to obtain measurements with high horizontal accuracy (<1 m with SBAS) under suitable conditions. In the case of real time or postprocessing corrections from the reference stations, the measurements can be corrected to ± 10 cm. The maximum productivity of this device is ensured by the Trimble Floodlight technology, which enables to reduce the satellite signal failure because of shading vegetation during the measuring, and Trimble H-Star technology ensuring high accuracy of measuring data (Vojtek et al., 2016a).



Figure 1: Trimble Juno 3B with Windows Mobile (control unit) (left) and Trimble Pathfinder Pro 6H (GNSS receiver) (right).

PDA with the appropriate software allows to display a digital map, thus replacing the printed map in which the individual map elements has to be manually drawn. The advantage is that, in addition to editing objects in the map (drawing, deleting and changing position), the PDA serves as a notebook. Object properties are entered in pre-prepared forms linked to the database (Voženílek, 2001).

Requirements for mobile GIS software are met, for example, by the ArcPad software by Esri or TerraSync software by Trimble (Figure 2), which are designed for field mapping and are compatible with Windows Mobile operating systems. In terms of field mapping, mobile GIS has the following important features:

- Supports raster and vector data in multiple formats.
- Includes map navigation tools (pan, zoom, spatial tabs, centering on current GNSS position).
- Enables queries for object identification, hyperlink display or object localization.
- GNSS navigation, map measurements: distance or area.
- Simple editing: creating and editing spatial data.
- Possibility of creating applications for automation of field work.



Figure 2: ArcPad software from Esri (left) and TerraSync software from Trimble (right).

DATA COLLECTION AND PROCESSING

Before collecting the data, it is necessary to perform basic steps, such as defining the coordinate system and projection and preparing the GIS layers for editing. The basis is a high-quality and current orthophoto with which it is possible to distinguish individual buildings in the municipality. The empty point layer is completed with the properties of the address points which attributes are gradually entered in the pre-defined forms, as shown on the example in Table 1.

Editing (inserting) of individual points on the orthophoto and writing values to their properties takes place on individual streets of the municipality. The result is a complete digital point layer of all addresses within a certain territorial unit. Such layer can be transferred to the desktop GIS software and if necessary modified, corrected or used for

various spatial analyses. These can include, for example, distance and travel time analyses to the nearest health facility, police station, fire station, shopping center or the least-cost network paths between several origins and destinations can be determined.

Correcting, aligning or adding new points to the layer can be also done after data collection from the field through the combination of desktop GIS software with loaded orthophoto, geocoded point layer, cadastral map and with the use of web portal of Geodesy, Cartography and Cadastre Authority of Slovak Republic (www.katasterportal.sk). This web portal offers a search of buildings based on the building number and also to display the cadastral map with the land parcel on which the building is located. However, it should be noted that many of these cadastral maps are missing on the cadastral portal. The result of geocoding takes the form of a digital GIS layer of address points, as shown in Figure 3, which specific use is for location-based needs. Moreover, spatial information obtained from postal addresses is an important part of the INSPIRE (INfrastructure for SPatial InfoRmation in Europe), which is developed based on the EU Directive 2007/2/EC in order to establish the European legislative framework needed to make quality and standardized information available in both the public and private spheres.

Table 1: Attributes of geocoded address point – an example.

Property of address point	Values
ID	481448
REGION	Nitriansky
REGION_ID	4
DISTRICT	Nitra
DISTRICT_ID	403
MUNICIPALITY	Nitra
MUNICIPALITY_ID	500011
MUNICIPALITY_PART	Chrenová
M_PART_ID	2
ZSJ	Vysoké školy
ZSJ_ID	2404350
POSTAL CODE	949 01
STREET	Akademická
STREET_ID	43
ORIENTATION_NUMBER	12
BUILDING_NUMBER	1579
TYPE_OF_BUILDING	1 (family house) 2 (housing unit) 3 (other building) 4 (garage)
NUMBER OF FLATS	0
PARCEL	1118/26
X_COORDINATE	-498569,097308
Y_COORDINATE	-1269977,83147



Geocoding of address points within a certain territorial unit can be applied as an effective field exercise when teaching geography in combination with geoinformation technologies. In this way, students' skills in working with mobile geoinformation technologies, such as PDA, GNSS and GIS, are being developed and enhanced. Students learn how to transform geographic coordinates from PDA/GNSS directly to a point that represents the location of a particular address. In this way, students are aware of the spatial dimension of processed data and information and learn to perceive how reality is depicted in GIS environment, thereby, developing their geoinformation thinking. Regarding the field geocoding, students learn to orientate in a particular municipality and system of streets based on the underlying maps or orthophotos, GNSS receiver and mobile GIS, which are integrated in the PDA device (Figure 4).

Problems with the use of professional mobile geoinformation technologies are mainly related to their financial demands since the necessary hardware and software is costly. The solution is seen in the use of students' smartphones with applications such as SW Maps (Google Play) or CarryMap (www.carrymap.com), which serve as mobile GIS applications enabling to perform more or less the same tasks as professional mobile geoinformation technologies, however, with lower accuracy.

Geocoding of address points is widely used in practice. Logistics or rescue services are highly dependent on the exact location of a particular address. GNSS navigation and web mapping services are also based on this principle. In addition, digital address point layers are used for various GIS analyses in the commercial sector. In telecommunications industry, for example, call center operators can access all the information on a customer and the associated network based on location (specific address). Databases containing information

on outside plant infrastructure, signal quality, and equipment can be integrated using GIS and made available using a corporate Intranet. Regarding the energy companies, for example, each electric supply meter or gas flow meter is given an exact location based on the nearest address point. For these reasons, part of the field practice should also be focused on learning how mobile geoinformation technologies work in the field giving the students practical experience, which may help them in their future practice (Vojtek et al., 2015, 2016b).

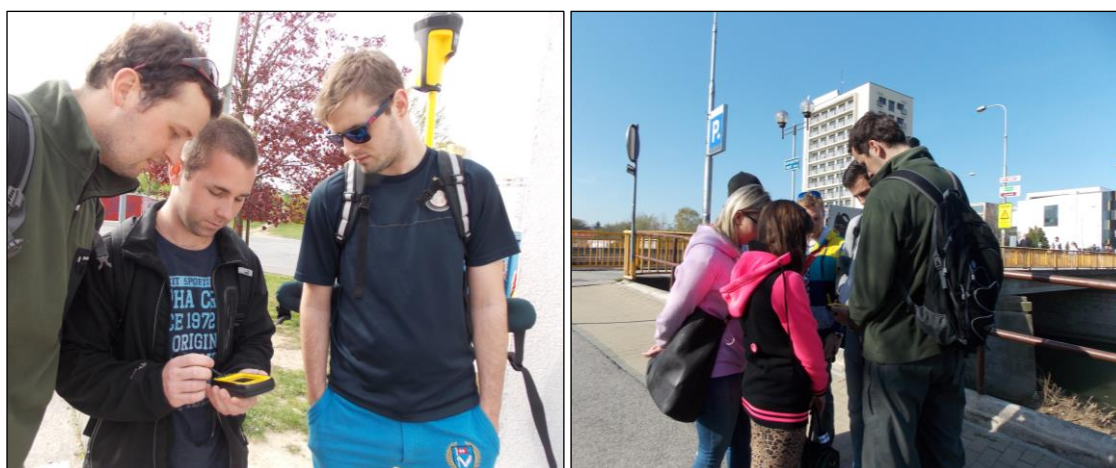


Figure 4: Students working with mobile geoinformation technologies during the field exercise.

CONCLUSION

The present time is characterized by constantly evolving information technologies that affect practically all areas of life (Cápay et al., 2011). Geoinformation technologies are a typical example of such technologies, which interdisciplinarity affects almost all sectors (Kusendová, 2002) while their development results from several scientific disciplines and practical areas of life (Lieskovský et al., 2018; Boltžiar et al., 2015; Ivanová et al., 2013).

One of the requirements of today's society is to quickly and accurately determine the location and description of the object in space and time. To meet this requirement, mobile geoinformation technologies (e.g. PDA/GNSS device) can be used to integrate multiple components to define the object based on geographic coordinates and describe its properties.

Regarding the field practice of geography students, field geocoding of address points is one way to learn the operation and interconnection of mobile geoinformation technologies directly in the field anytime and anywhere. It is the process of assigning geographic coordinates to a specific address that is displayed in GIS environment by a point feature. Such address point may have various characteristics that provide descriptive information about it. For this purpose, portable PDA technologies are used in practice along with, for example, ArcPad or TerraSync software as an integrated mobile GIS for field mapping.

Field geocoding of address points focuses on the creation of a digital point layer that contains address data about each building in a particular territorial unit. Such digital layer is the basis for various practical fields including logistics, rescue services, car navigation, web mapping services as well it is also used for specific GIS analyses, which are inevitable for

different companies. By geocoding address points, students gain experience in working with mobile geoinformation technologies, which they can use in their future job application and practice.

ACKNOWLEDGEMENT

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Albrechtic - A Modern Didactic Tool for Teaching Music Theory

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Abstract

Requirements for mastering playing on any possible basis are knowledge of music theory (notation, rhythm, meter, dynamics, agogics, melodic ornaments, etc.). Pupils or students acquire their theoretical knowledge in terms of music theory. Computer-aided teaching can be one of the creative and engaging ways of accessing and practicing cognitive knowledge in music theory. In practice, it is possible to find several music programs to support the teaching of rhythm or intonation. There are also available musical editors, which have been gradually extended to the didactic level (learning notes, keys, metrorhythmic values, dynamics, agogics and the way they are written). However, no available music program has a Slovak version. And since professional music terminology differs from Slovak music terminology, these software are not suitable for music education in Slovakia. Within the project KEGA 003UKF-4/2015 entitled "Application of Information and Communication Technologies in Teaching Music Theory", we decided to create our own educational software. The article deals with the development of the Albrechtic software, which is the final product of the project. With regard to the use and application of ICT in teaching we decided to simplify and streamline the study of music theory in this form. The developed software will serve to support the education of basic tasks in music theory. Specifically, it includes parts to support the education and practice of knowledge in notation, scales, intervals and chords. The software is developed by Embarcadero RAD Studio for the Windows platform.

Keywords

Albrechtic. Education Software. Music Theory. Didactic Tool

INTRODUCTION

Turning their attention to computer-aided learning seems to be anachronism, or at least useless, at a time of richly developed ICT. Nevertheless, there are trade unions in education where these technologies are penetrating at a slower pace. This is due not only to the technological equipment of the training facilities, the inability of teachers to use new technologies in the given field, but also to the fact that adequate didactically oriented programs in the national - Slovak language are not available for the given field. At the same time, vocational studies are increasingly raising warning voices indicating the negative impact of ICT on youth, the need for a creative approach to the learning process and creativity in the learning process, as well as questions about the role and role of teachers in computer-aided learning. Creativity, a term so often deceived in professional pedagogical

studies, is perceived as an extremely effective factor in the development of the abilities and skills of an applicant at any level of education. A dichotomy of the problem unfolds - conservative education vs. creativity, innovative education vs. negative impacts of computer-aided learning. A closed circle from which there seems to be no way out.

Before teachers, working in the field of music education and training raises the dilemma of which of the possible ways is to move forward: to continue teaching traditional conservative manner without computer-aided instruction, or be inspired by the new possibilities of music software? If he chose the second option, new questions arise again: what software, in what subject of music education, to what extent and how?

Artistic pedagogy focused on instrumental playing or singing uses, for understandable reasons of practical calibration of musical skills at schools of individual grades, conservative methods complemented by the possibility of comparing the interpretation of specific musical works by means of video or audio recordings. For self-learners, however, various courses in the basics of instrumental play in the Slovak or Czech language are available on the Internet, eg. in guitar playing (<http://www.marianguitar.com>; <http://mojagitara.com>), accordion playing (<http://harmonika.wz.cz/>; <http://heligonka.sk>), or even in the violin game (<https://violin.preferably.eu/?lang=en>) and others, which are often associated with video courses on the youtube website. The prerequisite for mastering the game on any instrument, however, is also knowledge of music theory (notary, rhythm, meter, dynamics, agogics, melodic ornaments, etc.). Teachers teaching instrumental play assume that this knowledge is acquired by pupils or students in terms of music theory. Self-learners sometimes have brief information about notepad, metrorhythmics, dynamics, or intervals and scales. Of course, only to the extent necessary. Similarly oriented programs are on the Internet a plethora of. However, the lessons and text lectures supplemented with necessary examples concern only a narrow section of music-theoretical curriculum. See e.g. Marian Mark Guitar University (Marko, 2020).

Teaching music-theoretical subjects, however, is generally considered a necessary evil in music education, and many educators deliberately avoid it in the structure of the lesson (often due to work evaluation tasks and examples). It is here that computer-aided learning can be one of the creative and engaging ways of accessing and practicing cognitive knowledge in music theory. The upward trend of lifelong learning for people and communication technologies (ICT) Examining the jobs and competences of teachers. Teachers need to respond flexibly to these changes and warnings of modern methods in the educational process. They are currently learning the ability to search for modern ICT capable of the most sought-after competence (Cápay, Magdin and Tomanová, 2012). Computer-aided instruction is most often encountered in intonation and rhythm teaching, where educators currently have several high-quality music programs available (eg Sibelius, Auralia, EarMaster, etc.). Equally good are notation editors (eg Sibelius, MuseScore, Finale, etc.), which were created primarily for computer recording of music tracks. In addition to the basic function, for practical reasons they were gradually expanded to include the didactic level (learning notes, keys, meter rhythmic values, dynamics, agogics and the way they are written). These notation editors are not intended to teach music theory, but they can be used by teachers for the notation of musical compositions to be interpreted, as well as by adept compositions for recording their own author's work.

For the teaching of such a frequently acclaimed music theory, only a few sophisticated software, available primarily in English, are freely available online

(<http://classic.musictheory.net/> (with translation into other languages - Icelandic, French, Polish, Swedish, Serbian, Portuguese) , in Spanish - <https://www.teoria.com> (with translation into English). Other software are bound eg. for teaching in a particular educational institution (see courses such as music theory at the University of Edinburgh - <https://www.coursera.org/learn/edinburgh-music-theory>) or are commercial (eg. software available in German language <https://www.musiklehre.at>). As foreign (English, German) professional music terminology differs from Slovak music terminology, these software are not suitable for music education in Slovakia (with the exception of bilingual schools, but it is also necessary to point out differences in terminology). The fact that computer-aided teaching of music theory in Slovakia is of interest is evidenced by eg. website of the Art School in Turzovka, where you can find links to music theory exercises (<https://zusnauka.webnode.sk/prakticke-vvicenia>). At the same time, however, there is a warning that for practicing it is necessary at least a minimum knowledge of English language, English music terminology. Why? Because if you click on the individual Internet links, you will get to the Spanish website already mentioned in English <http://www.teoria.com> and the commercial website <https://www.8notes.com> with selected free exercises.



Figure 1: Screenshot ZUŠ Turzovka

ELECTRONICAL AIDS FOR TECHING THEORETICAL FOUNDATION OF MUSIC

Teaching music theory is one of the basic educational activities in music education at elementary and elementary art schools, at secondary general and pedagogical schools, at conservatories, as well as at universities of arts and pedagogy. Each level of education has a defined range of music-theoretical knowledge and a specific content of the subject. In principle, however, it is about knowing the relationship between the horizontal and vertical components of music and how to record them in different variants. While at lower levels teachers can rely on a set of textbooks and methodological manuals of music education, respectively music education (Suchoň, Filip, 1962; Pospíšil, 1985; Šidlík, Dlháňová, 1994). Read more about this in (Čierna, 2017).

Teachers are thus forced to rely mainly on their own experience and conservative way of teaching by practicing tasks and writing examples on a blackboard. In the better case they use a data projector with prepared power point presentations of lectures as a didactic tool. If the teacher has enough space and time available, the teacher can prepare traditional

musical examples for students and practice them on a blackboard (or interactive whiteboard). However, if the teacher does not have this space due to the low amount of time allocated to music-theoretical subjects, the teacher must leave the exercise for the student's self-study. The possibility of using interactive music software for evaluation of correct and incorrect answers seems to be a very effective didactic tool accessible via mobile phone and wi-fi practically everywhere (at school, at home, on a train or on a bus). On the other hand, music-educational software can help educators to create online music-theoretical tests with evaluation (eg within the school's intranet space).

Educational software Albrechtic, prepared by the research team from the University of Constantine the Philosopher in Nitra within the project KEGA 023UKF-4/2018 "The extended possibilities of application of information and communication technologies in music education" thus fills the white space on the map of didactically oriented music software in Slovak language. The intention of the team is to prepare software that will offer variable exercises in the field of writing and determining notes in four basic keys (violin G-key, bass F-key, alto and tenor C-keys), determination and recording of musical scales (major scales; minor scales in natural, harmonic and melodic form; modal scales; pentatonic scales), notation and determination of ascending and descending intervals in all four keys ranging from prima to decima. Later, the creative team plans to extend the program by recording and identifying chords (quintacords, septacords), rhythmic exercises (writing and identifying tactical prerogatives based on rhythmic notation), as well as other functions (transposing melodic snippets, linking to midi, etc.). The software Albrechtic is developed in Embarcadero RAD Studio for the Windows platform. Previously, the creative team had already published information on some of the components of the Albrechtic program in (Brezina et al., 2016) and this article focuses on additional features and extensions to the original version.

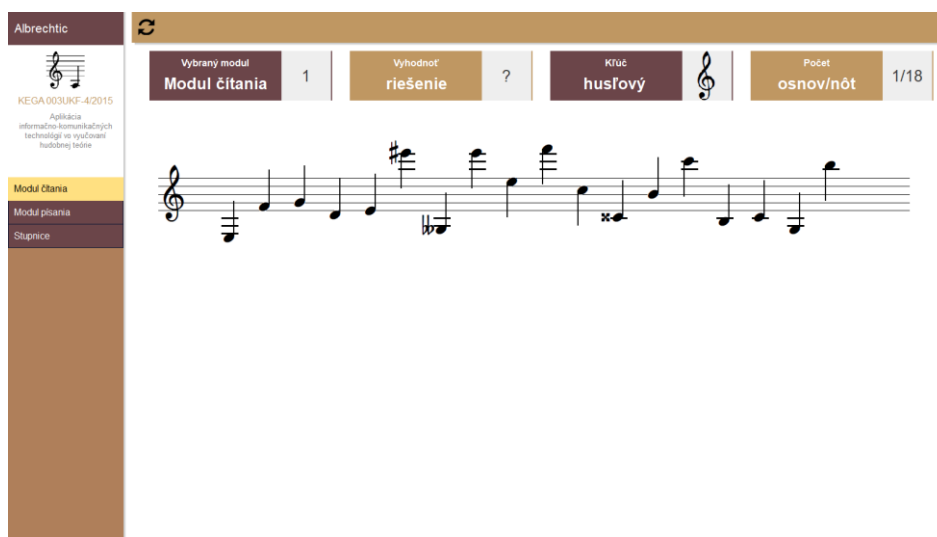


Figure 2: Albrechtic program environment

The function of the Albrechtic software

The software consists of a reader module and a writer module. Before choosing to read or write it is necessary to choose the key - violin, bass, alto and tenor. The music key is then displayed in the score bar at the beginning of the line.



Figure 3: Music key selection window

The second basic setting is the number of notes in one warp. By default, the number is set to 10, the user has the option to choose a different number.

Within the writing module, the user writes notes to the note outline by their names. The names of the notes are randomly selected from the built-in database of the Albrechtic software, and their number can be set by the user. The user's task is to assign the note location in the row to the generated name. After clicking on the appropriate place in the score sheet, a window with the option to place the note in the score sheet and the option of selecting the signature is displayed. Confirmation displays the note in the main note outline with the selected note. The user will verify the correct entry by pressing the Evaluate Solution button. Incorrectly written notes are displayed in red.

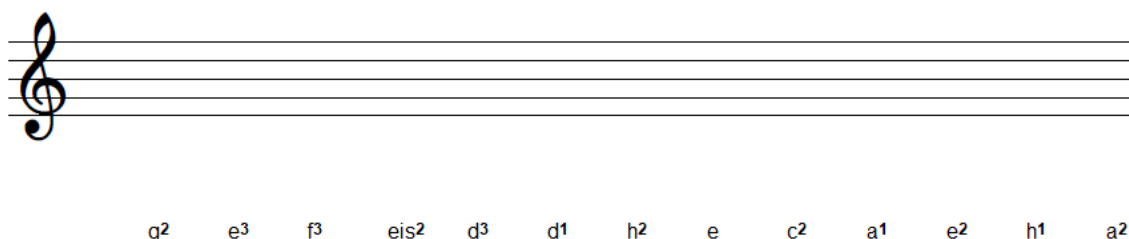


Figure 4: Display the note outline with the generated note names in the notation module



Figure 4: Window for writing a note by its name

The user has the option of selecting and testing using the reader module. In this case, the number of notes set by the user is randomly generated on the score sheet. The task is to name all the displayed notes. Clicking on the note displays a modal window with a list of note names, from which the user selects the name, chooses an octave, and also a dash. Confirmation will write the note name under the note. Verification of the correct naming of notes is possible in the same way as in the write module - by pressing the Evaluate Solution button.

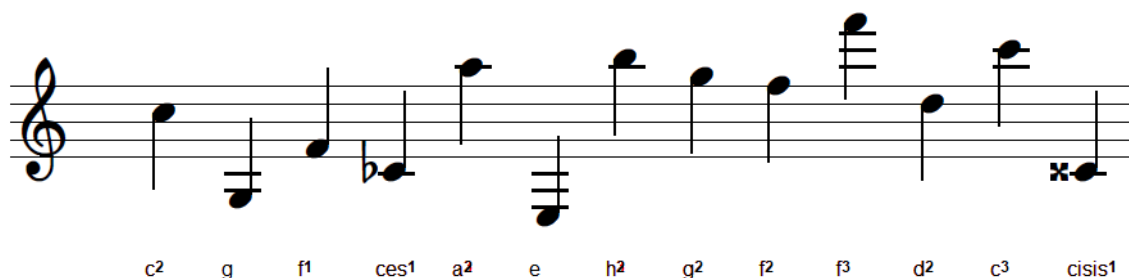


Figure 5: Name the notes in the reader module

Another function of the Albrechtic software is a module for practicing and testing scales. Running this section displays a modal window in which the user selects one or more types of scales to enroll. The Scale Selection window is shown in Figure 6. Albrechtic contains a large database of all scales that are categorized by their names. After selecting the scales, the scales of the selected types are generated in the row on the score sheet.

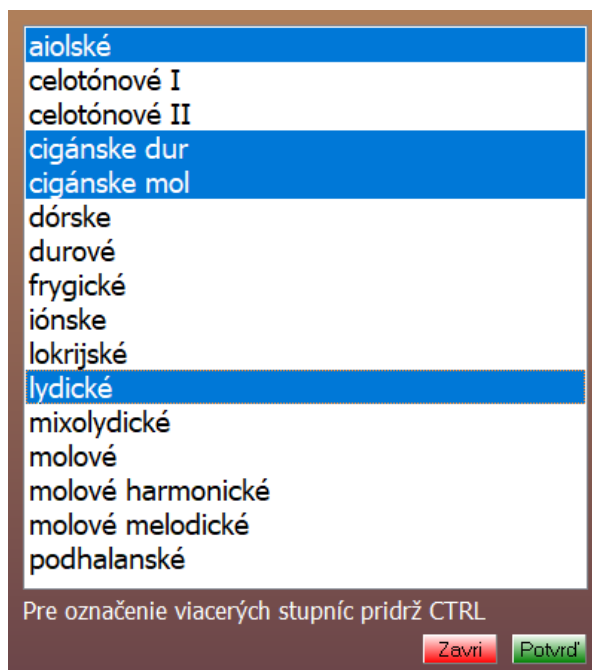


Figure 6: Scale type selection window

The user's task is to correctly determine the scale. To name the scale, the user is shown a window in which he selects the scale name, see Figure 7.

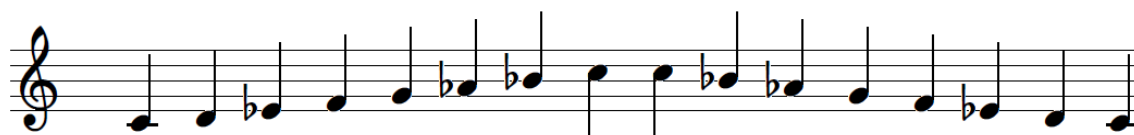


Figure 7: Display the generated scale

After confirming the scale name in the modal window, the software automatically evaluates the user's response and based on its previous responses the percentage response rate is evaluated. The percentage of success is displayed in the upper right corner of the main software window. If the answer is incorrect, the answer can be repeated several times.

The next randomly generated scale can be generated by pressing the corresponding button and it is also possible to return to the previous displayed scales.

Such a method is suitable for learning or practicing scales. We did not include the method of writing scales into the software, but in the future it is possible to program this method.

We are currently working on a scale testing module and on extending the Albrechtic software with an interval training module. The user will be able to practice writing intervals by name, as well as the practice of naming intervals. Of course there will also be testing with automatic evaluation of user responses. For this way of testing, Albrechtic must be complemented by an extensive database of intervals, which is several thousand. Therefore, we used teamwork to create the database and created a program to write intervals. The program is shown in Figure 8. Using it we can write intervals for all keys (violin, bass, tenor and alto). The database created in this way will then be used in the Albrechtic software, from which examples for learning and testing will be generated.

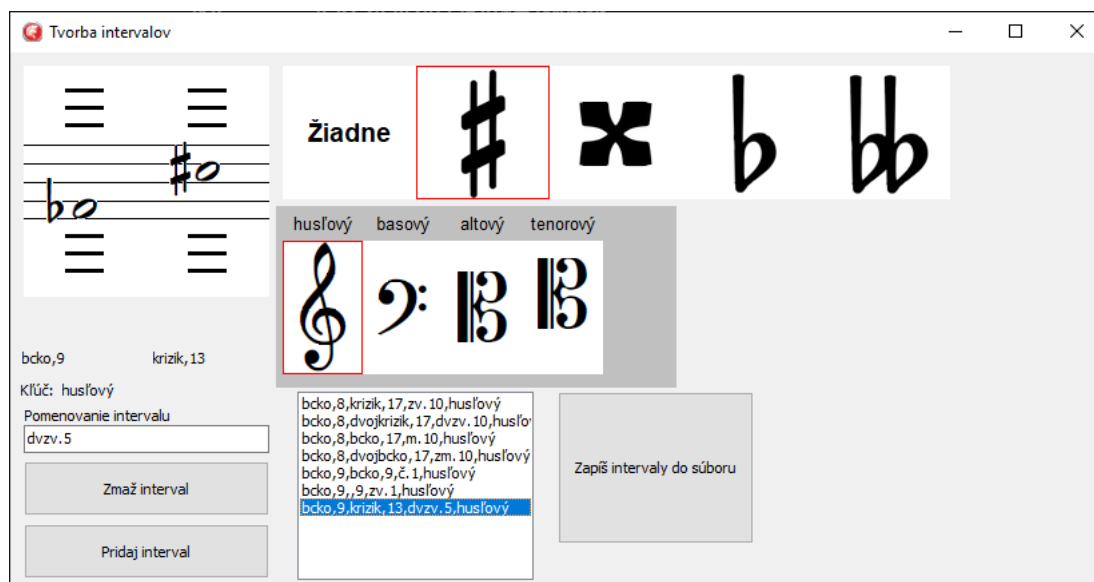


Figure 8: Interval database creation program

CONCLUSION

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. In the context of ICT in education, we cannot simply address the penetration of these technologies into current teaching methods. The purpose must be to change these methods in accordance with the requirements of the development of society and of scientific and technical progress. This requires the search for associations and the search for new ways of using knowledge from the issue in various fields (Balogh, Z., Turčáni, M.). At the beginning of the article we wrote that we can find several software or websites for teaching the theoretical foundations of music, which are didactically focused on teaching music theory. Although they can be well prepared in terms of content, they are not suitable for teaching in the Slovak language due to the linguistic diversity of terminology. The decision to create your own software to electronically support theoretical music instruction

is not just about language differences, but also about the features of the software we develop, which we can tailor to our needs. Even though we have not yet verified it, we know from our teaching practice what exactly we lack in teaching theoretical foundations and therefore we believe that Albrechtic software will be a good complement to teaching and learning music theory. It is a tool that we develop and adapt to our needs for more effective knowledge acquisition. By the end of this calendar year the software will be completed and we plan to test it in pedagogical practice.

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Assessment of Level of Teachers Work Competences with Selected Digital Tools in Intention of Their Own Educational Activity

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Abstract

Teachers, who actually work in school, will acquire didactic and methodological skills in the use of digital means within the scope of their pedagogical activities either through their own involvement or through programs and courses of continuing professional education. The goal of the paper is to present partial results of empirical investigation through which we mapped the current state and perspectives of teachers' professional development in the area of primary and secondary education in the frame of the regional education of the Slovak Republic. We focused our interest on developing of their didactic-technological competences. The mapping was based on the screening of teachers' opinions and attitudes according to the subcategory of the pedagogical employee. This classification is defined in the established legislative rules of the Slovak Republic (§ 20 Law No. 138/2019 Coll). We wanted to find out from a research sample of pedagogical staff what level of digital competences they have in using specified software applications/digital didactic tools usable within their own pedagogical activity through selected items of the questionnaire survey. The results of the observed survey items showed, that these current needs and requirements of teaching practice include, in particular, the acquisition of teachers' skills to effectively use the tools of ActivExpression2, ActiVote, QRF700 /900 and TurningPoint voting systems. These systems are devoted to usage in interactive educational activities and knowledge games oriented to verifying, testing and evaluating pupils' knowledge in the classroom with the goal of making the educational process more effective.

Keywords

Teacher educator. Regional schooling. Professional development. Digital technologies. Didactical and technological competences. Undergraduate preparing of teachers.

INTRODUCTION

Didactic-technological competences are an integral part of the professional profile of the teacher, independently from the educational discipline taught by the teacher. In

general, these competences can be defined as the skills and competences of teachers to use digital didactic resources in the teaching process of their educational discipline (Krumsvik, 2014). It is clear, that the content of these competences depends on time, and in the past progressed only slowly. But it is changing very quickly at present under the influence of the rapid development of modern digital technologies (Sølvberg, Rismark, Haaland, 2009). The didactic-technological competences of a teacher can be defined with respect to the latest digital technologies, as his/her professional skills in the field of digital literacy in order to use digital teaching tools and their applications in real education of the subject taught by the teacher (Gunčaga, Žilková, 2019).

The question is how to design an optimal model of training of future teachers of regional education in the area of didactic and technological competences, which concrete tools and which aspects of their usage should be underlined in the teaching process. So, finding answers to these questions became to be the subject of our research. The main goal of this research is to support modernization and optimization of undergraduate training of prospective teachers at the Faculty of Education of the Comenius University in Bratislava in the area of creating their professional didactic-technological competences, which are necessary for successful effective performance of their future teaching profession. It means to innovate relevant areas of selected study programs not only from the content point of view, but also from the aspect of time allocation of included relevant educational disciplines in the educational portfolio.

RESEARCH SAMPLE AND METHODS

We mapped, in the sense of the above-mentioned main intentions, in the first phase of our research focused on innovation of teacher education curricula in the relevant area, the current state and perspectives of teachers' professional development in the area of primary and secondary education of regional schooling of the Slovak Republic (SR) oriented to development of their didactic-technological competences. The mapping was based on screening teachers' opinions and attitudes. We prepared for the screening purposes of the teachers sample a questionnaire containing 41 items divided into four interviewed areas named as *area A* to *area D*, of which 30 items were ordinal (C1 to C13; D1 to D17) and 11 nominal (A1 to A4; B1 to B7).

A detailed description of the research sample of teaching staff, based on data processing from factual items of *area A* of the administered questionnaire, is given in the Table 1.

The created research tool was distributed from January to April 2019 among 210 pedagogical employees of primary and secondary schools. The research sample consisted of teaching staff who carry out their pedagogical practice in the three regions of the Slovak Republic, namely regions of Nitra, Trnava and Bratislava. In total, 173 members of teaching staff completed the questionnaire. The return rate of the questionnaire was 83.3 %. This fact can also indicate actuality and benefits of the solved topic of research.

We will focus, due to the limited scope of the paper, on statistical analysis and interpretation of the results of respondents' answers to items D1 to D17 of the questioned *area D* depending on the level of the factor SUBCATEGORY of teaching staff. This category is defined by § 20 of the Law No. 138/2019 Coll. Especially, the following groups of teaching

staff are concerned in our analysis: item A4: A4a – *teacher at the primary level*, A4b – *teacher at the lower secondary level*, A4c – *teacher at the upper secondary level*.

Table 1: Structure of research sample of respondents.

Factor (item)	Group	Absolute frequency	Relative frequency
gender (A1)	man	15	8.67 %
	woman	158	91.33 %
length of teaching practice (A2)	beginning teaching staff: teaching practice up to 5 years (included)	46	26.59 %
	experienced teaching staff: teaching practice 5 – 20 years (included)	87	50.29 %
	erudite pedagogical staff: teaching practice more than 20 years	40	23.12 %
category of teaching staff (A3)	teacher	173	100.00 %
	educator	0	0.00 %
subcategory of teaching staff (A4)	teacher at the primary level (ISCED1)	85	43.59 %
	teacher at the lower secondary level (ISCED2)	69	44.23 %
	teacher at the upper secondary level (ISCED3)	19	12.18 %

Note. § 20 Law No. 138/2019 Coll

RESULTS AND MAIN FINDINGS OF THE RESEARCH

Teaching staff of primary and secondary schools of regional schooling of the Slovak Republic was asked in the *part D* of the questionnaire, to assess what level of digital competences they have in using specified software applications and digital didactic tools within intention of their own pedagogical activity.

Respondents from our questionnaire survey expressed their evaluations on individual ordinal items (D1 to D17) on a four-stage scale, i.e. scoring from 1 to 4. Higher level of disagreement with the submitted statement is marked with lower value (*I have insufficient knowledge and skills*), complete disagreement is marked with level 1 (*I have insufficient knowledge and skills*). Higher level of agreement (*I have more sufficient knowledge and skills*) to the submitted statement is marked with a higher value, full agreement (*I have fully sufficient knowledge and skills*) is marked with level 4. We didn't include deliberately the choice of indifferent assessment attitude to items D1 to D17 of the questionnaire (although we are aware that this is not fully correct from methodological point of view). The reason was, that we wanted to obtain from the respondents from our questionnaire survey exactly defined opinions on our questioned issue. For this reason, it is compulsory for the respondent to take a position and not rely on the fact that he has not yet formed an opinion on the issue. We add in addition to the four options for answering these questions, also the type of answer „*In my opinion, it is not necessary for the performance of my profession*“. We speak here about the choice of a strong attitude where the respondent is convinced of his/her opinion that he/she needn't the knowledge and skills of working with the given software application, respectively digital didactic technique for the performance of his/her teaching profession.

The selected software applications that have been assessed from the teachers' (our respondents') perspective – items in the question *area D* – are listed in the Table 2.

Table 2: An overview of digital didactic tools in relation to evaluation of the knowledge and skills applicable in the context of the teacher's own pedagogical activity.

Questionnaire item	Digital didactic tools
D1	<i>ActivInspire – creating of interactive teaching materials</i>
D2	<i>Flow!Works – creating of interactive teaching materials</i>
D3	<i>SMART Notebook – creating of interactive teaching materials</i>
D4	<i>Prezi – creating of dynamic presentations</i>
D5	<i>Mindomo – creating of mind maps</i>
D6	<i>FreeMind – creating of mind maps</i>
D7	<i>ActivExpression2 – voting system</i>
D8	<i>ActiVote – voting system</i>
D9	<i>QRF700/900 – voting system</i>
D10	<i>TurningPoint – voting system</i>
D11	<i>Socrative 2.0 – creating of online tests and voting</i>
D12	<i>Alf – creating of interactive tests</i>
D13	<i>Google Documents – collaborative creating through sharing of online documents</i>
D14	<i>LEGO – educational sets</i>
D15	<i>Microsoft PowerPoint – creating of didactical presentations with educational content</i>
D16	<i>Microsoft Word – usage of tools of advanced word processing</i>
D17	<i>Microsoft Excel – usage of tools of advanced data processing</i>

Analysis of the dependence of teachers' self-evaluation on the factor SUBCATEGORY of teaching staff

We verified the following null statistical hypothesis in the statistical processing of our results, which represents de facto 17 partial null hypotheses:

H_0 : The answers of respondents to item D_i are not depended from the level of the factor SUBCATEGORY of teaching staff ($i = 1, 2, \dots, 17$)

We tested the null hypotheses at the 5 % significance level. In the case of partial null hypotheses, "independence from given factor" was tested using both procedures - parametric and non-parametric (Munk, Drlík, Benko, Reichel, 2017).

Based on the results of the analysis of the simple sorting variation as well as its non-parametric alternative, which is the Kruskal-Wallis test, the null hypotheses for the following variables are not rejected: D1, D3, D4, D7 to D14, D16 and D17, i.e. observed parameters are not depended from the factor SUBCATEGORY of teaching staff.

We obtain in the case of items from D1 to D17 the statistical dependence from the observed factor SUBCATEGORY of teaching staff only in the four cases, concretely by items D2 (*Flow!Works – creating of interactive teaching materials*), D5 (*Mindomo – creating of mind maps*), D6 (*FreeMind – creating of mind maps*) and D15 (*Microsoft PowerPoint – creating of didactical presentations with educational content*). We focus in the following part of our paper only on the final findings of the dependence of respondents' answers in the mentioned four items, accompanied by tables of multiple comparisons of differences in

the evaluation of these items between groups according to the level of the factor SUBCATEGORY of teaching staff and their graphical visualisations through boxplots.

We reject the null statistical hypothesis ($p < 0.05$) on the base of results of Kruskal-Wallis test in the case of following items: D2: $H(2, N = 173) = 6.698562, p = 0.0351$; D5: $H(2, N = 173) = 8.693615, p = 0.0129$; D6: $H(2, N = 173) = 8.961734, p = 0.0113$; D15: $H(2, N = 173) = 6.406162, p = 0.0406$. This hypothesis states, that the difference in rating of the questionnaire items D2, D5, D6 and D15 between groups of teachers is not statistically significant, i.e. the dependence parameters D2, D5, D6 and D15 are depended from the factor SUBCATEGORY of teaching staff.

We were interested after the rejection of the hypotheses H_0 for items D2, D5, D6 and D15:

H_0 : The answers of respondents to items D2, D5, D6, D15 are not depended from the level of the factor SUBCATEGORY of teaching staff,

which subcategories of teaching staff have statistically significant differences in the rating of items D2, D5, D6 and D15. The results of multiple comparison are given in the Table 3.

Table 3: Multiple comparison for items D2, D5, D6 and D15 in the dependence from the factor SUBCATEGORY of teaching staff.

Item D2				Item D5			
Rating of the factor	A4a	A4b	A4c	Rating of the factor	A4a	A4b	A4c
A4a		0.043721	1.000000	A4a		0.119763	0.584702
A4b	0.043721		0.596108	A4b	0.119763		0.031892
A4c	1.000000	0.596108		A4c	0.584702	0.031892	
Item D6				Item D15			
Rating of the factor	A4a	A4b	A4c	Rating of the factor	A4a	A4b	A4c
A4a		0.021931	1.000000	A4a		1.000000	0.046628
A4b	0.021931		0.156387	A4b	1.000000		0.131432
A4c	1.000000	0.156387		A4c	0.046628	0.131432	

We see from the Table 3, that there are exist statistically significant differences ($p < 0.05$) in the case of item D2 between the first group of teaching staff – *teacher at primary level* (A4a) and second group of teaching staff – *teacher at lower secondary level* (A4b). There are exist statistically significant differences ($p < 0.05$) in the case of item D5 between second group of teaching staff – *teacher at lower secondary level* (A4b) and third group of teaching staff – *teacher at upper secondary level* (A4c). We see also from the Table 3, that there are statistically significant differences ($p < 0.05$) in the case of item D6 between the first group of teaching staff – *teacher at primary level* (A4a) and second group of teaching staff – *teacher at lower secondary level* (A4b). There are statistically significant differences ($p < 0.05$) in the case of item D15 between the first group of teaching staff – *teacher at primary level* (A4a) and third group of teaching staff – *teacher at upper secondary level* (A4c).

The results of multiple comparison for items D2, D5, D6 and D15 in the dependence from the factor SUBCATEGORY of teaching staff are visualized via boxplots (Figures 1, 2, 3 and 4). These boxplots show median, quartile and variation range of rates by every item.

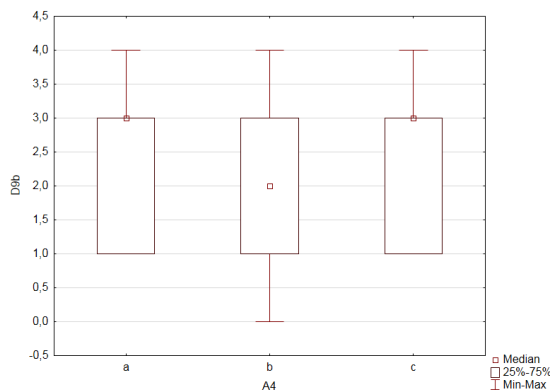


Figure 1: Visualization of answers to item D2.

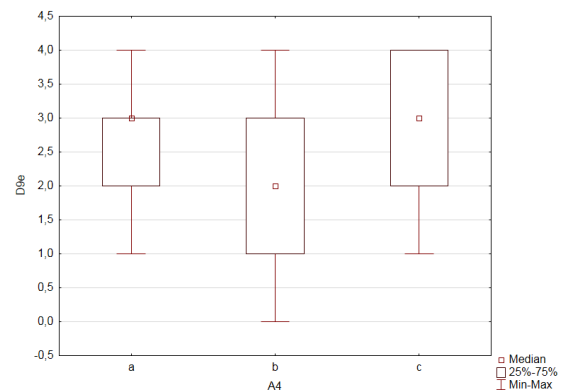


Figure 2: Visualization of answers to item D5.

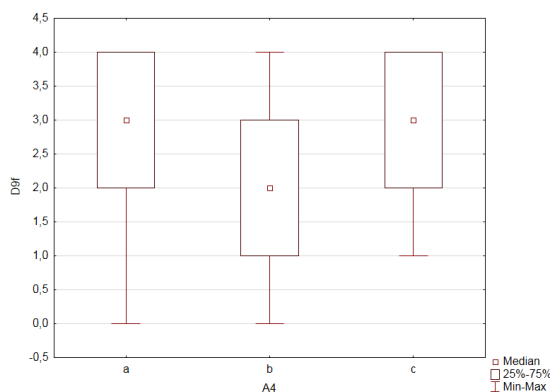


Figure 3: Visualization of answers to item D6.

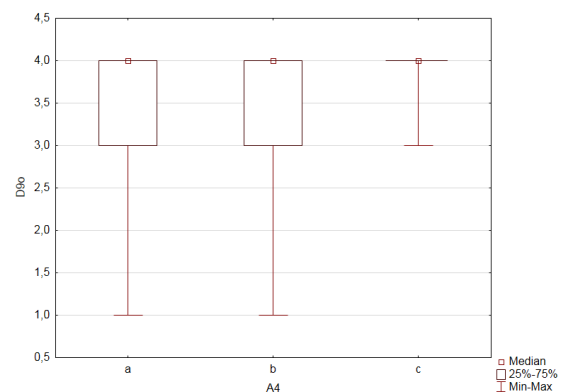


Figure 4: Visualization of answers to item D15.

Remarks to Figures 1, 2, 3 and 4: A4a – *teacher at primary level*; A4b – *teacher at lower secondary level*; A4c – *teacher at upper secondary level*.

We obtain on the base of Figures 1, 2, 3 and 4 the result, that the answers in the item D15 (*Microsoft PowerPoint – creating of didactical presentations with educational content*) by the group of teachers at *upper secondary level* (A4c) have the smallest quartile range (the value of quartile range 0). That means, the biggest homogeneity of answers from the side

of groups of teachers was by the mentioned teacher group and item (A4c and D15). It holds also in the case, that we make comparison of teachers' answers to every four mentioned items (D2: Figure 1; D5: Figure 2; D6: Figure 3; D15: Figure 4).

DISCUSSION

We wanted to find out through the item D2 in the frame of the field D of our research survey in the sample of teachers, how they evaluate their digital competences in the usage of tools of the authoring software environment *Flow!Works* of the interactive whiteboard QOMO designed for the creation of electronic educational activities, interactive tasks and knowledge games usable in the context of their own teaching activities. Our assumption that teachers have positive meaning about the statement made in this item, has not been fully confirmed. 50 % of ratings in every three groups of teachers, i.e. *teachers at primary level (A4a)*, *teachers at lower secondary level (A4b)* and *teachers at upper secondary level (A4c)* ranges from a scale of 3 (*I have more sufficient knowledge and skills for work*) to 1 (*I have insufficient knowledge and skills for work*) from a maximum of 4 (*I have fully sufficient knowledge and skills for work*).

We can formulate a statement, that the creating and usage of the tools of developmental software environment *Flow!Works* of the interactive whiteboard QOMO is not preferred by teaching staff of regional schooling (Brečka, Valentová, Hašková, 2019). This tendency has a root, that development of this software is stopped by producer. On the other hand, the diapason of tools supported by the *Flow!Works* authoring environment is much bigger than developmental environments *ActivInspire* and *SMART Notebook* (Erbas, Ince, Kaya, 2015). If we start from this fact, than we see, that the teachers at schools and school facilities more prefer enhancement of their digital skills with the ability to efficiently use *ActivInspire's* authoring development tools for the interactive whiteboard *ActivBoard* and *SMART Notebook* for the interactive whiteboard *SMART Board*, than the usage of the tools of software environment *Flow!Works*. This current tendency is also reflected in the content concept of updating and innovative educational programs devoted to the professional development of teaching and professional staff of regional schooling of the Slovak Republic (§ 40 Law No. 138/2019 Coll).

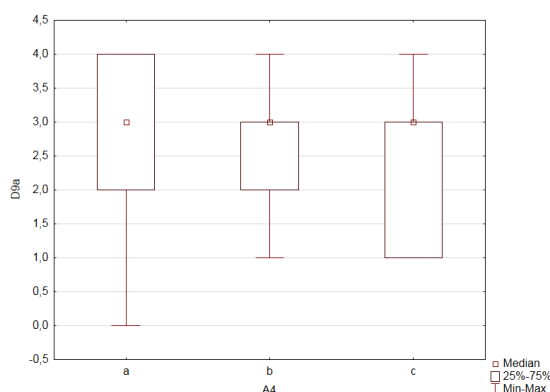


Figure 5: Visualization of answers to item D1.

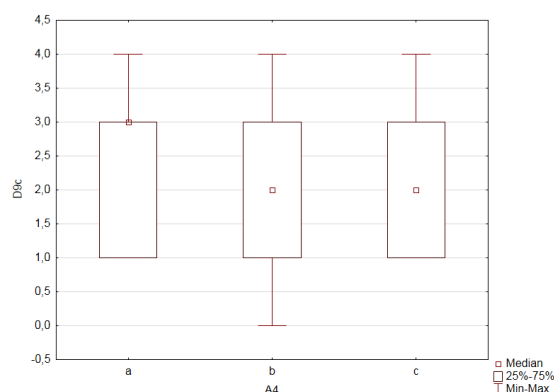


Figure 6: Visualization of answers to item D3.

Figures 5 and 6 support the tendency of strengthening didactic-technological competences of teaching staff in the field of complex interactive solutions *ActivInspire*

(ActivBoard; ActivExpression2) and *SMART Notebook* (SMART Board; SMART Response2) usable in educational situations via creating their own interactive educational activities and presentations of educational content attractive to the target group of educators-teachers of mentioned levels. Figures 5 and 6 also illustrate a graphical visualization of assessment differences between D1 (*assessing the level of digital competences of teachers focused on creating electronic education activities, interactive tasks and knowledge games in the ActivInspire environment*; Figure 5) and D3 (*assessing the level of digital competences of teachers focused on creating electronic education activities, interactive tasks and knowledge games in the SMART Notebook environment* (Figure 6) and item D2 (Figure 1) from the perspective of the *primary school teacher group* (A4a) and the *lower secondary school teacher group* (A4b).

We asked through the fifth item (D5) and sixth item (D6) of our questionnaire interviewed teachers, how they rate *the level of their digital competences in creating mind maps* useful for educational activities with pupils, including pupils with special educational needs through computer/tablet *applications Mindomo* (item D5) and *FreeMind* (item D6). The statements of individual groups of respondents recorded in these questionnaire items were almost identical. We obtain the value of median responses on the tested questionnaire variable D5 and D6 – *I have sufficient knowledge and skills* (median of scale 3) – in the *primary school teacher group* (A4a) and in the *upper secondary school teacher group* (A4c). For this reason, we can say that teachers of mentioned groups have relatively sufficient competences to create interactive thought maps. The question remains, if the answers of respondents declared by the above-mentioned groups of teachers in the *Mindomo* and *FreeMind* environments, bring also actually usage of these environments in the design and creation of illustrative mind maps in order to increase teaching efficiency and to support creative learning by pupils and students, for example in the context of developing key competences – mathematical, linguistic, literary.

The high potential of conceptual maps according Schubert and Bednárová (2018) is, that they help pupils to order and to organize facts and notions. They increase also the amount of memorized knowledge. Therefore, it is necessary to conduct teaching in an attractive way, using new innovative teaching methods, which undoubtedly include conceptual maps. We would like to argue that the use of innovative teaching methods in lower secondary and upper secondary schools (ISCED2, ISCED3) in the form of conceptual maps with integrated audio-visual elements and a high degree of interactivity could ultimately have a positive impact on pupils' and students' attitudes towards subjects generally belong to the so-called less or less popular (Záhorec, Hašková, Bílek, 2014). We see the benefits of conceptual and mind maps in school education at primary school (ISCED 1) with the possibility of interactive intervention not only in improving pupils' perception and pupils' remembering of educational content, but also in the active and creative approach of pupils to the course during the education. The process of creating and processing a conceptual and mind map in collaboration with the teacher at the lesson is very beneficial when pupils are aware the individual relationships and connections between various concepts. Teachers/pupils can repeatedly return to mind and conceptual maps, to use them, for example, in creative writing, or as a syllabus of knowledge on the done subject.

Teachers were asked in the fifteenth item (D15) in the *question area D*, how they assess *the level of their digital competences in creating didactic presentations of educational*

content with the application of feedback and multimedia objects supporting teacher's lecturing in the teaching process and systematizing pupils' knowledge through software applications *Microsoft PowerPoint*. It is evident from the graphical processing of the obtained results (Figure 4) that in all three surveyed teachers' groups (A4a, A4b, A4c), the median of responses presents teachers' statement of their *sufficient knowledge and skills in the work with environment of application Microsoft PowerPoint* (median of the scale 4). The teachers expressed in their evaluation a clear positive opinion on the issue formulated in this item.

It is generally known that creating/using presentations as a didactic tool for supporting school teaching in the environment of application *Microsoft PowerPoint* is quite popular among teachers at all levels of education (Urbanová, 2012; Schubertová, Bednárová, 2018). We believe that in the context of developing presentation skills, primary, lower and upper secondary school teachers should to give more space for knowing and using of new presentation software tools such as *Prezi* or *Microsoft Sway* and also internet online alternatives to the standard (offline) application *Microsoft PowerPoint*. The usage of presentation content by teachers in school practice, processed through the increasingly popular presentation platform *Prezi*, also provides scope for applying innovative methods in their teaching activities at schools and school facilities. The online tool *Sway* as the part of the Office 365 similar than *Prezi*, also builds on an innovative way to create interactive documents and presentations. We are therefore convinced that it makes sense to give attention to creating of these presentations by teaching staff and to the aspect, how this creation can be implemented in the field of regional schooling. We agree with the statement Fuchsova and Korenova (2019), that in the near future it will be similar important to have the ability to create a graphical representation of ideas as to write a coherent text.

CONCLUSIONS

The partial results of realized research survey show some needs and requirements of teaching practice for the design of proposal for the curriculum of the optimal model of undergraduate teacher training in the area of creating their professional didactic-technological competences necessary for successful effective performance of their future teaching profession (Hejný, 2006). Of course, the undergraduate teacher training at the Faculty of Education of the Comenius University in Bratislava should respond to these needs, i.e. the faculty education should innovate relevant areas of selected study programs with respect to aspects of content and time allocation by including relevant educational disciplines in the educational portfolio (Záhorec et al., 2020).

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Section:
**Learning/Teaching Methodologies, Assessment and
Learning Environments**

Computer Literacy of Primary School Learners Reflecting the Teacher's Adoption of Innovation

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Abstract

The paper deals with the problem of developing computer literacy in primary school learners. It particularly focuses on teachers' contribution to acquiring learners' ICT knowledge reflecting the their adoption of innovations in this field. Rogers' Diffusion of Innovation Theory is applied on intentionally selected sample of Czech primary school teachers (N=167) and computer competency of learners (N=173). Applying the tool by Kankaanrinta based on the Rogers' theory, teachers were structured into five groups (Innovators, Early adopters, Early majority, Late majority, Laggards). Consequently, the increase in knowledge of learners was considered in each type of adopter. Didactic pretest and posttest consisted of 18 tasks; five of them were analyzed in this paper. For the purpose of testing, an environment was designed to avoid any impact on the results, and a Dell Latitude notebook was set as a hardware platform. The software part was based on the open source software exploiting Xubuntu 15.10 operational system developed on Ubuntu/Linux basis. The findings proved learners' results depended on the type of adoption of innovations in their teachers.

Keywords

Computer literacy, computer literacy, primary school, Roger s' diffusion of innovation theory.

INTRODUCTION

Latest information and communication technologies (ICT) are considered potential means enhancing changes and innovations. However, various factors are impacting the process of implementation the technologies into education/instruction, starting from teachers' feedback on their exploitation to learners' skills in real use of them. There implementation itself results in changes in teachers' role and functions, their work content, which shifts from the role of information provider to qualitatively new levels. In such a situation, computer literacy, particularly teachers' basic ICT skills in mediating the learning content to learners, is the core precondition of efficient process of ICT implementation.

These days, we have been living in the information society, making efforts towards reflecting fast development of ICT. The i-sociate theoreticians forecast progressive automation of mental work and development of new forms of knowledge and new socioeconomic systems (Petrusek, 2006). The current knowledge has been produced and disseminated via strong ICT support. Expectations connected with the ICT implementation to the process of education/instruction are considerable. Therefore, the main objective of

the paper is to investigate whether learners' ICT skills depend on teachers' attitudes to innovations, particularly the ICT implementation in the process of instruction at primary school level.

Computer literacy and diffusion of innovation theory

Computer literacy has been defined in various ways and by numerous authors. Within the Czech education system, the definition set by Průcha is widely exploited, which states computer literacy as "a set of knowledge and abilities and limits of computers, computer networks, and frequently used computer equipment, a set of skills how to define a task and solve it with computer and Internet support, a set of habits necessary for work with computer and the Internet, a set of positive attitudes, values and expectations relating to computer and the Internet." (Průcha et al., 2013, p. 292; translated by author). In nonCzech sources, the terms of computer literacy, digital literacy, ICT literacy, digital competency, digital skills, information literacy, e-literacy, e-skills appear (Průcha et al., 2013, p. 292). On the other side, in Australia, definition clearly discovers that computer literacy includes three closely interconnected elements: work with information, sharing it and the exploitation of ICT (NAP, 2015). Despite new technologies are all-round us and respondents of various age-group have been researched, attention should be paid to the youngest ones, i.e. the primary school learners. This age is considered to be crucial for the process of acquiring new information, even though, these days, they are defined as digital natives (Prensky, 2001) who are expected to be born with computer literacy skills. We definitely agree that "the role of school should not be decreased in the time of artificial intelligence" (Kartous, 2017, p. 1). The ICTs as an unnecessary part of the instruction (Zounek, Sebera, 2005) provide strong support to teachers who, then, can become innovation leaders, both within the face-to-face instruction in the classroom and after the lessons (Schleicher, 2015).

Problems relating to dissemination, resp. diffusion of innovations, were the topic of numerous empirical studies. However, it was Everett M. Rogers who published Diffusion of Innovations Theory in 1962 (Zounek, Sebera, 2005). He mentions that "members of a certain social system do not acquire innovations at the same moment" (Zounek, Sebera, 2005, p. 98; translated by author). The adopters can be classified on the moment, when the innovation was applied for the first time, as Innovators, Early adopters, Early majority, Late majority and Laggards (Rogers, 1995).

Innovators are eager individuals who like trying new things while dispoing considerable financial sources to bear costs of their cosmopolitan lifestyle. These sources then cover potential losses from of unsuccessful innovation adoptions. The innovators are able to accept a rather high uncertainty rate with innovations; and although they are often not understood by other members of the social system, they open doors to the process of penetration of innovations.

Early adopters are the most probable leaders who are often questioned by other members of the social system about innovations and new ideas, as they are – compared to the innovators – much more integrated in the structures of the social system.

Early majority forms an important piece of diffusion chain, together with Early adopters playing the role of mediator of the uncertainty rate in the process of diffusing innovations in the social system, the members often play the role of leaders but the time period of innovation decision-making process is much longer in comparison to the innovators and Early adopters.

Late majority includes sceptics applying innovations from the reason of economic necessity and social pressure of the environment, if the innovation is not against directions and rules of their social system. Until this is not clear, they do not invest any sources.

Laggards are characterized as traditionalists preferring non-innovative solutions and values. If finally they acquire an innovation, it mostly happens in the time, when it is step-by-step replaced by another, new idea (Rogers, 2003).

As summarized by Rogers, in each category, single members express similar level of innovativeness (Rogers, 2003). Compared to this, Braak describes the innovativeness as a relatively stable, socially-built and innovation-related characteristics which signalizes the individual's good will to change practices (Braak, 2001). Thus the innovativeness is the key to understanding the required and substantial behaviour within the innovative decision-making process (Sahin, 2006), which is the cornerstone of classification (Sahin, 2006).

METHODS

Characteristics of single groups of innovation adopters were worked out by Kankaanrinta, who states that Innovators and Early adopters efficiently use hardware and software including global and local networks, Early majority successfully fights with new technologies, Late majority members depend on others' help and Laggards have no idea of what the problems are (Černochová, Siňor, Kankaanrinta, 2001).

Research problem, question, objective

Therefore, the dependency between the teacher's type of innovation adoption and learners' outcomes (i.e. increase in didactic test scores) was investigated. As teachers' contribution to the process of acquiring new knowledge is indisputable, the question appears whether (except of others) the level of learners' knowledge depends on the way how (when) their teachers adopt innovations. In other words, do learners taught by teachers-innovators reach identical knowledge and skills in computer literacy as those taught by Early adopters, Early majority, Late majority, or Laggards? Reflecting the above mentioned, the *main objective* of this research was to discover the impact of teacher's type of innovation adoption on learners' results.

Research hypotheses

The main research hypothesis was set as follows:

H1₀: The level of ICT competency in the primary school learners does not depend on the type of adoption of innovations in their teachers.

H1_A: The level of ICT competency in the primary school learners differs according to the type of adoption of innovations in their teachers.

Process of research

First, types of adoption innovations by the teachers were detected by Kankaanrinta Inventory (Kankaanrinta, 2000). It consists of 55 statements structured into three areas. Part 1 includes five sets of five statements; respondents express their dis/agreement on the scale from 5 – 1, where 5 means the highest level of agreement. Part 2 consists of 18 statements in which teachers' opinions on ICT in primary education is reflected. Each answer is scored

on six-level scale: 5 – I agree, 4 – I rather agree, 3 – I do not know, 2 – I rather disagree, 1 – I disagree and N – I do not know. Part 3 comprises of 12 statements which monitor teachers' attitudes towards ICT applications at the primary education level. Identically to Part 2, six-level scale is applied to each statement.

Second, the increase in learners' computer literacy was investigated via applying didactic pretest and posttest, each including 18 tasks, to test learners' knowledge and practical skills. Reflecting the primary learners' age, five tasks in Painting application which aimed at monitoring their computer competency were under the focus in this paper. The application is appropriate to learners' age and at the same time it diminishes dysdisorders (dyslexia, dyscalculia etc. which could provide impact on work with text editor. Within this research, computer competency at the primary school level was tested by following tasks set in learners' mother tongue: (1) Create MY FOLDER in DOCUMENTS and name it by your surname; (2) Start the graphic editor; (3) Draw a simple image of a house with garden, fence, and a tree; (4) Save the image to MY FOLDER on the screen; (5) Close the Painting application.

Third, the testing was conducted in an environment which was designed especially for the purpose of this research, i.e. to avoid previous knowledge and skills in work with computers which might make impact on research results, and a Dell Latitude notebook was set as hardware platform. The whole software part was based on the open source software exploiting Xubuntu 15.10 operation system developed on Ubuntu and GNU/Linux basis (Xubuntu, 2017). The graphic user interface of graphic environment Xfce was adjusted in such a way it did not include any graphic elements reminding of any concrete applications or operation systems. The design of single elements in the graphic interface met conventions and limits of current operation systems. In the bottom part, the toolbar with the key 'Start' to open the menu is situated; icons and names of running applications are displayed there. In the right part of toolbar, the 'notification area' is situated; icons informing about the charging of the battery, computer network, date and time are displayed there. Clicking on the date, Calendar is displayed, as well as icons of single applications and folders.

After switching on the Start key, the process of recording all user's activities begins automatically, and saves the recording in the video-file. The programme runs on the background and does not indicate its activity in any way. Thus the user is not disturbed by any other graphic elements. If required, the testee (teacher) can provide support to the tested person (learner). It is recorded in the protocol, whether the learner worked independently or was supported, and in what way.

Research sample of teachers

The research sample included 181 teachers. According to ČSU [Czech Statistical Office], in the Usti nad Labem region 2,432 the primary school teachers were registered. If calculating the size of research sample, following values are applied: tolerance to mistakes 5 %; trustworthiness level 90 %; answer distribution to five-level scale. Minimum recommended amount of research sample is 162 respondents (Raosoft, 2017).

In our sample 175 female (96.7 %) and 6 male (3.3 %) teachers were included.

Comparing to the ČSU data for 2015/2016 school year in this region, where 96.99 % of female teachers were registered, the research sample can be considered representative.

From the view of qualification, 169 respondents were fully qualified (93.4 %) and 12 were not (6.3 %). When the type of educational institution is considered, 11 teachers (6.1 %) worked at schools with multi-grade classes, 150 teachers taught at the urban type school (82.9 %), 8 ones at sub-urban (4.4 %) and 12 ones at rural schools (6.6 %).

Research sample of learners

The selected research sample was of intentional type. This approach reflected the fact that the main objective of the research was to monitor the state in a particular region (Northern Bohemia), which has high unemployment rate and other socio-economic problems. Therefore, the skill of computer literacy from the early age is highly required in such a district. The research sample consisted of 173 primary school learners of 3rd and 4th grades (N=173); 89 girls (51.4 %) and 84 boys (48.6 %), from urban, sub-urban and rural schools. The reason for selecting the third- and fourth-graders was they did not learn the subject of Informatics before testing. According to the Framework Educational Programme for Basic Education (FEP BE), the subject is taught in the fifth grade.

RESULTS

Normality of data distribution was tested by Shapiro-Wilk test against the null hypothesis on the probability level $p=0.05$. Consequently, appropriate parametric and nonparametric methods of statistic analysis were applied.

Types of Innovation Adopters

As presented in Table 1, differences were detected in relative occurrences in researchers conducted by Kankaarinta, Rogers, Zounek compared to our research (right column in bold).

Table 1: Comparison of relative occurrences in selected researches within Rogers' categories.

Category	Kankaarinta	Rogers	Zounek	Our research results
Innovator	3.0 %	2.5 %	10.0 %	15.5 %
Early adopter	13.0 %	13.5 %	3.0 %	10.2 %
Early majority	34.0 %	34.0 %	66.0 %	56.3 %
Late majority	34.0 %	34.0 %	20.0 %	12.6 %
Laggard	16.0 %	16.0 %	1.0 %	5.4 %

In the group of Innovators, the high increase in relative occurrence was discovered by Zounek compared to Kankaarinta and Rogers, and even higher values were detected in our research. This may be caused by the specification of the group, when teachers are "forced" by learners to pay attention to new trends. In the Early adopter group, our results are closer to Rogers' and Kankaarinta's values; the specific features of teachers' group might be the cause in this case as well. Zounek detected much lower occurrence. On the other side, Early majority group by Zounek is 10 % above the value of our research; however, Rogers' and Kankaarinta's works present half-occurrence. Late majority group in our research reached one third occurrence compared to Rogers and Kankaarinta, which also can be the reflection of specific features of teachers' community. In the Laggard group, higher occurrence was detected in our research compared to Zounek; the reason might be that whereas his respondents were university students, we focused on teachers of all age groups,

including those who were not exposed to ICT in education within their studies. Compared to this fact, relative occurrence was lower in our research compared to Rogers and Kankaanrinta.

Reflecting these findings, the first research question dealing with the structure of primary school teachers from the view of Rogers' diffusion of innovation theory can be answered. In our research, in comparison to Rogers' and Zounek's respondents, the increase in amount of Innovators was detected, reaching the maximum in Early majority. We understand this trend as a result of (1) pre-service teacher preparation which opens gates to the field of ICT, (2) systematic teacher education in the field of ICT, (3) "the necessity" of work with ICT as interactive boards, and last but not least – learners' interest in the field of ICT.

Learners' test scores

Normality of data distribution was tested by Shapiro-Wilk test against the null hypothesis on the probability level $p=0.05$. Consequently, appropriate parametric and nonparametric methods of statistic analysis are applied. Reflecting the fact that normal distribution of all data was proved ($p>0.05$) in all fields, parametric statistic methods were applied. However, the p -level closely relates to the sample size (Levine, 2002); therefore, $p=0.05$ was selected for further processing.

Pretest results

The collected data were processed by Statistica software. As the pretest scores are of ordinal type, the non-parametric Kruskal-Wallis test was applied. The null hypothesis is based on identical medians of pretest scores. Results are displayed in Table 2.

Table 2: Pretest scores – p -levels of single tasks.

Task	1	2	3	4	5
p -level	0.02	0.71	0.054	0.03	0.057

The results show that the null hypothesis was rejected in tasks 1 and task 4 ($p<0.05$). It means that in these tasks the statistically significant difference was detected in test scores of learners of different types of innovation adopters. These cases underwent post hoc analysis of multiple comparison. However, we did not expect differences in pretest scores. The post hoc analysis results for tasks 1 and task 4 are displayed in Table 3.

Table 3: Post hoc analysis of pretests scores in task 1 and task 4.

Task 1	Innovator	Early adopter	Early majority	Late majority	Laggard
Innovator		$p=0.95$	$p=0.96$	$p=0.89$	$p=0.93$
Early adopter	$p=0.95$		$p=0.26$	$p=0.12$	$p=0.04$
Early majority	$p=0.96$	$p=0.26$		$p=0.92$	$p=0.90$
Late majority	$p=0.89$	$p=0.12$	$p=0.92$		$p=0.97$
Laggard	$p=0.93$	$p=0.04$	$p=0.90$	$p=0.97$	
Task 4	Innovator	Early adopter	Early majority	Late majority	Laggard
Innovator		$p=0.75$	$p=0.89$	$p=0.88$	$p=0.90$
Early adopter	$p=0.75$		$p=0.31$	$p=0.35$	$p=0.04$
Early majority	$p=0.89$	$p=0.31$		$p=0.80$	$p=0.91$

Late majority	$p=0.88$	$p=0.35$	$p=0.80$		$p=0.75$
Laggard	$p=0.90$	$p=0.04$	$p=0.91$	$p=0.75$	

In both tasks, the statistically significant difference was detected between learners of Early adopter and Laggard types of teachers (in bold).

When summarizing and considering the pretest results from the view of pretest scores and types of innovation adopters, it can be stated that entrance level of learners' competency is more impacted by the out-of-school environment and after-school activities (interests) of learners than by teachers' types. However, this impact cannot be fully eliminated, particularly in learners of teachers-Innovators it can be the beginning of the impact. Statistically significant differences in types close to each other support the argument of out-of-school environment impact. Moreover, reflecting the fact that statistically significant differences were detected in tasks dealing with basic computer skills, we are inclined to think that it might be caused by the fact that most learners in outof-school environment use touch devices where these skills are not exploited. When working on PC, learners mostly play games, i.e. they do not work with files and folders, in text or graphic editors. These could be the reasons why statistically significant differences were rare in pretests.

Posttest results

The detailed analysis of single posttest tasks is presented below. Identically to pretesting, as working with ordinal data, the non-parametric test was applied: KruskalWallis test processed by Statistica software. The null hypothesis states that medians are equal in all tasks. In the tasks where $p < 0.05$, post hoc analysis was conducted based on multiple comparison. We expected the null hypotheses would be rejected with all tasks.

Table 4: Posttest scores – p-levels of single tasks.

Task	1	2	3	4	5
p-level	0.00	0.00	0.00	0.00	0.02

As displayed in the table 4, the null hypothesis was rejected in all tasks, i.e. there exist statistically significant differences in posttest scores in group of learners reflecting teachers' types. Therefore, post-hoc analysis was applied. As seen in Table 5, the results proved statistically significant differences in learners' posttest scores depending on the types of innovation adopters in tasks 1, 3, 4.

Table 5: Post hoc analysis of posttests scores in task 1, task 3 and task 4.

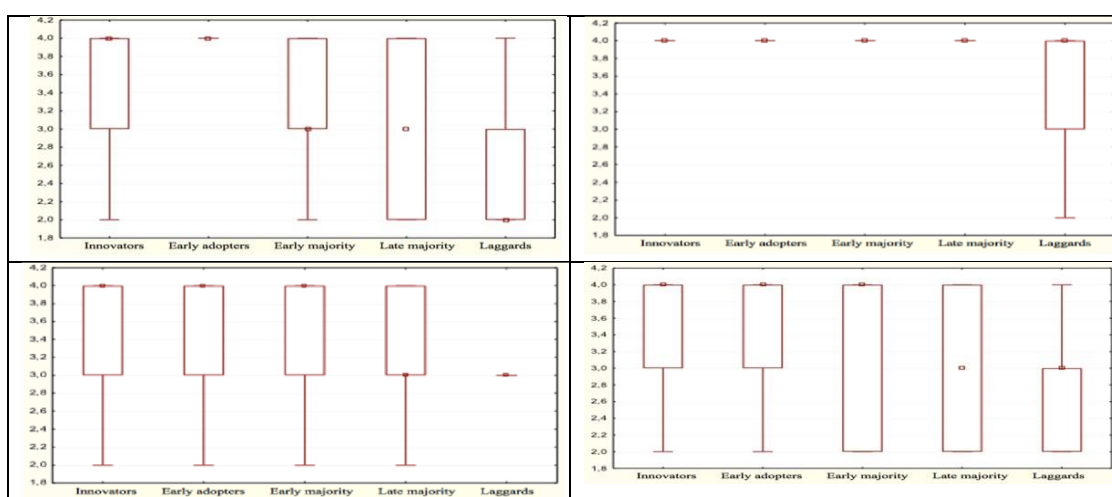
Task 1	Innovator	Early adopter	Early majority	Late majority	Laggard
Innovator	-----	$p=0.91$	$p=0.95$	$p=0.09$	$p=0.00$
Early adopter	$p=0.91$	-----	$p=0.16$	$p=0.00$	$p=0.00$
Early majority	$p=0.95$	$p=0.16$	-----	$p=0.99$	$p=0.01$
Last majority	$p=0.09$	$p=0.00$	$p=0.99$	-----	$p=0.66$
Laggard	$p=0.00$	$p=0.00$	$p=0.01$	$p=0.66$	-----
Task 3					
Innovator	-----	$p=0.96$	$p=0.97$	$p=0.79$	$p=0.00$
Early adopter	$p=0.96$	-----	$p=0.88$	$p=0.68$	$p=0.00$

Early majority	$p=0.97$	$p=0.88$	-----	$p=0.93$	$p=0.00$
Last majority	$p=0.79$	$p=0.68$	$p=0.93$	-----	$p=0.20$
Laggard	$p=0.00$	$p=0.00$	$p=0.00$	$p=0.20$	-----
Task 4					
Innovator	-----	$p=0.88$	$p=0.85$	$p=0.04$	$p=0.00$
Early adopter	$p=0.88$	-----	$p=0.89$	$p=0.02$	$p=0.00$
Early majority	$p=0.85$	$p=0.89$	-----	$p=0.95$	$p=0.07$
Last majority	$p=0.04$	$p=0.02$	$p=0.95$	-----	$p=0.97$
Laggard	$p=0.00$	$p=0.00$	$p=0.07$	$p=0.97$	-----

In task 1, the results of post hoc analysis show statistically significant differences between test scores in learners of teachers-Innovators, teachers-Early adopters and teachers-Early majority compared to learners of teachers-Laggards. Figure 1 (top left) displays that learners of teachers-Innovators, teachers-Early adopters and teachers-Early majority were better compared to learners of teachers-Laggards who needed help to solve the task successfully. It is interesting to observe the interquartile range, particularly with the learners of teachers-Early adopters, who solved the tasks without help. From our view, we can state most of learners of the first three groups of teachers master the work with files and folders successfully.

In task 2, the results of post hoc analysis do not show statistically significant differences on the 5% significance level between test scores of learners of single types of teachers. Figure 1 (top right) displays that learners of the first four types of teachers (Innovators, Early adopters, Early majority, Late majority) solved this task correctly compared to learners of teachers – Laggards; however, even in this group several exceptions were detected who solved the task without help. It can be stated this distribution was expected and it reflects learners' skills – this task belongs to basic ones. Large differences were detected with learners of teachers-Laggards, which is expressed by a wide variation range.

Figure 1 (bottom centered) displays that all learners solved the task successfully, without help.



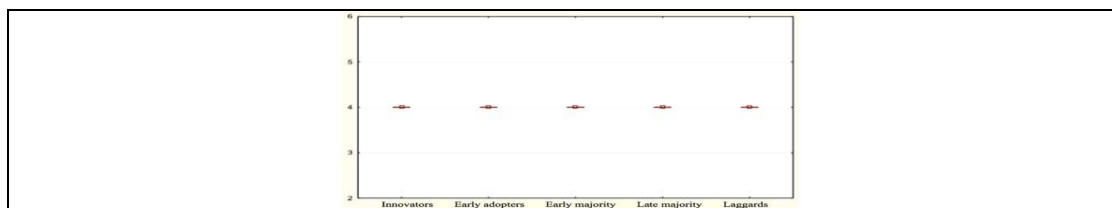


Figure 1: Posttest scoring with learners of single types of adopters for Task 1 (top left), Task 2 (top right), Task 3 (middle left), Task 4 (middle right), Task 5 (bottom centred) [axis x – types of adopters according to Rogers; axis y – test scoring (0- not fulfilled, 1- fulfilled with mistakes and help, 2- fulfilled without mistakes, with help, 3- fulfilled with mistakes, without help, 4- fulfilled without mistakes, without help)].

In task 3, the results of post hoc analysis show statistically significant differences between test scores of learners of the first four groups of teachers compared to learners of teachers-Laggards. Figure 1 (middle left) displays the demandingness of task was appropriate. When arising from the fact the Painting application belongs to those which are used before the learners reach the skill of writing, the results confirm that most learners reached good knowledge. The interquartile range of the first four groups shows most learners worked autonomously and successfully. Learners of teachers-Laggards also worked autonomously, but most of them did not fulfill the task precisely, e.g. the tree, or fence were missing.

In task 4, the results of post hoc analysis show statistically significant differences between test scores of learners of teachers-Innovators and teacher-Early adopters compared to learners of teachers-Late majority and teachers-Laggards. Figure 1 (middle right) displays that learners of first three types of teachers scored higher compared to learners of teachers-Laggards who needed help to solve the task successfully, and made mistakes. However, it is highly positive, that even in the group of teachers-Laggards not a single learner failed in solving this task.

In task 5, the results of post hoc analysis did not show statistically significant differences between test scores with learners of single types of teachers.

SUMMARY, CONCLUSIONS, DISCUSSIONS

For this research, tasks relating to the work with graphic software Painting were selected, as this one is frequently exploited by the primary school learners. The monitored tasks 1, 2, 4 cover the computer skills, work in the operation system and work with files and folders. Large differences were detected between Innovators and Early adopters against Late majority and Laggards, the former working independently and without mistakes, compared to the latter who needed strong support and made numerous mistakes.

Tasks 3 and 5 focus on work with applications. The differences between learners taught various types of teachers is clearly visible, following the results mentioned in the paragraph above.

To sum up, the collected results prove that at the primary school level the relation was discovered between learner's computer competency and the teacher's type according to the Roger's Diffusion of Innovation Theory. **The more the teacher is open to innovations, the better computer competency the learners have, and vice versa.**

The research results are limited by the fact that the level of ICT/computer competency is not impacted by the teacher only, but also family, schoolmates, friends must be included in the factors. Despite the role and contribution of "family" environment, it can be stated that teachers-Laggards provided minimum impact on learner's computer literacy development; the positive exceptions in learners' test scores are probably caused by these outer "family" reasons. This fact is reflected in wider variance values in teachers-Laggards and Late majority.

Moreover, the research results also prove that despite teachers often state that their impact on learners is weaker than the family and friends, it is not true to the whole extent. Reflecting these results, we suppose that teacher can be the person forming the creative environment in the class, the "creative nest", in which the spiral development of single skills is supported. Additionally, as Francisti and Balogh (2019) emphasize learners' motivation and complex emotional state are crucial for the successful process of instruction, no matter what age the learners are.

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Use of Mobile Devices for Physics Study in Secondary Education

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Abstract

In modern society, the use of mobile devices is gaining immense popularity. This is due to availability, technical specifications of mobile devices, the number of wireless and mobile networks. Moreover, the constant development of information technology allows to adapt some products to mobile devices, in particular augmented reality technology. This technology makes the imposition of any digital data on the image received in real time from the embedded cameras. This article discusses the use of mobile devices to study physics in secondary education and presents the advantages and disadvantages of using mobile devices in education. In addition, the paper has shown the analysis of the implementation of various innovative developments of mobile learning in some areas of human life. The mobile application to study physics in school was introduced and developed. It consists of laboratory work and practical tasks with 3D modeling elements working in two modes: normal and augmented reality. The Unity 3D cross-platform environment was chosen as the development platform and the main functionality was written in C#. To integrate augmented reality technology, the Easy AR library was used, and graphic models were created using Substance Painter. The article describes the development process of the application, its functionality, as well as the user interface. It has shown that the use of mobile devices in education opens up new prospects for widespread use at different stages of training. The results have shown that the developed mobile application allows to make studying physics more interesting and memorable, which lead to effective learning.

Keywords

Mobile devices. Augmented Reality. Education. Physics. Secondary Schools. Unity 3D.

INTRODUCTION

Mobile devices blur boundaries between everyday life, work, entertainment and learning. The reason for this is the huge expanding market of mobile communications. 66,53% of the world's population have mobile devices, including telephones, tablets and other gadgets (Gartner, 2020). Developed countries took the leading positions in the ranking by the share of smartphone users in 2019: the UK – 82,9% (55,5 million out of 67 million people), the Netherlands – 79,3% (13,5 million out of 17,1 million people), Sweden – 78,8% (7,9 million out of 10 million people), Germany – 79,9% (65,9 million out of 82,4 million

people) and the USA – 79,1% (260,2 million out of 329,1 million people) (NewZoo, 2020). In Kazakhstan, 11,9 million smartphone users are registered, which is 64,9% of the total population. Functions of modern mobile devices include the Internet access, email, messaging, audio/video recording, image getting and many more. Every year, the technical characteristics of mobile devices are growing, while prices are constantly decreasing, becoming available to more people.

The development of information and communication technologies poses new challenges for secondary educational institutions. The textbook is no longer the only source of knowledge for students. There is a need for students to develop such skills as navigating in the modern information space, solving non-standard tasks, the ability to work in a team, independently plan, analyze and evaluate their activities. This can be achieved through application of mobile devices, which are a powerful tool for modelling, interaction and observation. Thus, the idea of using mobile technologies in the educational environment is becoming increasingly relevant.

According to UNESCO, mobile technologies can significantly expand and improve learning opportunities in a variety of conditions (West et al, 2013). A growing number of projects related to the use of mobile technologies in education is an example of this. For instance, the Nokia Life project (Bhanu, 2013) is a series of mobile educational services that include cutting-edge educational information, health, agriculture and entrepreneurship, designed specifically for the population of agricultural regions and small cities in developing countries. The BridgeIT project uses mobile phones to provide teachers with materials for professional development and access to educational resources in the Philippines (Center for education innovations, 2016).

In education, mobile devices provide several advantages (West et al, 2013). There are instant feedback and assessment of learning outcomes, learning anytime, anywhere, efficient use of time in classroom lessons, support for situational learning, the development of continuous "seamless" training, the relationship between formal and non-formal learning, the continuity of the educational process during the crisis period, inclusive education, improving the quality of communication and management, maximizing cost effectiveness.

However, it should be noticed that mobile learning is not a substitute for traditional classroom learning. The opportunity to get to know each other, to develop relationships, interaction in a dialogue, mentoring is the basis of human education.

The International IT University (Almaty, Kazakhstan) has experience in developing mobile and e-learning systems with the use of new technologies. Thus, the authors developed a virtual physical laboratory, which is a software package for studying the behaviour of object models (Daineko et al, 2017a, Daineko et al, 2017b). The authors also developed applications for studying physics using the technology of augmented reality (Daineko et al, 2018, Daineko et al, 2019). This article is devoted to the development of mobile application with the function of augmented reality for the study of physics in secondary education.

USING MOBILE DEVICES IN LEARNING

Mobile technology can be a way to bring education to the next level. In (Bourekache et al, 2020) an educational system for mobile devices was developed that provides students with the opportunity to learn English outside the classroom and encourages them to actively participate in their own learning processes. In (Lotter et al, 2020) a study was conducted that focuses on the use of smartphones as a tool for social constructivism. The results showed that through the use of smartphones as a tool for collaborative learning, student learning improves. At the same time, universities can reduce costs by encouraging students to bring their own device (BYOD) for learning and study. Kamrozzaman et al in their work (2020) showed that smartphones are the most suitable devices for lifelong education. In (Burianova et al, 2016) the authors have developed an innovative educational model, which, along with outdoor training, project training includes application of mobile, information and communication technologies. The developed model has such advantages as an effective combination of various pedagogical approaches using ICTs to increase the motivation of students to learn, an interdisciplinary approach, as well as the development of a wide range of knowledge, skills and competencies. In (Inmaculada et al, 2019) a review was conducted on the benefits that mobile devices provide for student learning. The results showed that mobile learning increases student interest. The most effective mobile applications to improve the learning and teaching processes are also presented.

The use of mobile technologies in training provides not only many opportunities, but also creates certain problems or even technostress. Qi et al (2019) compared the improvement in academic performance with the stress of mobile device use among university students. The results showed that the use of mobile devices by students for training does not lead to the emergence of technostress. However, individual differences between students, for example, independence and the degree of use of mobile technologies significantly affect technostress.

Very often, when developing online courses, their use in mobile learning is not taken into account. In (Baldwin et al, 2019) the online course assessment tools were identified and studied, and the criteria that guide course developers in developing online courses for learning on mobile devices were examined. The authors offer such tips on the development of courses for mobile training as device compatibility, convenient readable content, format optimization and convenient navigation.

Gupta et al (2020) examined how mobile devices can be integrated into radiology workflows, as well as the impact of IoT on education, research and patient involvement in the field of radiology. In (Sakibayev et al, 2019) the authors studied the impact of mobile devices on academic performance and student interest in the subject of "Databases" at the college level. During the study, the authors studied both quantitative (student ratings and attendance) and qualitative characteristics (student and teacher opinions). It is shown that in relation to the "Databases" course at the college level, mobile devices can successfully replace traditional computers and positively affect the educational activities of students.

Computer modelling of physical processes, implemented in the form of physical experiments on mobile devices, is increasingly used in the process of teaching physics. Salnyk (2019) discussed the possibilities of using mobile applications and sensors of mobile devices as measuring devices for conducting physical experiments. In (Rirdy et al, 2019) an engine generator was developed for Android applications to simulate experiments that

allow the study of the Balmer series. The developed engine consists of image processing, object conversion, browser connector, interactor and visualizer. In (Zakaria et al, 2019) it was studied three real experiments in the field of mechanics, namely: inelastic collision, centripetal acceleration and spring, using some sensors of a mobile phone. The data obtained was processed using the Phyphox software.

Thus, mobile devices have high potential, which, with proper integration, can form a new effective model in learning.

RESULTS

A software application for physics study on a mobile platform Android was developed in the International Information Technology University (Almaty, Kazakhstan). It is designed for 9th grade of secondary schools in Kazakhstan (approximately 14-16 years old) and is applicable on smartphones and tablet computers. Mobile application has two main components: set of virtual laboratory works and set of problems on physics. The main advantage of this project is an additional mode with Augmented Reality (AR) for both labs and problems tasks. It allows observing full simulation using special images – markers. Such entertainment approach creates immersive environment for students and makes educational process more interesting and memorable. In the core of the program, there is the Unity Engine and C#. Additional modules are Easy AR library (EasyAR, 2019) for AR integration. There are also several supportive modules like a folder with all the common models, and scripts, folders for each problem and laboratory work with necessary stuff are integrated into the software. In addition, there is a module for user interface with different menu controllers, scripts and designed buttons (Figure 1).

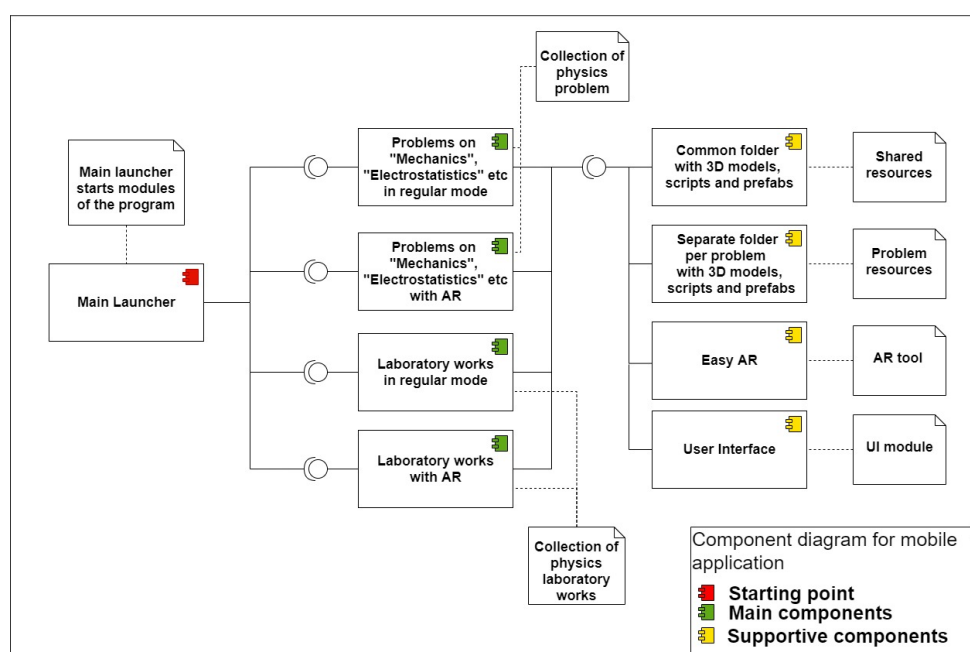


Figure 1: Component diagram.

The class diagram in Figure 2 displays relations between classes within the application. It can be noticed that all the modules of the program inherit from MonoBehavior. It is a base

class in Unity, and other classes must be its descendants. The SceneController is a class that controls a certain scene. There is an example of laboratory work, which is controlled by a script on “Mixed connection of conductors”. Attributes of this class are elements of the laboratory’s equipment like rheostat, voltmeters etc. In addition, the UIController class is presented on the diagram. It manages interaction and correct work of buttons, sliders, panels and other visual elements. The remaining classes serve for the proper behaviour of Easy AR module. ImageTrackerBehaviour implements detection and tracking of markers. AR session initiates and manages launching of augmented reality session. ImageTargetController is an image to be tracked by Image tracker. Easy AR behaviour instantiates, and controls augmented reality in the project, tracks its work.

The Figure 3 demonstrates possible activities of a user and their logical sequence. The first step of the user is to launch the program. Then he/she will see application’s menu with different buttons such as “play”, “settings”, “help” and “credits”. Then the next menu with two buttons appears, one is for problems and the other one is for laboratory works. If the user chooses problem tasks, he/she will see the 16 possible problems. Then the chosen scene with two buttons is shown. The first one is for menu and the second is for the problem’s description. From the menu, the user can change the mode, change the settings, make restart and go back to the higher-level menu. If the user chooses laboratory works, he/she will see the menu with five available laboratory works. Then after picking one of them, the scene with all the required equipment ready for execution of the experiment will be shown to the user. User interface in laboratory works is the same as in the problem’s scene, except description of problem’s condition, which are replaced with laboratory work’s step-by-step guidance.

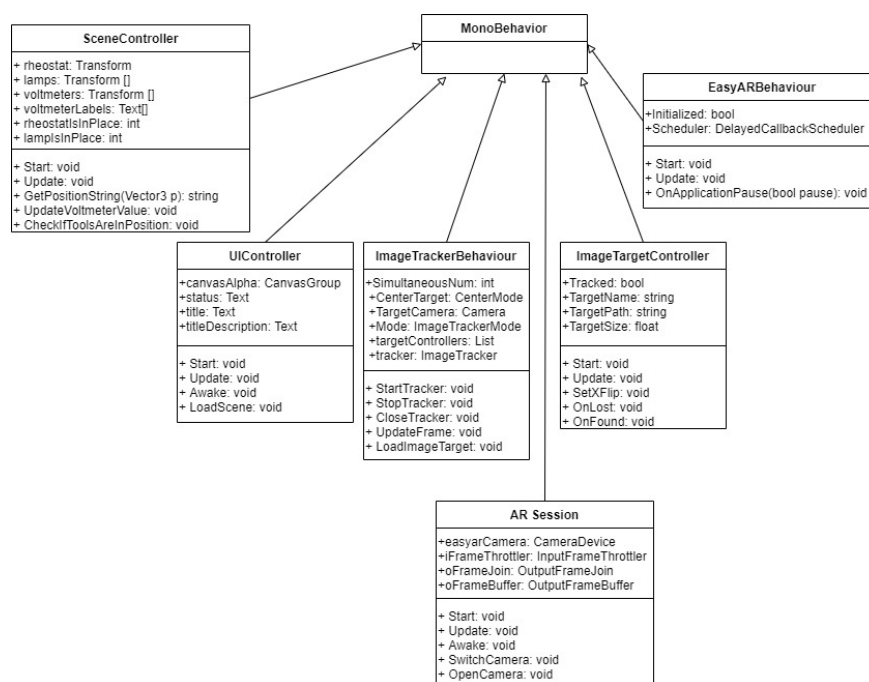


Figure 2: Class diagram.

In the Figure 4, there is a demonstration of the laboratory work about the determination of the ball’s moment of inertia. The left picture displays the ordinary mode of the lab, which consists mainly of installation itself, user interface and surrounding media

like a laboratory room and supportive objects like a table, a desk and etc. The user needs to put balls of different weight and diameter into a gutter. Then it is required to define the length of the flight, which will be shown after falling of the ball down. The task is to calculate the moment of inertia based on the height of the gutter, weight of the ball, diameter and distance of the flight.

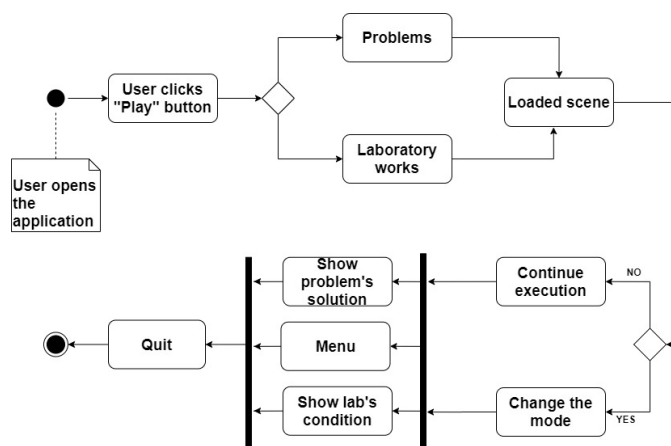


Figure 3: Activity diagram of the application.

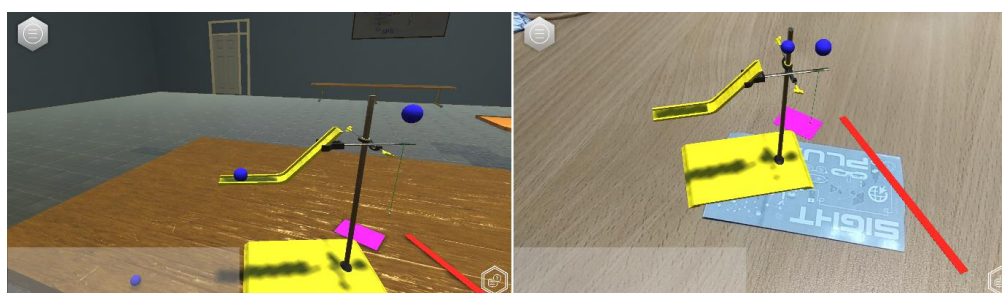


Figure 4: “Determination of the ball’s moment of inertia” laboratory screenshot.

The same lab is demonstrated on the right side picture. The only difference between them is a mode – the second screenshot is shown in AR. The other features of the lab are the same with the ordinary mode. The user can switch the modes easily from the menu button. In addition, the application is provided with the buttons to restart the program and exit to the higher-level menu. Another scene button is the laboratory work guidance.

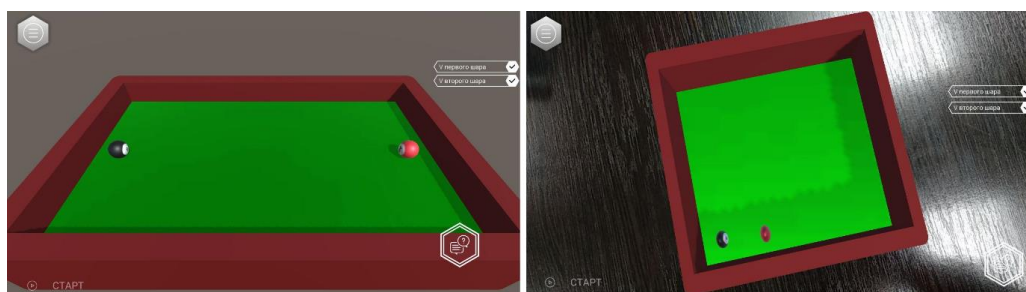


Figure 5: “Inelastic collision of solid bodies” laboratory screenshot.

For the problem tasks, the logic of the scenes is the same. Figure 5 demonstrates the screenshots of the problem task about the inelastic collision of solid bodies in the ordinary (left) and the AR (right) modes.

The first ordinary mode of the problem suggests viewing its condition and allows observing its conduction within three-dimensional space. The mode with augmented reality also represents visual demonstration of the problem but additionally it is possible to view the installation from all the sides by rotating the marker. The user is involved into the problem changing the input data like initial velocity, weight, height, etc. depend on the given task.

EVALUATION

In order to know the opinion of students about the developed program, a survey was conducted.

30 students of the 9th grade of the Specialized Physics and Mathematical School took part in the experiment during the first quarter of the academic year 2019-2020 (September – December) the age of 14-16 years old (18 male/12 female). During these months, the students used the virtual laboratory in physics lessons to solve different practical tasks and execute laboratory works. The evaluation procedure was as follows.

In the beginning of September, a survey among the students was conducted to find out, whether they used computer programs like virtual laboratories earlier on other subjects or did not. And the only answer was “No”. The students had not used such applications on other disciplines before. However, around 20% of them noted that they had used similar programs by themselves during their self-study, not in school.

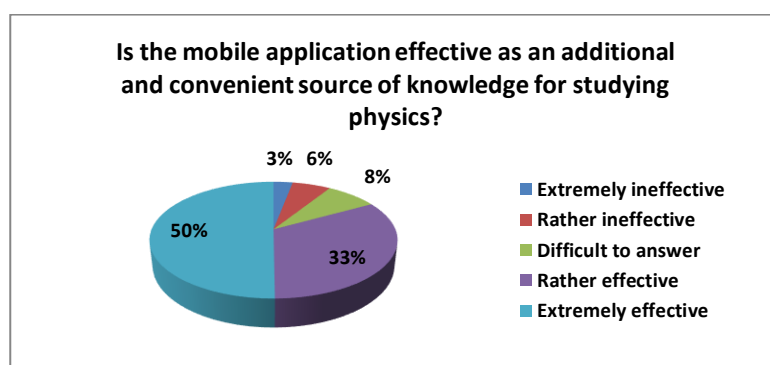


Figure 6: The results of the survey in terms of the effectiveness of the virtual laboratory.

Then, at the end of December, another survey was conducted about the effectiveness of the laboratory as a whole. The question was “Is the mobile application effective as an additional and convenient source of knowledge for studying physics?”. And more than 83% of respondents answered positively (see Fig. 6). The comments of the students to the survey showed that the students are interested in using similar applications on other subjects, for example, chemistry, geography or biology.

DISCUSSION

The conducted work on the project demonstrated the need of software development that involves students into educational process in a form of independent education and theme research. It helps them increasing the rate of understanding and improves the

perception of the topic and specific meanings and processes. Thanks to this approach it is easy to notice the necessity of adoption of the traditional learning material to the modern technologies in order to improve education as a whole and to make it more accessible to everyone.

However, despite the convenience of the educational mobile application there still could be three following problems: lack of communication and equipment failure and teachers' training. The higher digitalization is the lower level of interaction between people goes. In educational area it is more meaningful because except knowledge exchanging education is a way of human-human relationship installation, social skills gathering. Another problem is equipment failure. It can be caused by updating of the software pursuant to technologies improvement. For example, surface tracking is high-demand technology that requires certain technical characteristics and not every smartphone goes under them. So, it should be considered during software development and updating. The last one problem is familiarity and understanding of teachers with application and technologies at all. It is a common problem that teachers are not ready to use different apps and modern multimedia tools. The only way to solve this problem is to conduct special trainings for them to show all the features of modern technologies. The familiarity of teacher with technologies is one of the ways to improve interaction with students. It also works vice-verse students can help teacher with new versions of the application in case of difficulties.

The previous works were linked with virtual physical laboratories for laptops and PC. They have shown that mobile devices like smartphones and tablets are more preferable due to size and accessibility. It led to switching of the platform and the form of the representation of the labs.

Our future work is connected and dedicated to software refinement, and extension to the other subjects, creating of the full-cycle educational programs within virtual space. Another aim is accessibility increasing and work on web-based apps.

CONCLUSION

The potential for using mobile devices in education is huge. Their specifications are constantly growing, opening up unique learning opportunities. However, the possibilities of using m-learning should be carefully studied by educational authorities.

In this article, the mobile application for smartphones and tablet computers with integrated augmented reality for studying physics in secondary schools was presented. It allows solving problems and conducting laboratory work in physics according to the curriculum of the 9th grade of secondary schools in Kazakhstan. The developed mobile application was tested in the educational process in Specialized Physics and Mathematical School in Almaty (Kazakhstan) at the beginning of the 2019-2020 academic year. The first feedback showed that this application makes studying physics more simple, open and creative.

In the future, the authors will work to expand the functionality of the mobile application by integrating new practical tasks and laboratory works from other areas of physics, as well as animations, which will describe physical processes in detail using augmented reality technology.

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The Sense of E-learning Community

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Abstract

Research on on-line communities emphasize that the sense of community (SoC) and self-efficacy perceptions could be critical factors on knowledge sharing behaviours. The paper's aim is related to the answer of the following question: Which are the behaviour attributes that must be considered to build and nurture a vibrant e-learning community (in terms of creating a strong SoC)? The research objective is to create a model for the SoC behaviour attributes assessment and the article's chapters show the research approach developed in order to find a feasible solution for creating a vibrant e-learning community (continue support of on-line learning and collaborative processes of knowledge sharing). The proposed model is based on the 3P Model (Biggs, 1989) from which the research methodology has been focused on the Product phase where SoC is considered. Thus, a survey based on a designed questionnaire has been proposed by considered behaviour elements as: membership, influence, fulfilment of needs and sharing an emotional connection; each element was characterized by specific behaviour attributes (in total 20). From the practical perspective, the research methodology has been applied to characterized behavioural elements and the related attributes in the case of the TeachSUS community members in the process of development and nurturing the created e-learning community (112 subjects have defined the research sample). Investigation results underline that the majority of TeachSUS community members agree that fulfilment of needs and shared emotional connection behaviour attributes are the most significant elements for the sense of the TeachSUS e-learning community.

Keywords

E-learning. Sense of Community. Behaviour attributes. TeachSUS project.

INTRODUCTION

During recent years, scientists and practitioners have defined and implemented feasible models of building and nurturing e-learning communities by including group dynamics in the learning processes in order to gain highly interactive learning and activate the sense of community (Rogers, 2019; Francisti & Balogh, 2019). It has been demonstrated that the existing information system is not enough condition to build vibrant communities.

The intensive use and exploitation of the e-learning system functionalities, together with the associated social media facilities can assured effective and efficient learning experiences (Balogh & Koprda, 2014; Li et al., 2020; Balogh & Kuchárik, 2019).

Initial researches on SoC has been identified and characterized in offline communities as the key attitudinal factor which predicts individual and community outcomes. Then, the knowledge achieved have been transferred on understanding antecedents and consequences associated with sense of community in virtual communities. Related members feel an increase sense of belonging to the virtual community by exchanging information, seeking advice and emotional support. If the effects of their interactions are of high utility the SoC is higher; social interactions play a pivotal role in the formation of online communities (Mamov, 2013). Later in the work of Peacock and Cowan (2019) SoC has been considered from the perspective of the sense of belonging (SoB) which has been recognized as a valued concept in campus-based learning, being firmly linked with improved student attainment, increased learner satisfaction, and reduced attrition rates (Francisti & Balogh, 2019).

As can be seen from different approaches in the literature, SoC concept is recognized as a strong predictor of users' behavioural intentions affecting sustainability of online communities. Furthermore, inspiring researches on SoC has been considered for the present approach on discovering the behaviour attributes that could transform international e-learning communities into a vibrant one (Draghici & Reiner, 2014; Draghici et al., 2014). Creating a sense of community has traditionally been a challenge for on-line teachers and learners, yet links between students having a sense of community and student retention have been strongly established (Baxter, 2019).

In this context, the question that will be answered by the present research is: *Which are the behaviour attributes that must be considered to build and nurture a vibrant e-learning community (in terms of creating a strong SoC)?* The answer is convergent with the research objective (identify a model for the SoC behaviour attributes description) and the article's chapters show the research approach developed to define a feasible solution for creating a vibrant e-learning community (continue support on-line learning and collaborative processes of knowledge sharing). The content of the article's chapters are: (1) a brief literature review on e-learning communities and the SoC in this case; (2) description of the conceptual model used for the research design methodology; (3) presentation of the the research results and their interpretation. Finally, conclusions and recommendations for future research are presented.

This paper context refers to the the Erasmus+ project: "TeachSUS - Teaching and Educating for Sustainability" (TeachSUS_2018-1-RO01-KA204-049253) during which an e-learning community of trainers (educational materials developers members of the TeachSUS international consortium) and learners (students from pedagogical programmes at higher education level and teachers from pre-university educational level) have been developed using different tools: the on-line learning platform developed under Moodle software (<http://teachsus.projects.uvt.ro/>); project web page (<https://www.teachsus.eu/>); Facebook community (<https://web.facebook.com/teachsus/>). In the following sections there will be presented and examine the ways in which the TeachSUS partners are looking to create the SoC, the focus and interest of each learning modules as subject to be learned and then thought by teachers in the pre-university level, and how members of the target group feel that these interventions promote learner engagement and a concomitant SoC.

METHOD

For the purpose of investigating the SoC in the case of e-learning environment there have been considered the Presage – Process - Product (3P) Model also, known as Biggs's 3P Model and which refers to an integrated system of three major phases (Biggs, 1989).

- The Presage phase occurs prior to the learning process and it relates to learner attributes, instructional attributes, and contextual attributes.
- The Process phase facilitates learning by planning and delivering knowledge acquisition interventions, as learning and teaching. It highlights the more significant aspects for learning related to collaborative practice (associated to collaborative communities that are created in the e-learning context together with the communication facilities that are created).
- In the Product phase, learning to collaborate is vital to professional training and development; the anticipated products refer to domain-specific knowledge, skills, attitudes, and collaborative competencies of knowledge management.

Developing this approach, Biggs (1989) noted that understanding learning progress and improvement involves interactive and contextual approaches. So, for the purpose of the presented research, the 3P Model description was adapted in order to generate a large overview of the e-learning community and not only to instructional intervention (Figure 1).

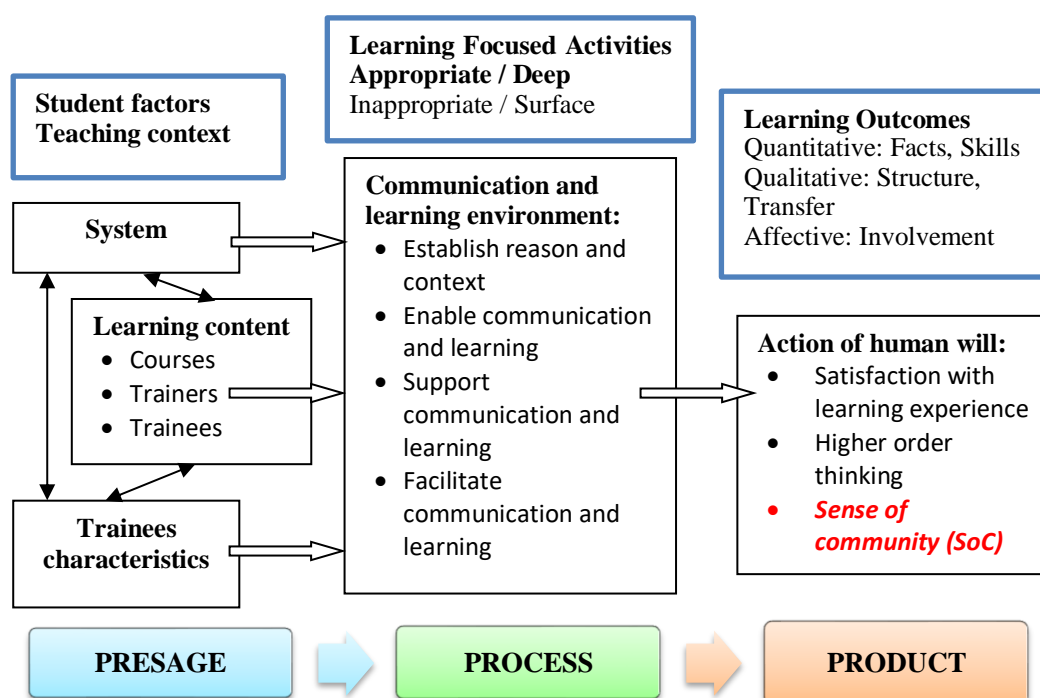


Figure 1: The 3P Model description (adapted from (Draghici & Reiner, 2014))

The proposed framework has considered factors that can be associated to the process of e-learning community development and a myriad of outcomes including SoC (similar with the suggested issues described by Brook & Oliver in 2003). The methodological approach of the SoC investigation will consider the Product phase related to the 3P Model which includes

and refers to socio-psychological and behaviour elements of the community that has been considered the most valuable aspect in building and nurturing an e-learning community (Brook & Oliver, 2003).

The research methodology is focused on the SoC in a case of the e-learning community by characterizing the willingness of members to share resources (information, knowledge, experiences, believes), accept and encourage new members, communicate, supporting one-each other approaches of systematic problem solving and preparedness to share success. On the other hand, social phenomenon may generate negative influences on community members. Potentially negative influences include the members' need to conform and the subsequent loss of individuality, and the potential to hoard knowledge and thus restrict innovation and creativity. Sometime, community structure could generate pressure on individuals with nonconforming behaviours that could evolve in formation of sub-communities (Brook & Oliver, 2003). These behaviour aspects of the e-learning community members could affect the entire community. Thus, analysing in deep Brook & Oliver (2003) research there have been built an inventory of the SoC elements and attributes which were assimilated with a model for the SoC behaviour attributes, as shown in Figure 2 (the items considered has been inspired by the work of (Brook & Oliver, 2003) and the proposed description and approach of (Draghici & Reiner, 2014)).

Starting from the proposed approach (described in Figure 1) and the described aspects of human behaviour that could be associated with the SoC (Figure 2), the research will be focused on identifying and characterizing the e-learning communities development (development and nurturing). Based on the model for the SoC behaviour attributes (Figure 2 presents 4 chapters and 20 related behaviours attributes) a questionnaire was developed and each behaviour attributes have been evaluated by the e-learning community using a Likert scale with 5 points (1 - very unimportant, poor perception, disagree with the affirmation, strong perception and approval of the affirmation, ..., 5 - very strong perception, very important).

1. Membership	2. Influence	3. Fulfilment of needs	4. Sharing an emotional connection
<ul style="list-style-type: none"> • Boundaries that separate <i>us</i> from <i>them</i> • Emotional safety • A sense of belonging and identification • A common symbol system 	<ul style="list-style-type: none"> • Individual members matter to the group • The group matters to the individual • Making a difference to the group • Individual members influence the group • The group influences the individual member 	<ul style="list-style-type: none"> • Benefits and rewards • Members meeting their own needs • Members meeting the needs of others • Reinforcement and fulfillment of needs 	<ul style="list-style-type: none"> • Identifying with a shared event, history, time, place or experience • Regular and meaningful contact • Closure to events • Personal investment • Honour • Spiritual connection

Figure 2: A model for the SoC behaviour attributes (elements of human behaviour associated with the SoC characterization)

Based on these methodological considerations, a survey based on a questionnaire has been developed for characterizing behaviour attributes related to the chain of events that lead to an e-learning community development (in association with the collaborative

knowledge and wisdom base available and well known in the particular community that was investigated). The research was developed with the support of the trainers and experts of the TeachSUS consortium. This community could be defined as a reunion of numerous e-learning communities (that were investigated) that were established in the context of projects developed (2019-2020).

RESULTS AND DISCUSSIONS

Before the assessment of the behaviour attributes of SoC, there have been identifies the most important challenges to achieve a successful e-learning community (Table 1 issues were established based on references and the ideas aroused from a focus group with 12 persons of TeachSUS board members during the second transnational project meeting; the evaluation made use of the Likert scale, too). Preliminary results indicated that importance (as hierarchy) challenges were: understanding and managing user expectations (perceived by 66.67% of the respondents as "5 - very important", strong perception for development of the community), data integration (perceived by 66.67% of the respondents as "5 - very important") and data quality (perceived by 50% of the respondents as "5 - very important"). As can be observed from the data presented in Table 1, education and training has been considered important aspect (58.33% of the respondents has answer "4 - important:), as similar for customer collaboration and support (50%), budget constraints (50%). The average perceptions have been associated with the score 3 to the following items: time required to implement (66.67%), culture change (58.33% and tool capability (58.33% of average importance).

Table 1: Results on the challenges' perception for developing the SoC and to assure a successful TeachSUS e-learning community.

Assessment Items	5		4		3		2		1		Count
	#	%	#	%	#	%	#	%	#	%	
Education and training	3	25	7	58.33	2	16.67	0	0	0	0	12
<i>Understanding and managing user expectations</i>	8	66.67	4	33.33	0	0	0	0	0	0	12
Data quality	6	50	4	33.33	2	16.67	0	0	0	0	12
<i>Data integration</i>	8	66.67	2	16.67	2	16.67	0	0	0	0	12
Customer collaboration and support	3	25	6	50	2	16.67	1	8.33	0	0	12
Budget constraints	3	25	6	50	3	25	0	0	0	0	12
Culture change	2	16.67	3	25	7	58.33	0	0	0	0	12
Time required to implement	2	16.67	2	16.67	8	66.67	0	0	0	0	12
Tool capability	2	16.67	3	25	7	58.33	0	0	0	0	12

From the preliminary research results it can be concluded that TeachSUS consortium board members are very attached and devoted to the e-learning community where they are involved (managing user expectations is the first priority, together with data integration and

quality related to the training materials, certification process and communication support through the facilities used on the TeachSUS e-learning platform). Trainees' needs satisfaction and their expectations related to training and competencies development are very important aspects that pilot TeachSUS researchers, developers, trainers and/or tutors' behaviour inside the e-learning community.

In the following there will be presented the research results and debates on the survey implementation. The sample considered consists of TeachSUS members' community that were announced via e-mail and the dissemination events organized in Romania, Slovenia and Portugal. Thus, team managers and researchers of the six teams of the TeachSUS consortium have built and developed the e-learning community. Initially, more than 300 messages were sent (via e-mail) and 60 potential trainees were target during the multiplier events that have been organized, but only 112 valid questionnaires were processed. The respond rate was 0.485 that is considered a very good one. The research sample included 112 subjects, of different TeachSUS partners, having different nationalities: Romanian (53), Hungarian (18), Slovenian (25) and Portuguese (16); age of participants ranged below 27 and above 56.

The first research question has pointed out the global perception of the TeachSUS members (researchers, developers, trainers and/or tutors) about the sense of community characterized by the four behaviour elements: membership, influence, fulfilment of needs and sharing an emotional connection. As shown in Figure 3, the global score has underlined an equally- high perception of membership and sharing an emotional connection, despite the culture diversity of the investigated sample and of the e-learning community's members.

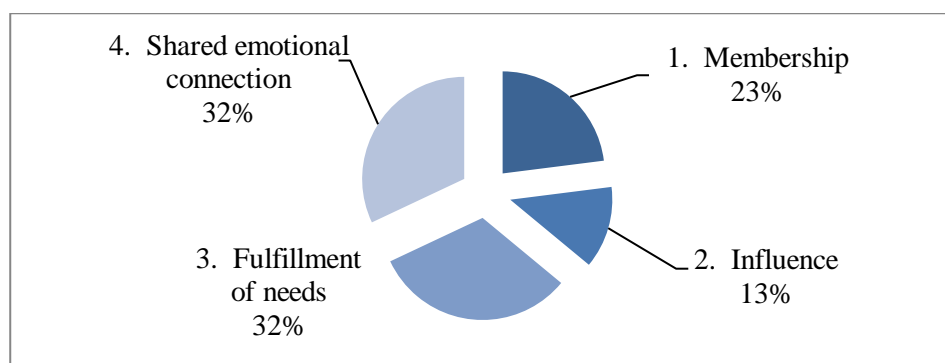


Figure 3: The global perception of the SoC behaviour elements

At the same time, a relative equilibrium of the behaviour elements perception can be observed but two elements are in the same percentage of perception (32%), considered as most important: fulfilment of needs and share emotional connection. In conclusion, trainers' perception on TeachSUS community members sense can be characterized by a behaviour model based on four elements: membership (23%), sharing an emotional connection (32%), influence (13%) and fulfilment of needs (32%).

Furthermore, Figures 4, 5, 6 and 7 show the research results regarding the TeachSUS community members perception on each of the behaviour attributes associated with the SoC that has been assessed (based on the absolute data value analysis as research results). This analysis reveals a behaviour profile of the TeachSUS community members related to the developed e-learning community.

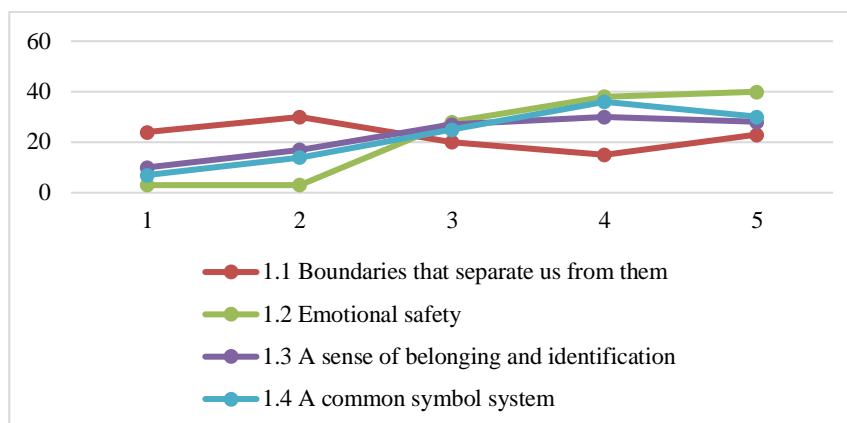


Figure 4: Membership perception in relation to the sense of TeachSUS e-learning community.

As seen in Figure 4, results of the behaviour attributes related: 1.2 Emotional safety (0.39 strong perception); 1.3 Sense of belonging and identification (0.27 very strong perception); 1.4 Common symbol system (0.39 strong perception) there is a dominant of strong and very strong perception of the TeachSUS community members regarding the e-learning community where they are involved and they are attached with (most of the answers delivered were for the scores 4 and 5 of Likert scale). Related to the behaviour dimension 1.1 Boundaries that separate us from them, TeachSUS community members are very attached to the e-learning community activity and matters and do not believe there are any boundaries between them and the users as trainees (weak perception of 0.31).

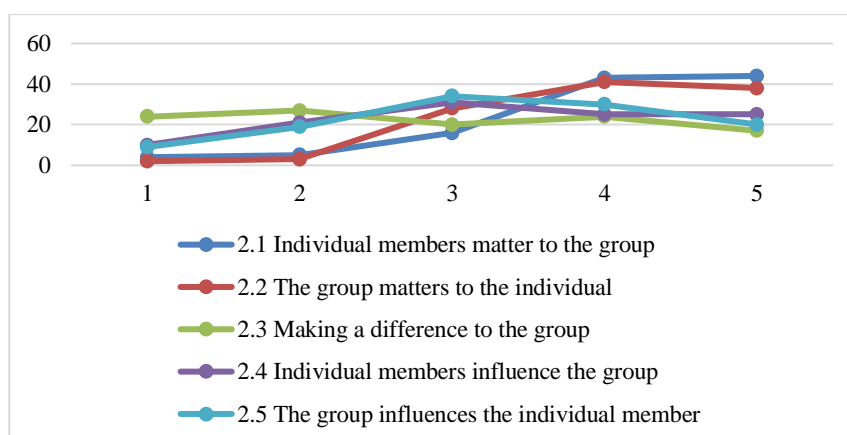


Figure 5: Influence behaviour as the sense of TeachSUS e-learning community perception.

In the case of the second behaviour element, the perception of influence (Figure 5), results identified a very strong perception on the attribute 2.1 Individual members matter to the group (0.40); a strong perception on 2.2 The group matters to the individual (0.37); a weak perception on 2.3 Making a difference to the group (0.28); an average perception on 2.4 Individual members influence the group (0.32) and on 2.5 The group influences the individual member (0.34). As concluded, results of the study identified a weak perception on making differences to the e-learning community as a group, but TeachSUS community members have a strong relation and dedication to each trainee in the e-learning community and to the whole group.

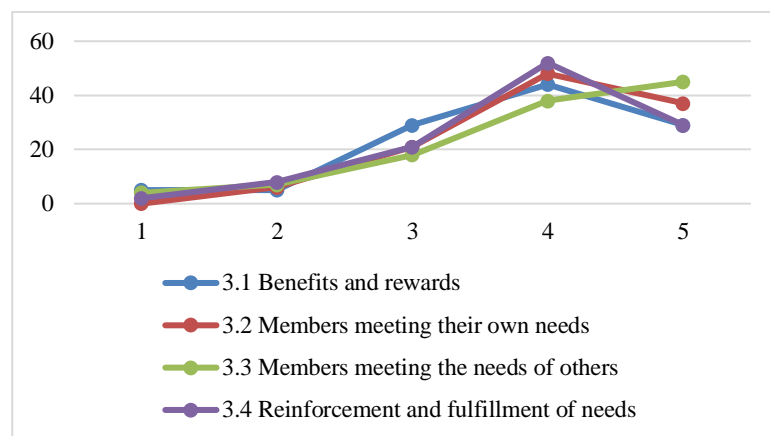


Figure 6: Fulfilment of needs behaviour attributes related to the SoC.

The evaluation of the fulfilment of the needs behaviour element (the third element of the model) identified a strong perception related to all attributes: 3.1 Benefits and rewards (0.38); 3.2 Members meeting their own needs (0.41); 3.3 Members meeting the needs of others (0.40); and 3.4 Reinforcement and fulfillment of needs (0.43), (Figure 6). These results identified a strong relation of TeachSUS community members to the trainers that belong to the related e-learning community. All these actors are linked together mainly because of their reciprocity of needs satisfaction. The sense of belonging to the e-learning community can assure benefits and rewards seen as success in accomplished training and certification tasks, together with the related projects success.

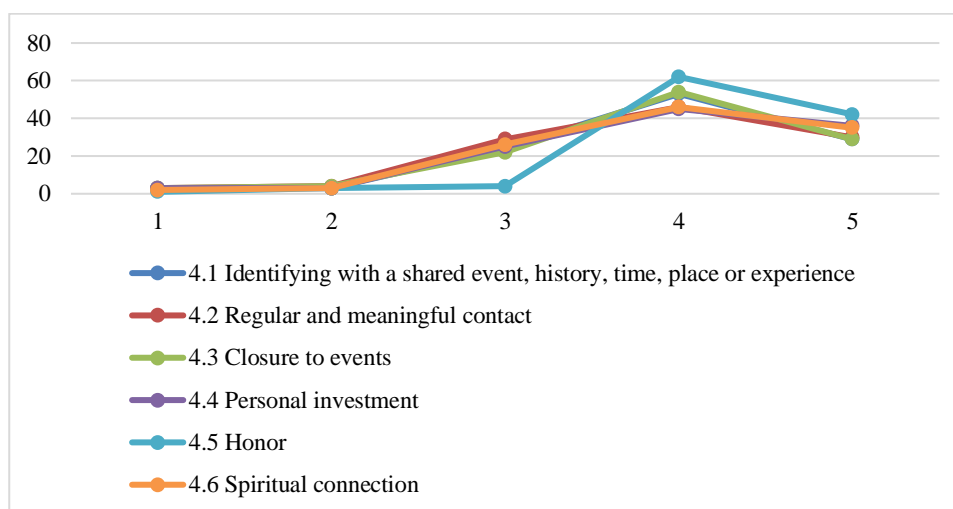


Figure 7: Sharing an emotional connection – behaviour attributes related to the SoC.

Evaluation of sharing an emotional connection revealed a strong perception of all behaviour attributes: 4.1 Identifying with a shared event, history, time, place or experience (0.42); 4.2 Regular and meaningful contact (0.37); 4.3 Closure to events (0.45); 4.4 Personal investment (0.39); 4.5 Honour (0.54); 4.6 Spiritual connection (0.37) (Figure 7). TeachSUS community members recognized a strong emotional connection with the related e-learning environment based on their share actions in training and practical implementation of the achieved knowledge. Results revealed that the respondents place a high value on integrity, with the most important characteristic of the emotional connection being the *honour* behaviour attribute (with a frequency level 0.54).

CONCLUSION

The article presents a brief analysis of literature that has suggested the possibility of describing the processes and procedures for developing an on-line learning community as a model containing a chain of events that comprise presage, process and product factors already suggested by the 3P Presage – Process – Product Model (Biggs, 1989). The presented research has been focused on the Product factors that outline the sense of community experience, among other outcomes. Thus, the adopted methodology consists of a survey based on a questionnaire with 20 questions related to the assessment of the behaviour attributes. Furthermore, the proposed research model is based on the 3P Model (Biggs, 1989), debated also, by (Brook & Oliver, 2003). The 3P Model was adapted to detail those aspects relevant to methodological investigation of the e-learning community members behaviour and the characterisation of their SoC. Behaviour elements including membership, influence, fulfilment of needs and sharing an emotional connection were considered. Each element was characterized by specific behaviour attributes.

From the practical perspective, a preliminary focus group conducted with TeachSUS trainers evaluate the most important issues of supporting the SoC development by considering four elements in the model has been characterized by the following proportion of their perception: membership (23%), sharing an emotional connection (32%), influence (13%) and fulfilment of needs (32%). A detailed analysis of the attributes associated with each behaviour element has characterized the SoC in the case of TeachSUS e-learning community. The adopted research scenario and the research results with comments and debates were presented. The results characterized behavioural elements and the related behaviour attributes in the case of the TeachSUS community members in the process of development and nurturing the created e-learning community (112 subjects have defined the research sample).

Through this research and the involvement of trainers in mentoring and tutoring activities on the TeachSUS e-learning platform there has been confirmed that the behaviour attributes investigated can be considered important in developing and nurturing the community by valorising their SoC. The majority of TeachSUS community members agree that fulfilment of needs and shared emotional connection behaviour attributes are the most significant elements for the TeachSUS e-learning community support. The proposed research methodology can be applied for any e-learning community in order to describe members' sense of community through relevant behaviour attributes characterization. This will contribute to the e-learning communities' development and nurture. In addition, future recommendations of research include the statistical data process and analysis that will conduct to a deep analysis of the SoC characterization and the empirical model description in the case of the e-learning community (as suggested by (Cápay et al., 2011)).

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Expectations of business university students regarding their further professional development and lifelong learning

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Abstract

The aim of the research is to find out what types (forms) of further professional development and lifelong learning will university students prefer in their future life. The strategy of Lifelong learning needs to answer the growing need for different types of e-learning for many jobs. This research using the Delphi method is focused on business university students from the Czech Republic. The Delphi study used three separate groups of students. Three panels of students listed types of continuing education, such as language education, professional corporate courses, workplace rotation and methods (types) such as coaching and mentoring. In the final list we also find the types related to ICT such as PC courses and e-learning (online courses). The results show a moderate degree of consensus in the ranking of the items for two panels of respondents. The findings brought by the research have a significant impact on education and should be reflected by lecturers at universities and managers in organizations responsible for professional development, and by experts responsible for lifelong learning development.

Keywords

Business University Students. Expectations of Continuing education. Delphi Method

INTRODUCTION

Internet penetration by country, household equipment with ICT, and experience with ICT use at home, at school and also at work or in leisure time are very important prerequisites for many everyday activities and life in society today (cf. Eurostat, 2018). Continuing professional development is the ongoing process of developing and maintaining professional knowledge and skills. It is absolutely necessary for university graduates and for this purpose it is important to identify which learning methods will be important for young people in their future life after graduating from university.

For graduates, both professional development supported by their employer, and also development that will be part of their own lifelong learning activities will be important. The strategy of Lifelong learning needs to answer the growing need for different types of e-learning for many jobs. The CEDEFOP study (2018) indicates that from 1997 to 2017 the Czech labour market shifted from medium to high-skilled jobs in industries such as

manufacturing, IT and services. Thus, demand for a highly skilled workforce is steadily increasing.

The purpose of this research is to identify what kind of further education will be preferred by young people, university students, in their future life and to understand what students really think about lifelong learning in the context of the knowledge society in the 21st century. The conducted research specifically focuses on ICT-related education. The study contributes to the literature on generations, particularly generations Y and Z, and the attitudes of young people towards lifelong learning.

THEORETICAL BACKGROUND

ICT (digital) competence

ICT competence has become an essential aspect of the teaching and learning toolkit in the 21st century and the last two decades have also witnessed the dynamic inclusion of ICT in higher education. It is also clear that the current higher education environment at universities demands ICT skills. Without advanced ICT skills, students are not able to successfully study at current universities (Eger, Klement, Tomczyk, Pisoňová, & Petrová, 2018).

Baleo and Mayo (2010) argue that the integration of ICT into universities is essential for the development of a university system in line with the requirements of the knowledge society. Based on the evaluation of many sources, Toro and Joshi (2012, p. 22) summarize: 'ICT provides student support services such as course outlines, digitally recorded classroom material, discussion groups, laboratory manuals and lab assignments, lecture notes, live lectures for later viewing and re-viewing, links to course specific websites, online tutorials, supplementary readings, and virtual office hours for teacher-student consultations.' New students' competences connected with ICT are needed when solving problem, communicating and collaborating through digital channels (Siddiq, Gochyyev, & Wilson, 2017). It may also be noted that these ICT (digital) competencies have become a prerequisite for their continuing education.

The importance of digital competence was recognised by the European Parliament and the European Council in 2006. Digital competence was identified as one of the eight key competences for lifelong learning and involves the confident and critical use of Information Society Technology (IST) for work, leisure, learning and communication (European Commission, 2014). Competence includes skills, knowledge and attitudes (Hatlewik, Gudmundsdóttir, & Loi, 2015, p. 346). This understanding emphasizes the student's ability to not only be skilled but also critical, responsible and creative in their use of ICT. ICT / digital competence is developed in various domains (at home, at school, among peers, in professional or leisure time settings) that interact with each other.

According to Hatlewik, Gudmundsdóttir, and Loi (2015), digital competence contains the skills, knowledge and attitudes that make students able to use digital media for participation, work and problem solving, independently or in collaboration with others in a critical, responsible and creative manner. Digital competence is developed in various domains (at home, at school, among peers, in professional or leisure time settings) that interact with each other (cf. Guzmán-Simón, García-Jiménez, & López-Cobo, 2017). Of

course, generally, for today's students (generation Z and Y) the use of ICT at home, at school or during their leisure time is a common matter.

Digital competence is in current situation precondition for further professional learning of young people. It is assumed that their level also affects what forms (types) of further education young people want to use in their future lives. The research is focused not only on expectations of business university students in this area, but also on the level of their consensus when they predict the types (forms) of lifelong learning.

Young people at universities

Young people at universities in contemporary society are commonly labelled as generation Y and (younger) generation Z. The rapid growth and common availability of computers, mobile phones and other devices facilitate web browsing, allow them to access social media and support their everyday communication.

Generation Y (Millennials) is characterized by the habitual use of ICT in their everyday life. Demographers and researchers define Millennials as born from 1981-1996, some of them end the generation in the late 1990s or early 2000s (cf. Howe & Straus, 2000). Due to the context of development (social, economic, technological) in the Czech Republic, students born in the early 2000s are considered as Millennials. Generation Y is the fastest growing segment of the workforce and represents a significant part of today's workforce (Kutlák, 2018). By 2020, this generation will account for more than a third of the global workforce (Manpower Group, 2016).

Oxford Living Dictionaries describes Generation Z as 'the generation reaching adulthood in the second decade of the 21st century'. | Generation Z is sometimes referred as Generation M or the Internet generation (Kutlák, 2018). The youngest Generation Z does not significantly differ from Generation Y in its values. This Generation Z grew up with technology, the internet, and social media. The most important factor for Generation Z is that they are looking for a suitable job, which means that they are able to rotate through many different jobs (Forbes, 2017). The question is how this fact can also affect their lifelong learning.

According to Linde and Greece (2014), expectations refer to the individual's anticipation of receiving something. De Hauw and De Vos (2010) demonstrate that Millennials have high expectations in areas such as job content, training, career development, and financial rewards. Gresse, Linde, and Schalk (2013) found similar results regarding university students, identifying expectations such as attractive remuneration, benefits, personal skill development opportunity, and career opportunity.

The following research question was developed from the literature review:

RQ 1: What expectations do business university students have regarding their further professional development and lifelong learning?

RQ 2: Is there a consensus among the business university students on their continuing education requirements after graduating?

METHODOLOGICAL APPROACH

This study is based on the Delphi method to identify university students' expectations regarding their future professional development and lifelong learning.

As was mentioned above, the Delphi method was used to address the research question. Delphi is a formal consensus method and a systematic means for measuring and developing consensus among participants regarding a particular topic (Egerová & Mužík, 2010; Green, 2014; Linstone, & Turoff, 1975). Using the Delphi method, researchers can obtain accurate data by means of questionnaires distributed to a group of participants. The Delphi Method is accepted as a useful method for solving problems, as a planning tool for forecasting future trends, and for recruitment purposes (Nevo & Chan, 2007; Humphrey-Murto & de Wit, 2019). This method uses a set of carefully designed questionnaires with summarised information and feedback of opinions derived from earlier responses of participants to gain new information about a particular topic (Green, 2014). The Delphi process is conducted over several rounds, initial and subsequent (Geisser, Alschuler, & Hutchinson, 2011). In this study, three rounds were undertaken and three panels of university students were used.

Panel Selection

The selection of the panel of experts (business university students) is a critical aspect of the Delphi method (Pollard, C. & Pollard, R., 2004). Expert panel selection in this study was based on the following criteria: the participant is a final-year business student (master's programme) and is seeking employment. The Delphi panels in this study consisted of 64 final-year faculty of economics students. All students represented Generations Y / Z.

The Delphi study used three separate groups. The first group was a pilot and had only 15 respondents, including 7 women and 8 men, 10 of whom worked at least part-time. In the second group, there were 24 respondents, of whom 19 were women and 5 were men, 18 of whom worked at least part-time. In the third group, there were 25 respondents, of whom 22 were women and 3 men, 22 of whom had at least a part-time job; in the third round the number of panellists in this group fell to 20. It is important to mention that 50 respondents already had at least part-time work. It shows that university students currently have work experience not only in practice and occasional work. Most of them are no longer in the role of university students, but as young workers they also know the corporate (organizational) environment, including how employees continue their professional development.

Rounds of the Delphi study

The first round (initial stage) constructed the issues related to the research. In this case, the participants were asked to indicate items that are important for young people when looking for further / continuing education (lifelong education) after graduating from university. More particularly, the following open-ended question was asked: 'What type of education do you expect to use in your professional development after graduating from university?'

The second round provided the participants with feedback from the first round and presented them with a questionnaire. Participants were then asked to rate the items on the questionnaire using a predetermined 5-point Likert scale ranging from 'Not at all important'

to 'Very important'. The Delphi moderator applied measures of central tendency to determine consensus from the second round.

The third round provided feedback from the previous round to reach a final consensus or indicate whether a consensus can be reached (Green, 2014). In our case, the participants were asked to indicate their agreement with the list of items formed in round two.

RESULTS

Each panel of respondents worked separately. However, Table 1 presents a list of all the items that the first round generated for all three groups.

Table 1. List of types (forms) of continuing education, three groups of panellists

Language courses	Workshops
PC courses (software training	Coaching and mentoring
Professional training in the company	Webinars
Certified courses	E-learning (online courses)
Internships abroad	Access to professional resources
Self-education and self-study	Gamification
Professional training, external courses	Case studies
Excursions	Job rotation
Trainee programs	Team building activities
Conferences	MBA
	Other university studies

Source: own

These 21 generated types (forms) of continuing education were created by joining only some items that were substantially the same. As can be seen from Table 1, there are also types (forms) of continuing education directly related to ICT such as PC courses, webinars, and e-learning (online courses). Of particular interest are the last two items in the right-hand column, which refer to the requirement for further comprehensive education at university, again finishing in a diploma. However, they were nominated in only one group, see below.

After the third round of Delphi, it was necessary to create the summary information, see Table 2. To prepare a final list, we used the outcomes of the third round and the first decisive criterion was always the "nomination" of the (type) form in the individual panel, and then a consideration of its significance was made according to the assigned sub-points.

Table 2. Final list of types (forms) of continuing education, three groups of panellists

Nomination, 3 panels	Order	Nomination, 2 panels	Order
Language courses	1	Certified courses	1
Professional training in the company	2	Job rotation	2
Professional training, external courses	3	PC courses (software training...	3
Internships abroad	4	Coaching and mentoring	4
Workshops	5	E-learning (online courses)	5
Self-education and self-study	6		

Source: own

In Table 2, quite surprisingly, students list language courses first. These groups of students are just finishing their university studies (?). It is obvious that professional courses will be very important for them. Under the term workshop, students usually consider activity in teamwork with a practical focus. However, in the left-hand column with nominations by all groups, are mostly the types (forms) of continual education associated with corporate training. This group of types of continuing education concludes with the fact that in all the panels the panellists were aware of the importance of self-learning. It means that students know that the ability to acquire the required knowledge and skills is also based on their own activity.

In the right-hand column, besides specific types of continuing education such as workplace rotation and methods (types) such as coaching and mentoring, we also find types related to ICT. In the left-hand column we can also find PC courses and e-learning (online courses). We emphasize that this is a naming of items by respondents, not a professional definition of forms or methods of continuing education, etc. The research was focused on the view of the target group on their further professional development and lifelong learning (RQ 1).

In relation to continuing education using ICT, webinars, or for example managerial games, received a weak evaluation by the target group. These educational activities are also usually associated today with the application of ICT.

What was the consensus among the business university students on their continuing education requirements after graduation in round three? (RQ 2)

Thus, to measure the degree of consensus in the ranking of the items across all participants within an expert panel, Kendall's coefficient of concordance (W) in Equation (1) was applied in the third round. Kendall's W ranges from 0 (no agreement) to 1 (complete agreement).

$$W = \frac{\sum x^2 - \frac{(\sum x)^2}{n}}{\frac{1}{12}k^2(n^3 - n)} \quad (1)$$

Notice. k = number of respondents (panellists), n = number of factors (Chráska, 2007)

Kendall's W for students of the first pilot panel was only 0.476, for the second panel 0.344, while that for students from the third panel was the best, 0.555. These calculated values indicate some levels of agreement between participants (judges).

Thus, to test the significance of W for results, the following formula was used.

$$\chi^2 = W \cdot k(n - 1) \quad (2)$$

The calculated value for all groups was greater than the critical value (first panel, 78.54 > 19.675, second panel 82.56 > 18.307, third panel 177.6 > 26.296, $\alpha = 0,05$); thus, we can declare a statistical significance and reject the null hypotheses.

DISCUSSION AND CONCLUSION

This study provides an insight into the expectations of university students (Generations Y / Z) when they think about their further professional development and lifelong learning.

The first research question (RQ 1) plays an important role in understanding what kind of continuing education business university students would prefer in their future life. To help them to maintain and develop their competence, employers and experts in education need to understand their expectations and use this knowledge in planning, organising, evaluating and developing suitable learning activities demanding by this target group.

The research was focused on ways in which students plan to apply their ICT competence in continuing education in their future life. The obtained results only partially confirmed the general assumption that young people (Generations Y and Z) in contemporary society are characterized by skilled use of ICT and prefer large implementation of ICT also in continuing education.

The findings in Table 2 show how respondents from the three panels listed types of continuing education. Analysis of the data indicates a variation in what students do and are able to perform in continuing education by using ICT. As mentioned above, in their choice, the students named these types of education in connection with ICT: PC courses and e-learning (online courses). Other educational activities, such as webinars, did not obtain the necessary evaluation from the respondent panels. The results show a moderate degree of consensus in the ranking of the items for the two main panels of respondents (RQ 2).

The results of the conducted research are also interesting in comparison with the Gartner prediction for 2020 in eLearning (Gratner, 2020). The prediction states: 'Like learning culture, the future of work is driven by the sense that skills quickly grow irrelevant'. The prediction also expected that social learning and mobile learning are actual trends. The research findings using the Delphi method show that students are aware of the need to innovate their knowledge and skills (competences) in future life, but they have not identified social learning or mobile learning as being important in their continuing education.

It is supposed that young people (Generations Y and Z) frequently and intensively work with computers, mobile devices, and the Internet. Previous researches (e.g., from the USA, the UK and South Africa, Jones, Ramanau, Cross, & Healing, 2010) noted that young students (digital natives) may have very different levels of command of ICT. For example, Bruneel, De Wit, Verhoeven, & Elen (2013) observed that students with more ICT experience did not show increased levels of expertise with all types of ICT. Research by Eger et al. (2018) also indicated a considerable variation in what students do and are able to perform with ICT. Further research is needed. What impact will these different levels of command of ICT have on their further professional development and lifelong learning?

The obtained results have a significant impact on education and should be reflected by lecturers at universities and managers in organizations responsible for professional development, and by experts responsible for lifelong learning development. The results also show that it is necessary to look in more detail between a student's ICT competence and the offer of continuing education. As mentioned above, the research was focused on business university students, many of whom were already working. It is also necessary to pay attention to people from the group called NEETs (Tomczyk et al., 2018) and to compare the findings of this research with the expectations of a different group of young people.

The present research has certain limitations. First, this research focused only on business students from one university in the Czech Republic. Second, the sample of students in the Delphi study is small. Finally, the scope and depth of the discussion in the paper is compromised by being confined to the selected resources.

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Moodle as a Platform for an Online Reading Comprehension Competition

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Abstract

The article reports the experience gained while organizing a regional online competition in understanding English texts for high school students in the Pilsen region, the Czech Republic. The competition was conducted using the Moodle learning management system (LMS). Two successive years of the competition have been performed and the competition has been gradually improved, receiving feedback from pupils, teachers and the evaluation of learning analytics. In the first year of the school year 2018/2019, the competition was entered by 1105 students from 27 schools, and in the second year, 1707 students from 20 schools. There were four school online rounds, an online semifinal and face-to-face finals. In the school rounds, the competition was supervised by trained teachers in schools. Pupils could access the online system from the school computer room or from mobile devices (tablets, smartphones). The semifinals and finals at the University of West Bohemia in Pilsen were attended by the winners of the school rounds. The article describes the division of students into categories according to the type of school and age and presents technical solutions in the form of online test tasks in courses in LMS Moodle, as well as possible prospects for future years of the competition.

Keywords

Online Competition. Language Experience. English Text Comprehension. Moodle Learning Management System. LMS. Learning Statistics. Pilsen Region. M-Learning. MALL.

INTRODUCTION

During the year 2017, representatives of the Pilsen Region Regional Authority from the Department of Education, Youth and Sports contacted the Lifelong and Distance Learning Department at the University of West Bohemia (UWB) in Pilsen to inquire about the possibility of an online English language contest for high school students in the Pilsen region. The competition was aimed at all high school students regardless of their level of English. Therefore, the Institute of Applied Language Studies was invited to participate in the organization of the competition as a guarantor of language proficiency, language testing as well as preparation and realization of the finale. The Lifelong and Distance Learning

Department provided the technical implementation of the online competition and the organization of the finals at the University of West Bohemia. The Pilsen Regional Authority helped with the promotion of the competition and provided the necessary funds for the preparation and implementation of the competition.

Since several other competitions had already been taking place in the region, it was agreed to organize a competition on understanding English texts. As the goals, study materials, methods, and often the knowledge of teachers themselves may vary from to school, we proceeded to use a taxonomy for text understanding (Hillocks and Ludlow, 1984; Fitzpatrick, 2008). The taxonomy helped us conduct an initial analysis to set up categories according to school type and student age (to determine/estimate their level of English). The types of schools which took part in the competition were: grammar schools, technical schools and vocational schools. The categories used and their descriptions are shown in Table 1.

Table 1: Categories according to school type

Category	Description
1A	students of grammar schools 1st–2nd Year (5th and 6th year - 8 year study programme)
1B	students of grammar schools 3rd–4th year (7th and 8th - 8 year study programme)
2A	students of technical and vocational schools with matura exam 1st–2nd year
2B	students of technical and vocational schools with matura exam 3rd–4th year
3	students of vocational schools

The online competition was prepared and executed in LMS Moodle (Moodle, 2010). The competition was called “KONTEXT - Regional Online Competition in Understanding English Text” (kontext.zcu.cz, 2018). The organizers of the competition invited high schools in the Pilsen Region to participate in the planned competition. Eventually, 27 schools entered the KONTEXT competition in the school year 2018/2019 – 6 grammar schools and 21 technical schools or vocational schools. Since some high schools and apprenticeships have been merged in the Czech Republic in the past years, there are often several types of schools within one institution. Thus, one school can enter multiple categories of the competition at the same time, e.g. 2A, 2B and 3.

A different topic was chosen for the competition each year. The topic of the KONTEXT competition for the school year 2018/2019 was “Planet Earth” and for the school year 2019/2020 it was “New Technologies”.

THEORETICAL CONTEXT

The initial idea of the KONTEXT competition was to allow high school students in the Pilsen region an opportunity to compare their reading comprehension skills in online tests. Worm and Buch (2014) note that competition is a natural aspect of our lives, including our education, and highlights the importance of challenge as a motivating factor. The results of

their research study tap into an interesting conclusion that competition in an e-learning setting might be a very vital part of students' motivation. Liu and Young (2015) focused their research on motivation in an online reading contest. They discuss the two different types of motivation: intrinsic and extrinsic. Intrinsic motivation involves positive emotions generated internally when someone takes part in an activity; the good feelings are enough to motivate the person. On the other hand, extrinsic motivation refers to the external reasons what are the ideas from the outside world that motivate and stimulate somebody to take part in an activity, i.e., a prize or a reward. The results of their study demonstrate that "when students had a higher intrinsic motivation, they performed better on comprehension tests (Liu, Young, 2015, 58).

To test a high number of students from different schools in the Pilsen region, it was decided to hold the competition online. Nowadays, online English testing has become a common practice (Gokturk, 2018). When it comes to testing reading comprehension online and reading strategies, Kobrin and Young (2010) conducted research where they examined the impact of paper-based and computerized tests. The results of their research study show that the difference in reading strategies between computerized and paper-based reading comprehension tests was not significant. Besides, according to Yu and Zhang (2017), using technology for testing purposes is very efficient when it comes to testing development. The same authors suggest that technology is no longer perceived as a tool for testing, but as a part of the test: a test format that is tightly linked to the tested language skills.

The organizers of the KONTEXT competition decided to deploy the e-learning platform Modular Object-Oriented Dynamic Environment (Moodle), which has become the most popular online platform (Chang and Lan, 2019) since it was launched in 2002. For instance, some studies (Kargiban and Kaffash, 2011) indicate a positive attitude of students to English learning via Moodle. In addition, the study of Chang and Lan (2019) show that Moodle is a useful tool for reading comprehension, and the results of their research demonstrate that the implementation of Moodle could improve reading comprehension skills.

The participants of the KONTEXT competition could take part in the competition using school computers or mobile devices. Using mobile technology such as tablets or smartphones in language learning is referred to as Mobile-assisted language learning (MALL) (Wang, 2016). According to Wang (2016), several studies have demonstrated that mobile devices have a positive impact on the development of reading comprehension skills. Ling (2016) claims that the experience of taking a test on a desktop computer or a tablet is very similar. Moreover, according to Ling (2016, p.1035), "Mobile technologies have been found to be effective in improving language learners' reading both cognitively and affectively."

METHODOLOGY

Text preparation

In 2018, a team of five English teachers, who work at the Institute of Applied Language Studies at the University of West Bohemia, prepared 112 texts. Since all the texts were required to be science-related, "Planet Earth" was chosen as the main theme of the first edition. So as to challenge the students as well as broaden their horizons, the text designers decided to use authentic online news sources, e.g. www.share.america.gov,

www.voanews.com, www.washingtonpost.com, and www.nytimes.com. The chosen news dealt with the topics of pollution, energy sources, fossil fuels, climate change, global warming, the Paris Agreement, environmental law, and others.

After appropriate texts had been selected, their levels were adjusted so that they were within high school students' capabilities. This was done by adapting the vocabulary and grammar structures within each text. It was also decided that every round would increase the difficulty levels so as to challenge the students. The division of levels according to the Common European Framework of Reference for Languages – CEFR (CEFR, 2007) during the first edition of KONTEXT is presented in Table 2 below.

Table 2: Division of levels in rounds 1-4

	Category 1A	Category 1B	Category 2A	Category 2B	Category 3
round 1	A2	B1+	A2	A2+	A2
round 2	B1	B2	A2/B1	B1	A2/B1
round 3	B1/B2	B2/C1	B1	B1/B2	B1
round 4	B2	C1+	B1/B1+	B2	B1/B1+

Apart from using their own linguistic knowledge and personal experience to simplify the texts, the team utilized an online *text inspector* (www.languageresearch.cambridge.org/wordlist/text-inspector), which classifies words by their level. Thanks to this tool, the process of vocabulary level analysis was accelerated.

Competition structure

The competition is divided into several rounds – see Table 2. The first four rounds of students took LMS Moodle tests remotely from their home institutions, one round each week. After four rounds, the most successful students were invited to the fifth round, which was again an online test in LMS Moodle. The final round was in the form of an oral test in front of a committee.

Table 3: KONTEXT competition structure

Round	Description
Round 1	via LMS remotely from school (1st week)
Round 2	via LMS remotely from school (2nd week)
Round 3	via LMS remotely from school (3rd week)
Round 4	via LMS remotely from school (4th week)
Round 5	via LMS at the University of West Bohemia in Pilsen
Round 6	final oral part in front of a jury at the University of West Bohemia in Pilsen

First year

Each student participated in four rounds (one per week) of the competition – see Table 3. All rounds included an online reading comprehension test which had to be taken during class time and students were allowed to take part in the test using school PCs or tablets. For the first two rounds, the students were given 15 minutes to read a half-page-long text and

answer 3 true/false and 2 multiple-choice questions with only one correct answer. To increase the difficulty levels in the last two rounds, one additional exercise was added. Two words were removed from every single text for the students to fill in. To decrease the number of possible answers, the students were always given the first letter. After the four rounds, the students with the highest scores were invited to participate in the finale, which was held in April at the University of West Bohemia. The finale was divided into two main parts — a reading comprehension test and an oral examination. The English proficiency levels that were determined for the finale are detailed in Table 4 below.

Table 4: Division of levels for the finale

	Category 1A	Category 1B	Category 2A	Category 2B	Category 3
reading comprehension test	B2+	C1+	B2	B2+	B2
oral examination	B2+	C1+	B2	B2+	B2

To maintain consistency, the reading comprehension test resembled the tests that the students had taken before. Nonetheless, in order to increase the difficulty levels, each test for the finale included a page-long text with two missing words for the students to fill in and 10 questions (5 true/false and 5 multiple-choice). It is also worth mentioning that the students were given 20 minutes to complete the task.

Having calculated the results, the computer identified the 25 best students (5 from each category) to take part in the final oral round. The Institute of Applied Language Studies selected 5 professional juries (each of three English teachers), who evaluated the students' performance during the final round. In order to remain objective, the juries provided all the students within one category with the same text and questions. Firstly, each participant was given a page-long text with six removed clauses to be filled in; the task had to be completed in maximum 10 minutes. Secondly, the results were presented in front of the juries; it is important to mention that the contestants could receive 1 point for each correct answer. Then, each jury selected three out of the six clauses and asked the students to justify their choice (each justification was assigned the maximum of 2 points — the more detailed the justification, the higher the score). Finally, after evaluating the students' justifications, each participant was asked a series of eight open questions concerning the text content. The juries could award each student with the maximum of 8 points (one for each question) depending on how detailed their answers were.

Second year

The second edition of the KONTEXT reading comprehension competition in 2019 revolved around "new technologies". Different authentic online news sources were carefully selected in order to cover topics such as virtual and augmented realities, nanotechnology, artificial intelligence, social media, new technological solutions, and others. Since the number of participants increased significantly (more than 1700 students), the test designers prepared 164 texts of different levels whose division is presented in the table below. Having analyzed the results of the first edition, the test designers agreed to increase the proficiency levels for the category 1A.

Table 5: Division of levels in the 2nd year of the competition

	Category 1A	Category 1B	Category 2A	Category 2B	Category 3
round 1	B1	B1+	A2	A2+	A2
round 2	B1+	B2	A2/B1	B1	A2/B1
round 3	B2	B2/C1	B1	B1/B2	B1
round 4	B2+	C1+	B1/B1+	B2	B1/B1+

Due to the increase in the number of participants, the selection of the 25 best students for the final oral part posed a much greater challenge. For this reason, a few changes were introduced so as to decrease the number of students who would receive the same number of points. For the first two online rounds, the students were provided with a page-long text followed by 6 true/false and four multiple-choice questions with only one correct answer. Since the tests were significantly extended, the time limit for their completion was also increased to 20 minutes. Furthermore, an additional “fill in the gaps” exercise that followed the pattern that was already utilized during the first edition was added in the last two online rounds.

The difficulty levels and the rules of the finale remained unchanged, with one slight improvement in the reading comprehension test. In order to be able to select only the 25 best students for the final oral examination, the organizers decided to use the weighted arithmetic mean to count the students’ results. Each “fill in the gaps” exercise contributed more to the final score than each multiple-choice question, which contributed more than each true/false question.

Since the organizers experienced difficulties choosing the winners during the first edition and the number of participants significantly increased in the second one, the test designers decided to address the issue and introduce some changes in the tests so as to facilitate the process in the second edition. The changes turned out to be particularly helpful, as the issue did not reoccur. It is worth noticing that some further adjustments are being taken into consideration for the third edition. It has been noticed that the exercise with six removed clauses to be filled in should already appear in the four online rounds; it is believed that this would increase the consistency of tasks and the students would be able to practice this type of exercise before the oral part.

RESULTS AND IMPLICATIONS

Modifications applied to the second year of the competition

The score for the first four rounds of the first year of the competition was set at 5, 5, 7 and 7 points, with a time limit of 15 minutes for each round. For the next edition of KONTEXT 2019, this scattering with little variance proved to be insufficient to unambiguously distribute students' knowledge and select them for the semi-final fifth round. Therefore, in the second year the scores for individual rounds were increased to 10, 10, 12 and 12 points, with a time limit of 20 minutes for each round.

A fair comparison of the quality of teaching and student knowledge from different schools in the same categories was not possible in the first year because some schools sent

only the best prepared students to the competition, while other schools enrolled whole classes. The average of a larger number of students was thus significantly lower than the elite selection. For this reason, the Pilsen Region Authority issued a recommendation for the second year that fewer schools could participate in the competition, but always with whole classes. Therefore, only 20 schools enrolled in the second year (of which six were grammar schools), but the participation of students increased from the original 1105 to 1707 – see Table 6.

Table 6: Comparison of KONTEXT 2018 and KONTEXT 2019

	Kontext 2018		Kontext 2019	
	Schools	Students	Schools	Students
Category 1A	7	205	6	276
Category 1B	7	166	6	284
Category 2A	17	372	11	513
Category 2B	19	322	11	518
Category 3	6	40	6	116

In addition, based on the first year of the competition the preparers of the English texts and tests decided to modify the English level CEFR and the structure of the English texts – see the Methodology section.

Moodle implementation

The existing LMS Moodle, which has been operated and upgraded at the University of West Bohemia since 2009, was chosen for online testing of students in the KONTEXT competition. The system is normally used internally; however, external students can enter the LMS, for example, for lifelong learning programs and courses prepared for the business community.

External accounts “student1” - “student1763” were set up for the purpose of the competition, each with its own access password, which was gradually assigned to competitors from individual schools. Within the system, it was only possible to see the students’ school, not their names. The identification of the contest accounts with the students’ names was kept in a document that was not part of the LMS.

A separate course category “KONTEXT” was allocated for the competition in the LMS Moodle, which was further divided according to the enrolled schools, i.e. each school had its own category in LMS. Once the individual categories were set up, the reading competition tests were uploaded. One course corresponded to one school registration in a competition category.

Initially, there was a little concern about the ability of LMS Moodle to cope with the burden generated by the competition. The server on which the LMS is operated at UWB is the older Dell PowerEdge R420, 1U version with 1xCPU Intel Xeon E5-2420 1.90GHz (12 cores) and 16 GB RAM. In the event, it proved to work well. The load generated by the competition was not cumulative, but it spread over the first week of the first four rounds; see Figure 1, which shows the number of activities of the KONTEXT students in LMS Moodle.

Hour / Day	04.11.2019	05.11.2019	06.11.2019	07.11.2019	08.11.2019	09.11.2019	10.11.2019	11.11.2019	12.11.2019	13.11.2019	14.11.2019	15.11.2019	16.11.2019	17.11.2019	18.11.2019	19.11.2019	20.11.2019	21.11.2019	22.11.2019	23.11.2019	24.11.2019	25.11.2019	26.11.2019	27.11.2019	28.11.2019	29.11.2019	Σ		
6			2																								2		
7		57	9	15				46	87	1	36					93	36		27	137			5	44	6	63	21	683	
8	220	336	143	865	242			333	342	712	1128	334				201	516	460	1037	710			280	692	699	1168	120	10538	
9	848	333	134	783	209		6	1086	160	680	548	172				796	461	806	535	116			547	354	357	548	39	9518	
10	663	825	280	521	165			650	705	1151	177	17				822	911	949	261				679	901	1074	587	122	11460	
11	690	726	7	404	33		2	682	542	638	627	105	1	10		603	379	686	465	6			941	559	930	563	484	10083	
12	995	639	169	392	295			1127	643	775	603	692		28		1274	742	644	341	406	4	11		954	625	658	225	206	12448
13	502	327	350	429	185			477	489	460	167	405		12		523	231	257	410	399				633	339	265	375	300	7535
14	190	217	106	139	51			149	183	84	98	6		36		123	138	6	130	36			2	113	151	66	157	110	2291
15	9	20	3									5														8	12	57	
16						6																				5		11	
Σ	4117	3480	1203	3548	1180	6	8	4550	3151	4501	3384	1736	1	86	4435	3414	3808	3206	1810	4	13	4152	3665	4055	3699	1414	64626		

Figure 1 - Load distribution generated by students in the competition in 2019

The fifth semifinal round was held at the University of West Bohemia for the students who achieved the highest scores in the first four rounds. The students all took the test at the same time. The first year there were 80 students, and 56 students in the second year. The load generated by the fifth round was negligible.

CONCLUSION

Two years of the online KONTEXT competition, in 2018 and 2019, LMS Moodle proved to be a suitable platform for conducting a language competition aimed at understanding texts. It would most likely be an appropriate platform for testing other knowledge or skills, not just language skills.

In the preparatory phase of the competition, the authors of the article searched for publications reporting the conduct of other online reading comprehension competitions, in order to learn about the experience of others and possibly repeat established procedures. Unfortunately, we found no such publications. We managed to find another language-oriented contest with a broad international scope, which is organized by a company in the Czech Republic. However, apart from the competition, the company itself has not issued any publications.

Further research on the KONTEXT competition could trace and compare the results and/or progress of students who participated more than once in the online competition and also compare the performance of males and females. In addition, different research could aim at how much this technology is being used in regular classroom language learning and testing, and how it might affect performance in a competition such as KONTEXT.

Finally, further research could investigate the association between the participants' scores in the KONTEXT competition with their academic performance in English and the number of English classes per week.

In the absence of publications on LMS online competitions, we are still learning and collecting "on the go" experience. Nevertheless, preparations for the third edition of the KONTEXT 2020 are already underway.

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Curricular Changes Through the Eyes of Teachers and the Results of a Case Study Testing Deployment of the Hour of Code

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Abstract

The paper is focused on the use, benefits and problems of the project Hour of Code and possibilities of its deployment in regular teaching practice at secondary schools (age 11-15). It summarizes the findings of a larger scale quantitative case study conducted by the author at a selected elementary school in the Czech Republic in 2015. The results are compared with two similar studies, which achieved the same conclusion, that a single Hour of Code lesson has a significant positive impact in terms of pupils' attitudes and motivation towards programming, but it does not improve pupils' algorithmic development thinking and programming skills. Part of the study were also qualitative interviews with two information and communication technology teachers at the school. The same teachers were approached again in the year 2020 and the development of their opinions has been evaluated based on their previous interviews in the light of upcoming curricular changes, that are happening worldwide. The results show, that in spite of Czech Ministry of Education endeavours to propagate said changes, the teachers who are not actively participating in development and testing of new curricula and its supporting educational materials are unaffected. The final section of the paper presents the inbuilt e-learning capabilities and features of the project Hour of Code, and more specifically of the whole curricula created by the Hour of Code authors, the Code.org organization.

Keywords

Computer and Information Science Education. Visual programming. Hour of Code. Code.org. Qualitative and quantitative research.

INTRODUCTION

The rapidly increasing technological level is influencing our lives to much greater extent than ever before. Personal computers and smart mobile phones are no longer the only two gadgets in possession of general population. People's lives are now connected with a plethora of smart devices, ranging from small and personal wearables to whole smart homes, whose "significance is growing rapidly." (Alam et al., 2012, p.13) This development puts higher demands on the content of the school lessons and requires a shift of the topic of programming from universities to high schools and even elementary schools, which is in turn reflected by changes happening in school curricula worldwide.

Ever since 1980s there have been educational programming languages developed specifically for the purpose of teaching basic programming concepts and ideas. However, only in the last decade emerged the focus on implementing Computer Science

(CS, which includes and strongly depends on the subject of algorithmic thinking and programming) as a mandatory part of the school curricula worldwide. Because the focus shifted to the deeper understanding of the computer science, the educational programming languages and projects started to emerge in great numbers, including Scratch and Snap, Hour of Code, CodeCombat, OzoBot, even Raspberry Pi and others.

Curricular Changes Worldwide

Passey (2017) is in his study about CS in compulsory education curricula listing and discussing the essential arguments regarding the inclusion of the topic of computer science and then further analysing curricula of selected thirteen countries, but more importantly for the purposes of this paper, he is stating the importance of the pedagogic approaches: *"The pedagogic approaches that teachers and others use in supporting learners are likely to be crucial factors in terms of outcomes."* (p.430)

Based on the analysis of the current situation worldwide, Passey suggests several research questions that would help to address the need of effective CS addition in curricula, the most important ones for this research are: *"What forms of pedagogy can teachers deploy to best support the development of computational thinking, problemsolving and creativity through programming skills, for the 5 to 16 year age range?"* (p.439) and *"What approaches enable learners of different ages to engage with CS or computing? & In what ways can this interest and engagement be maintained?"* (p.439)

Currently, the compulsory curriculum in the Czech Republic is undergoing major changes with regard to the subject of information and communication technologies. We can see the same downwards shift in terms of when the algorithm development and programming is being taught as in the rest of the world. The introduction to the basics of algorithm development and programming is taught at elementary schools, which in the Czech Republic consist of primary (ISCED-1) and secondary school (ISCED-2) and the mandatory content of the lessons is given by the Framework Education Programme.

Unfortunately, in the still valid version of the Framework from June 2017 (Národní ústav pro vzdělávání) the field of computer science is utterly obsolete and insufficient. The new conception of the field is presently under development (Národní ústav pro vzdělávání, 2018) and the ongoing changes are aided by a project called PRIM (acronym, that can be translated as the Support of Development of Computational Thinking), which focuses on creation of new educational materials for teachers, thus addressing the complete lack of such materials so far. Even though the lessons are becoming more Computer Science oriented, traditional name Information and Communication Technology (ICT) remains common and as such it is used in this paper.

Project Hour of Code

All these changes are connected with a search for a suitable programming language or project, that would enable effective education process. Asking the same questions as Passey, the project Hour of Code was selected by the paper's author for his research as one of the most influential options even five years ago in the year 2015, when PRIM was at its

very beginning. One of the demands, that influenced the choice was the fact, that the Hour of Code is tutorial-based e-learning style project which enables the teacher to approach pupils individually without slowing down the rest of the class.

Project Hour of Code was created by Hadi Partovi in 2013 with a main goal to present the topic of programming to the general population, including girls and minorities. At the time elementary schools were teaching the topic only rarely, but Hadi Partovi wanted to include at least one hour on every school to show that this topic is nothing to be afraid of. In his own words *"In one hour you are not gonna become a software engineer [...] but in one hour you'll learn that computer are fun. [...] Mostly than anything else, you'll learn that computer science is easier than you think, it's more fun than you think and that your eight year old daughter can do it."* (TEDx Talks, 2014) In the same speech he also states, that just one hour *"doesn't teach that much."*

The same information is also published directly at the project's website: *"The measure of success of this campaign is not in how much CS students learn - the success is reflected in broad participation across gender and ethnic and socioeconomic groups."* We can thus infer, that the main focus is put on the motivation factor and the skill level is seen as a subsidiary factor, that is not supposed to change in any significant way by absolving a single hour.

The project Hour of Code and its use in regular teaching practice on elementary schools in the Czech Republic present a number of questions: Is the project Hour of Code truly usable worldwide (e.g. can it be effectively used in the specific environment of the Czech Republic)? Does it motivate the pupils in the Czech Republic to the same extent as the pupils in the USA? Is the project still relevant, even eight years after its origin? What do the teachers think about the project with regard to their lessons?

METHODS

To answer the aforementioned questions a selected elementary school in the Czech Republic was approached and a pedagogical experiment was conducted on the secondary school pupils in the school year 2014/2015 as a part of the author's diploma thesis research (Hornik, 2016). Because of the number of computers, pupils in the school were divided by gender for their IT lessons, which spanned two regular lessons and are taught to the given group once every two weeks (groups of girls and boys are alternating on weekly basis). At the time of the research, the topic of programming was not taught at the school in any way and this was the first encounter for both teachers and most of their pupils. The whole study consisted of qualitative research based on semistructured interviews with teachers and quantitative research conducted on pupils with data gathered by means of pre-test and post-test questionnaires, where individual pupils were anonymously identified by a randomly assigned random number. There was an option to follow up the sample Hour of Code lesson with another lesson in three of the classes. Scratch was used for this purpose, however, findings from this extension was not included in questionnaires and as such it is not part of the presented findings.

Complete questionnaires with exact formulation of all the questions and reasoning behind their use as well as questions for interviews are published as a part of the author's publicly available and successfully defended diploma thesis. All the gathered data are part of the appendix.

Quantitative experimental study

Research design of the quantitative part was based on two complementary questionnaires, pre-test given to the pupils at the beginning of the lesson and post-test at the end of the lesson. The lesson itself consisted of the original Hour of Code complemented by online Lightbot for faster pupils. The whole research sample was comprised of two pilot groups with the total size of 19 pupils, two control groups with the total size of 23 pupils and nine experimental groups with the total size of 104 pupils. Out of these 104 pupils five pupils did not send the post-test questionnaire and one pupil intentionally sabotaged all his answers (answering nonsensically "bagr" to everything).

Both questionnaires were constructed of various question types, including attitudinal Likert-scale questions, open-ended questions and selecting answers from a given list. Both questionnaires were concluded with two test questions focused on proving basic algorithm understanding on simple tasks. Not counting gathering basic information about the pupil (their randomly assigned number, age, class and sex), the first questionnaire had nine questions and the second one had ten questions.

Questions in the first questionnaire were focused on surveying existing preconceptions of the pupils about the topic of programming. Pupils were asked to select on five-point Likert scales how much do they like ICT lessons and how important is the subject of ICT according to them. Then they were given an open-ended question to explain in their own words, what do they imagine under the term "programming" and if they have already encountered the topic somewhere. Last personal questions were about selecting their other ICT interests and answering whether or not they would like to try programming in their lessons.

Both testing questions were open-ended. The first task was to navigate a mouse on a short path to the cheese (the pupils were encouraged to think of a "trick" to make the instructions shorter, which should have been a simple cycle), whereas the second was to explain someone, who has never before seen a road and cars, how to cross the road safely. Purpose of these questions was to determine the quality of instructions, which were in both cases extremely simple algorithms that can be created in one's own words without any prior knowledge of programming and algorithmic constructions.

The second questionnaire started with the same basic information questions and continued by pupil's evaluation of the lesson on a single five-point Likert-scale question. Same question about defining the "programming" was asked again in order to find out how did their understanding shifted during the lesson. Pupils were given two questions about their progress in the Hour of Code in order to determine their overall work speed. In order to confirm positive attitude towards the topic of programming, pupils were asked whether they would like to continue with such lessons and whether they would like to join a programming or robotics extracurricular group (thus proving their interest because in such a case they would have to sacrifice their free time). Skill testing questions remained same, only the mouse had a little bit longer path to cheese. In question about crossing the road, pupils should try to re-formulate their answers using newly acquired knowledge.

Qualitative interviews with the teachers

The school had at the time of the research only two ICT teachers. The qualitative part was focused on semi-structured interviews with the ICT teachers, where analogically to the

quantitative part there were two sets of questions, one for the interview before the teachers saw the lesson and one afterwards.

The first interview contained twenty-one open questions loosely divided into four categories. First category was assessing their teaching practice (how long are they teachers; if they have ICT qualification; how long are they teaching the subject and to what extent; what is the content of the lessons and if they can program in any language), after which the questions shifted to the particular topic of programming in ICT lessons (whether it is a part of regular lessons; what is their opinion about the inclusion of the topic and its possible positive and negative outcomes). The third category was focused on how do the teachers see their pupils (what are the pupils' abilities; are they interested in technologies) and the last part was about projects intended for teaching programming.

The interview after the sample lesson was shorter, with only twelve open questions divided into two parts. The first part was concentrated on the teachers' evaluation of the lesson (including the impact of the lesson on pupils and teachers' opinions about possible gender differences in programming) and the second part about the possible shift in their opinions and future teaching practice (if the lesson was beneficial and they intend to continue further exploration of the topic).

The follow-up interviews after five years were designed with a clear focus to compare the development of the teachers' opinions and their teaching practice since the research in 2015 in the light of upcoming major curricular changes. The goal of the questions was to determine whether the "common" teachers, who are not actively taking part in development and testing of new curricula and its supporting educational materials, are even aware of the changes happening on a national level and identify the streams through which they gathered the information. Following questions were used:

- How long are you a teacher and to what extent do you teach ICT? What are your other work duties?
- What is your opinion on including the topic of programming into regular ICT lessons?
- Do you include this topic in your lessons? If so, in what way and how much? What is your experience with pupils and how do they react on the topic?
- What do you know about current Framework Education Programme (national curricula) and about changes in the field of computer science and ICT?
- In what way will the mandatory inclusion of programming and algorithm development impact your lessons?
- How can you broaden your horizons in the field of ICT and programming? Were you offered any courses or materials?
- Do you actively search on your own for new content for your ICT lessons?
- Do you exchange your experience and materials with other ICT teachers on your school? If so, in what way and how often?
- Do you know something about project PRIM and/or the website imysleni.cz?
- In your opinion, what are the biggest complications for inclusion of the programming into regular lessons from the point of view of teachers and pupils?

- Would you, from the point of view of a teacher, prefer tutorial-based e-learning style of a project (such as Code.org courses) or a textbook with a lot of examples and readymade materials and tasks with solutions?

RESULTS

Findings from Pupils' Questionnaires

The quantitative part of the study was focused on the point of view and progress of the pupils. There were four initial hypotheses to be tested, which were all focused on aspects that could indicate positive preconditions for deeper understanding of programming and algorithm development thinking. The hypotheses were:

- H0: Completion of at least one Hour of Code would improve pupils' algorithm development skills.
- H1: The amount of importance that pupils put on the ICT is directly proportional to their success rate in defining what the programming is.
- H2: The broader the scope of pupils' ICT oriented interests is, the better is their algorithm development thinking.
- H3: The age of the pupils is directly proportional to the quality of answers.

Last three hypotheses are based on ordinal variables and according to Skutil (2011, p. 179) a suitable statistical test to measure their association strength is Kendall rank correlation coefficient. The hypotheses were tested by means of non-parametric Kendall Tau- α . The correlation between perception of ICT importance and understanding what programming is (H1) lead to the score of 0.03004, which means the lack of association between tested variables. Perceiving ICT as an important field does not lead to higher interest in the topic. In case of the H2 hypothesis the scope of pupils' ICT interests was compared with scores in all three test tasks, leading to value of 0.11583 in case of defining the term programming, 0.15741 in the task about a mouse and a cheese and 0.10072 in the instructions for crossing the street. Even though the numbers are still very low, they can be assessed as "*a very weak dependency*." (Skutil, 2011, p. 177) It indicates that the higher amount of different ICT interests could lead to better thinking in the terms of a computer. The same approach was used for the last hypothesis, where the age of the pupils was compared with answers in all three test tasks individually. Surprisingly the scores were -0.03737; 0.0014 and -0.0652, which are all values approximating zero, that means there is complete independency between the tested variables. Algorithm development thinking is a skill that must be learned, because it is not acquired as a part of the brain's maturation process.

The most surprising was the H0 hypothesis, where the initial scores of the test tasks in the pre-test were compared with the scores in the post-test. The only improvement could be seen in definition of programming, where the average score of 0.571 improved to 1.02, meaning that the understanding of the essence of programming was better. However, the average score in the task with the mouse and the cheese dropped from 1.051 to 0.52 and the average score in crossing the street was lowered from 2.734 to 2.329. This result can be probably accounted to pupils' exhaustion after the lesson during which they had to focus very hard the whole time, which is also what some of the pupils said during the break after

the lesson. Another issue is, that a single lesson is usually not enough to properly absorb new abstract concepts. Regardless the reason, we can state that a single Hour of Code does not improve pupils' algorithmic skills.

The authors of the project Hour of Code, founder Hadi Partovi and organization Code.org, are aware of this fact (as stated in the introduction), but their main goal is the rise of motivation and improvement of attitudes of pupils towards the topic. In order to ascertain the matter of pupils' attitudes, there was a question paired in pre-test and post-test regarding their interest in programming lessons that would be incorporated into their ICT lessons and post-test also contained a five-point Likert-scale evaluation of the presented Hour of Code lesson.

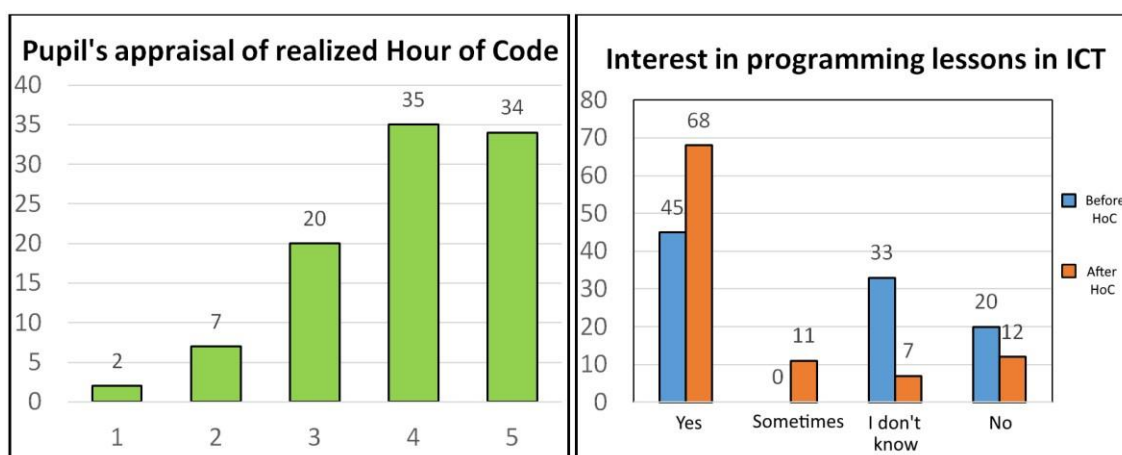


Figure 1: Evaluation of the lesson (5 is the best) and changes in pupil's interest

The results (in Figure 1) validate and support the Code.org claim, about significant improvement of motivation and the test tasks further confirm that the pupils' skills are not affected. At the time of the research in 2015 there were no other published researches that would be comparable with this one. The closest one in terms of research methods was Jie Du's study conducted on undergraduate university students. (Du et al., 2016) Despite the vast difference in target group, the study outcome was that *"the findings indicated the positive impact of the Hour of Code tutorial on students' attitude toward programming. However, the students' programming skills did not significantly change."* (p. 53)

Another research was Code.org's own study conducted by Phillips and Brooks (2017), where the attitudes were evaluated based on four four-point Likert scale questions. The question closest to this research question regarding interest of pupils' in studying programming as a part of their ICT lessons was *"I think computer science is interesting."* In this question the average Likert-scale rating aggregated from all age groups (ranging from elementary to high schools) shifted from the value of 3.18 before the Hour of Code to 3.34 after the sample lesson. If we evaluate our answer "Yes" as equal to 4 points on a Likert scale "Sometimes" as 3 points, "I don't know" as 2 points and "No" as 1 point, we get average score of 2.714 before the Hour of Code and 3.378 after, which is far more significant change fully supporting the conclusion that *"Given that most students engaged in tutorials for only approximately 40 minutes, these study results suggest that simple exposure to computer science, with the right activity, may be a critical first step to engage more students."* (Phillips & Brooks, 2017, p. 6)

Findings from Teachers' Interviews

The interviews were conducted with two ICT teachers, both of them without ICT teaching qualification. The interviews were fully transcribed, segmented and coded by key words according to Juklová (in Skutil, 2011). Complete analysis including observed extra-linguistic phenomena is published as the part of aforementioned diploma thesis.

One of the respondents was a male teacher with seven years of teaching practice (six years of which was teaching ICT), who was previously working as a military radio operator for twenty years. His teaching qualification is physical education. The lack of ICT specialization was clearly visible in most of the responses and in quite narrow orientation on simple use of basic application software. Before the Hour of Code his opinion was, that programming is completely unsuitable for elementary schools, on grammar high schools it would be just a diversification and it should be mainly on specialized IT schools. After he saw one of the Hour of Code lessons in one of his classes, his opinion changed only very little. The lesson was interesting for him and for the pupils, but he still described the project as *"just playing"* and *"variegation"* and he did not plan to incorporate the topic into his lessons *"until it is thoroughly tested."*

The second respondent was a female teacher with twenty-two years of teaching practice (fifteen of which teaching ICT). Her teaching qualification is chemistry and mathematics, although she signed for and passed ECDL exam (European Certification of Digital Literacy). Even before the Hour of Code, she displayed strong agreement with the necessity to include the topic of programming at least on high schools, however on elementary schools it could be problematic. After the Hour of Code, she assessed such lesson as entirely suitable for elementary schools but probably a little childish for high schools. She also stated, that she would not look for projects of this type on her own, but being introduced to it she intends to further explore the topic in the future.

Opinions and approaches of both teachers are diametrically different. However, both teachers unanimously agreed that teachers are generally overstrained and there is no time or energy to expand their area of expertise on their own. Only viable option would be a high quality professional training course (however, the male teacher also stated that he has no intention to learn programming). They also agreed in their evaluation of pupils, as mostly being relatively smart, but extremely lazy and too comfortable to think at all. Interesting contrast could be seen in gender differences. The male teacher described programming as *"boys' realm"* and interest of girls only as an exception, which is specifically one of the stereotypes Hour of Code is trying to break (Code.org, 2017). On the other hand, the female teacher evaluated potential of both genders as equal with the only difference of their approach. Boys were described as faster and more intuitive and girls as more thorough and precise.

After five years, the observed changes in teachers' opinions and lessons were only marginal. Neither of the teachers continued with Hour of Code and both reiterated same complications as five years ago (lack of time and energy caused by being overstrained by other school duties). Both teachers were also completely unaware of major changes in national education curricula (RVP) and emerging educational materials for teaching algorithm development and programming. In the course of last five years they were not actively looking for information regarding the inclusion of programming in ICT lessons and none was offered to them by any third party (such as in form of a training course).

If they had to add the topic into their lessons, both would definitely prefer interactive e-learning course for pupils to a set of materials in a form of a textbook. Even though their opinions on the inclusion of the topic also remained unchanged, there were significant changes on their school. A new ICT teacher was hired, who has Computer science teaching qualification and who has taken over eight and nine grades, where the programming is now being taught.

DISCUSSION

The follow-up interviews identified possible problems in modernization of ICT lessons, mainly the fact that the information about ongoing changes is not effectively delivered to teachers who are not actively participating in the development and testing of new teaching materials. They are not aware of project PRIM and its accompanying website imysleni.cz where the tested materials are published for free.

The published materials are thoroughly tested and suitable for teachers with Computer science teaching qualification, however, the problem of mandatory inclusion of programming is mainly concerning the teachers without it and teachers with outdated technological knowledge. In such cases, a viable option to printed materials could be an e-learning course for pupils in style of the Hour of Code (which both interviewed teachers confirmed). Organisation Code.org does not publish only short Hours of Code, but also creates complete courses in several languages with full e-learning support (creation of accounts, saving the progress of pupils and giving the teacher an option to create classroom to better monitor the pupils' work and problems). According to Code.org Summary Report (2016), the teachers feel confident to teach programming with their courses, which is supported by a study conducted in Italy. (Corradini, 2017)

Regular experienced and seasoned teachers often perceive Framework Education Programmes (RVP) as a formal matter which affects their everyday teaching only to the slightest of extent and as such after the School Framework is drawn (which is based on RVP) they do not feel the need to check it at all. Further interviews should be conducted with both experienced and novice teachers as well as with ICT teachers with and without Computer science teaching qualification in order to have representative sample large enough to determine final conclusions.

CONCLUSION

In the light of ongoing curricular changes and rising importance of computers in every aspect of human life, we can see overall shift of ICT lessons, mainly focused on simple use of computers, to Computer science style of lessons concentrated on much deeper understanding of the computers, including algorithm development and fundamentals of programming. The novelty of the topic and visually appealing programming environments, such as for example Hour of Code or Scratch, are positively accepted by pupils. Nevertheless, the significance of the choice of programming language and environment as well as specific tasks and especially the first encounter with the topic cannot be underestimated. Both printed materials and online courses should be objectively considered and carefully

selected. Hour of Code and Code.org courses are to be considered as one of the viable and tested options especially for less programmatically skilled teachers.

The results of the interviews suggest that the biggest obstacle in the process of incorporation of the new topic is the lack of ICT teachers with modern Computer science teaching qualification as well as the utter lack of time and energy to study new and complex area of programming, that can be observed in current generation of teachers. This requires a solution of an effective way of information delivery, that would be viable to most ICT teachers, possibly even outright mandatory.

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Extended Reality in Education

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Abstract

The scientific articles have been recently enormously devoted to the issue of augmented, virtual, and mixed reality and are already being fully established in our normal life. They infiltrated into gaming, industry, medical, manufacturing, etc. However, the area of education (especially in Slovakia) is still lagging behind and is influenced by the fragility of the underfunded system and the inability to respond quickly to today's needs. Educational gaps need to be sought and filled with meaningful projects, which can not only show the potential of all realities in IT, but also attract more young IT enthusiasts (or new future IT teachers or IT students in general) to Slovak education.

That is why we have been trying in recent years to look for a specific focus, where the area of education could be helpful and, at the same time, would shift our knowledge base a little further. 6 years ago, we started working with a psychotherapist to create models and applications for the treatment of various phobias and then we created an optional subject where students can learn how to create these virtual environments themselves. In the last year, we have managed to set up the important hardware for these ideas and currently we are fully engaged in the research, creation and education in this area. In the article, we also present the possibilities of our newly established laboratory, the aforementioned subject, as well as the outputs of student works that have been created over the past few years.

Keywords

Virtual Reality. Augmented Reality. Mixed Reality. Extended Reality. Education.

INTRODUCTION

The problem we are trying to discuss in our article is focusing on different kinds of realities, their understanding, the ability to create them and the possibilities of their use. In this article, we will look at the different resources that deal with all these aspects and we will focus also on the methods we use in education to bring this issue closer to students. Next, we will describe our work together with the presentation of results. Finally, we will evaluate the fulfilment of previously set goals and discuss today's problems as well as our vision for the future.

The rapid development of digital technology is forcing teachers to consider how new technologies, methods and practices can be applied to teaching to achieve higher quality of education. One such dynamic and prospective area seems to be the virtual and augmented

reality and their various combinations. The border between the virtual and real world continues to break down, providing breath-taking experiences that a short time ago could only be found in the imagination of sci-fi writers.

The basic concepts include the reality-virtuality continuum as can be seen in the Graphic representation of The Virtuality Continuum. Milgram et al. introduced this concept in the 1990s in their work (Augmented reality, 1994). Based on their idea, there are following forms of reality:

- Real Environments (RE),
- Augmented Reality (AR),
- Mixed Reality (MR),
- Augmented Virtuality (AV),
- Virtual Reality (VR).

Here are individual characteristics of each of the aforementioned terms.

By **Real Environment** (RE), we mean unchanged, unadjusted reality. A real environment is any environment consisting exclusively of real objects, including everything that can be seen when viewing the real scene directly or displaying it with some type of video display. Observing the real world through a phone or tablet does not make it virtual (Abdullahi, 2016).

Augmented Reality (AR) is a system that complements the real world with computer-generated virtual objects existing in the same space, combining real and virtual objects in real-time environments and allowing real-time interaction (Schmalstieg, Hollerer, 2016) (Bimber, Raskar, 2005) Azuma (Azuma, 1994) defines AR as a system or visualisation technique that fulfils three main criteria: a combination of real and virtual worlds; real time interaction; and accurate 3D registration of virtual and real objects. It is commonly accepted as a real-time technology whereby a physical environment has been augmented by adding/embedding virtual information in it (Enyedy et al., 2012).

Mixed Reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time. Mixed reality does not exclusively take place in either the physical or virtual world, but is a hybrid of reality and virtual reality, encompassing both augmented reality and augmented virtuality via immersive technology (Milgram and Kishino, 1994).

Augmented Virtuality (AV) is a type of environment in which the main task is to display real, physical information (objects or resources) to the virtual world. The task is situated in a virtual world and the user works with digital information by manipulating physical objects (Arnaldi et. al., 2018).

In Undersanding Virtual Reality Sherman and Craig describe **Virtual Reality** (VR) as a medium consisting of computer simulations, giving the user a sense of presence in the simulations (Craig, 2013). In other words, it is a completely virtual world made by a computer in which the user interacts only with virtual objects. Virtual Reality technology has traditionally consisted of cumbersome created environments and has often required complex sensors worn on the body of an individual in order to interact with the environment. The emergence of head mounted virtual reality devices is shifting the

technology into the commercial consumer area. In 2014 Facebook purchased the Oculus VR Company, and Mark Zuckerberg has stated that this form of virtual reality is the social platform of the future (Carter, Potter, 2016).

There is one more term, referring to all real-and-virtual combined 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 inputs to immersive virtuality. XR is a superset which includes the entire spectrum from "the complete real" to "the complete virtual" in the concept of reality–virtuality continuum introduced by Paul Milgram. 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 rapid growing field being applied in a wide range of fields, such as entertainment, marketing, real estate, training and remote work (Hui-Wen, 2018).

Mixed and virtual realities support in the immersive environment our feeling of presence and recreate our sensorial apparatus in the fictional featured space in which our entire body can interact with digital objects or assets (Intel, 2019).

VR has been the “next big thing” for several years, but its time has finally come as a way to generate realistic images, sounds and other sensations that put you directly in the middle of a spectacular imaginary world. AR, which adds virtual stuff to your real-world environment, is contributing to the buzz, and both technologies should become a big part of our future. With MR, you can play a virtual video game, grab your real-world water bottle, and hit an imaginary character from the game with the bottle. Imagination and reality have never been so intermingled (Gouveia, 2016).

WHAT BENEFITS BRINGS EXTENDED REALITY IN EDUCATION

All these technologies have an exciting impact also on education. They make the education system more attractive and entertaining. Students learn new things very fast as compared to traditional education system (Bernardo, 2017). Let us see what benefits XR technology brings to education.

Virtual reality in education

Steve Bambury produces new graphics detailing what he feels are the 10 Key Benefits of VR in Education (Bambury, 2019).

Global Teleportation – breaking down geographical boundaries. For a school this can be priceless as it means that students can virtually visit places that are beyond their means in the real world – whether that be on the other side of the globe or even on The Moon!

The Time Machine Effect – allowing students to travel in time and experience the past first hand.

Contextualised Learning – allowing students to actually see what cannot be seen in the real world (objects of micro and macro world, objects of the past and the future).

Multi-Sensory Experiences – being able to move within a virtual space and engage with elements, manipulate various objects and engage learners like never before.

Extraordinary Abilities – allowing students to break the laws of physics and to do the things they do not or cannot do in the real world. It opens up new learning possibilities in the classroom.

Active Autonomy – letting students go on their own journey, with a great deal of autonomy in how to engage with the content. This starts with the simple fact that they are able to choose where to look and expands when they are offered experiences which allow them to explore freely.

Empathy Agent – VR can be used to foster self-respect, evoke empathy and influence emotions.

Virtual Rehearsal – using VR to practice and hone skills without fear of failure. This is incredibly powerful and can help students build confidence in new areas of learning. It could mean for example using VirtualSpeech to practise public speaking.

Focused Immersion – The very nature of VR being framed inside a headset means that the learners are less prone to distractions in their physical surroundings. For some students this can be immensely beneficial as they may be prone to distraction leading to loss of focus and ultimately loss of learning.

Remote Presence – using VR to connect with other students as well as attend lectures and lessons delivered by educators across the globe. Multi-user, social VR platforms like Engage, AltSpace and more will become thriving hubs for educational content as the entire concept of what a school is and can be begins to morph into something truly new.

Augmented reality in education

Many development companies build commercial, educational and entertainment AR applications, which depict real life scenarios. They achieve this using improved and enhanced computer-generated sights and sounds. This is a huge multi-billion dollar industry with massive potential for the future. There are also many ways to use AR in education to achieve better learning process. The integration of AR into lectures and classrooms drives unparalleled attention from students. Here is a list of some of the benefits of AR application development in education (Harnil, 2018).

Nurtures the learning process – The introduction and use of AR in education creates fun and excitement for students. It stirs up their motivation for the learning process and pushes them into a learning place where they become critical in dissecting new ideas. Students improve their imaginative and thinking ability, they discover and get to know more about themselves through the learning process.

Increases student participation in classes – AR applications help students grasp concepts faster and easier through the provided models. They are eager to learn with a high level of curiosity. This results in active class participation increases student motivation and curiosity in the learning process.

Improved and increased memory – Students can access educative and learning AR models through scanning. AR apps helps students improve and retain their knowledge over time. This is possible due to the level of curiosity that comes with learning via AR. AR

stimulates high level of learning passion and inspiration in students. Thus, improves imagination which results in improved and increased memory.

Interactive lessons – The use of AR in education provides interactive lessons for students. They have full access to educative and interactive models on their devices. On the long run, this propels clear and better understanding of educational concepts.

Increased sensory development – The use of AR in education will enhance the mental and physical dexterity of students. AR gives students the privilege to see, observe, and feel at the same time while learning. In the long run, this results in increased sensory development.

Less expensive – The cost of acquiring educational materials, supplies, nature of 3D physical models, etc. is high. Difficulty is not only with buying, but also maintaining these materials. They can be damaged by years of use, lost or stolen. Some get worn out and others become outdated. AR once acquired does not need a lot of money to maintain, they do not get damaged, lost nor stolen. Students have access to AR learning models on the go, at home, and in the classroom. This reduces the expense of repetitive buying of learning materials. Thus, makes learning less expensive over time as there is no need to invest in physical materials.

Enriched ways of telling a story – The use of AR in education brings about enriched ways of telling educational stories. Through augmented reality, educational storytelling has become powerful thanks to visual models, which help bring to life educational concepts and the learning process. This all creates the impression of originality and realness for educational concepts.

Increased learning activity – Technology has become part of education. Today, students rely more on technology in everything which has contributed to the laziness noticed among students. Fortunate enough, AR apps in education cover the various lapses in educational technology because of their interactivity, learning process and fun experience.

Visiting the past, present, and future – AR in education exposes students to knowledge of the past, present and future events, giving them the opportunity to use the knowledge acquired to solve problems. Therefore, improves understanding and increases curiosity in the learning process.

Mixed reality in education

MR blends real-world and virtual content to create compelling interactive experiences. It offers fully immersive experience that requires students to wear an HMD (head mounted display) and a motion controller, through which they can interact with an environment produced by a mix of real and virtual worlds. Here, the physical and digital objects co-exist. Students can touch and manipulate objects generating a greater understanding of them, and they can interact with data sets, complex formulae and abstract concepts, which could be more difficult to understand through teacher's verbal instructions. For many students, in fact, learning by doing is easier than learning by listening. MR provides a more engaging, fun and effective learning experience than all the other traditional educational methods. MR gives professional educators new innovative possibilities to explore with their learners thanks to its features (Acer and Education, 2017):

Engaging – direct experience generates an effective way to captivate those students who struggle, or it can just provide another opportunity to boost the engagement during lessons at school.

Universal – regardless of social, economic or geographic disparities, MR at school brings people together and encourage human interaction.

All-purpose – MR can be used to teach any topic, because it is easier to see and hear something instead of having it explained, above all with abstract concepts.

Faraway worlds – using MR devices, students and teachers can go back in time, interacting with objects, animals or human beings that are no longer existing, for example dinosaurs and primitives, and get a new, more realistic image in learners' minds.

No geographical limitations – it is not always simple to plan the perfect school trip to pyramids or coral reef. Thanks to MR, the class has no more limits. Everything is possible wherever and whenever we like.

OUR METHODS OF TEACHING MIXED REALITY

Since 2016, our department has been teaching the subject "Virtual Reality", where students become acquainted with the area of VR. In the following years, when other related areas appeared, we also implemented information about AR and MR into our teaching. To support the subject, an electronic course in LMS Moodle is offered, in which students can find presentations, tasks, links to various websites and learning materials. Using video tutorials for each task, they build VR applications in Unity 3D, panoramic video and photography, to combine models and panoramic video, and to create AR applications too.

We decided to use Unity 3D software or Unreal Engine to create VR applications. We use Unity 3D with Vuforia framework to create AR applications, Action Director to edit and create videos captured by the panoramic camera, and GoProPlayer to play them.

As an example, we present a few applications in which the methodology of creation is briefly described and which students can follow during the learning of the subject, as well as in the creation of their final theses.

Methodology of creation VR applications helping with phobias

Clinical psychology describes phobias as an anxiety disorder, characterized by an intense irrational fear of specific objects or situations. This excessive amount of fear does not correspond to the potential amount of danger of stimulus. Despite the fact, people suffering from phobias experience intensive psychic symptoms (anxiety, loss of control, fear) and physiological symptoms (increased heartbeat, fainting, sweating, problems with breathing) etc. Within the subject of VR, students get acquainted not only with the process of creating such applications, but also with the demands that are required for them. Therefore, it is good if these applications are designed so that they can be controlled not only by the patient but also by the therapist. Thus, the therapist has the whole process under control. (Voštinár et al., 2019)

The methodology of creating applications most often consists of the following steps: specification of requirements and selection of hardware and software tools (we prefer to have a methodology that uses our purchased hardware and free software, which we

provided), creation of interactivity and application management. Here we take into account not only the comfort of patient control, but also the complete management of the treatment process by the therapist. Once the application is ready, it is tested. First in a school environment, where students debug each other's mistakes and improve their applications, and then the therapist himself has the opportunity to try the application. The last application he tested was the one of Arachnophobia with his daughter, who suffers from this disease. Experience with this application will be mentioned in the next chapter on learning results.

Methodology related to implementing MR to learning process

Another example is from the area of combining panoramic video, captured in the real world, and an animated model of an object. The process of creating a MR depends on circumstances, but in general consists of several steps. First, markers must be placed on the contrast points in the movie - the number of them depends on the video capture technique. After placing enough tags, we can track them. An important step is to set the camera parameters. We must ensure that the virtual camera in the program has the same parameters as the camera with which we record the video. Then the program calculates the movement of the real camera based on the amount and quality of the traced tags. The calculation result in information on the size of the deviation. In the next step, the scene should be prepared so that the 3D object could be placed in the video, which included dividing the scene into the foreground and background. Then the 3D model should be imported into the scene and placed in the desired position, rotated correctly, and resized to fit the video exactly. The lighting for the scene is provided using two lighting methods, which are combined to create the same lighting conditions as in reality. The first method is IBL (Image-Based Lighting), which uses image information from real photography to illuminate. As a second method, the virtual illumination found in the program is used. Finally, the scene is rendered into the resulting panoramic video enriched with an artificial 3D object. (Voštinár et al., 2019)

Methodology of creation AR applications

The third methodology captures the process of creating AR applications (Horváthová, Blšák, 2019). To create AR applications, we use the Unity3D game software with the Vuforia library, which has been directly integrated into Unity3D since Unity 2017.2.

First you need to create a hierarchy of scenes. We insert GameObjects (2D or 3D) into each scene, which form the content of the scene. These are various graphic elements that can be visible and invisible. For buttons and other objects to work, we need to assign them an action that we program in C#. These are scripts that have different functions - view, activate, print, save, check. We must assign a method contained in the script to each GameObject. The final step is to complete the data needed to run the program such as application name, application icon, operating system version, and other specifications, and subsequent compilation.

LEARNING RESULTS

Over the past six years, a number of applications have been developed at our department aimed at using various realities (VR, AR, MR) in multiple areas. We began in the field of phobia treatment with VR, for which we were inspired by expert psychotherapist

Ján Záskalan. Based on his inspirational ideas, we started creating applications, object models and environments to treat agoraphobia, hypsophobia, claustrophobia, arachnophobia, etc. We gradually analyzed various methods of creating objects and phobia environments, such as: 3D modeling, animation, photography and filming with a 360° panoramic camera and adding (combining) such an environment with animated objects, creating a virtual environment, or enriching the real environment with digital objects and so on. (Horváthová, Siládi, 2016) The laboratory that we have built in recent years contains for example a set of HTC Vive glasses with drivers or previously mentioned other devices. In addition to immersion into the virtual environment, it also enables various interactivity with virtual environment objects.

Results of treatment with support of VR

Testing of the application Arachnophobia was carried out in the laboratory of virtual reality and exploring the user experience at our department on a sample of 33 respondents, who completed our electronic questionnaire. The largest group of respondents were secondary school and university students and also some teachers of the department and faculty staff participated. A very important volunteer was the psychotherapist himself and his 12-years-old daughter, who suffers from arachnophobia. Of these 33 respondents, 24 were men and 9 were women between 12 and 65 years of age, with the highest age share between 21 and 25 years. This was a relatively well-balanced sample of respondents suffering from arachnophobia (21.21%), claustrophobia (9.09%), social phobia (3.03%), unspecified phobia (6.06%), and totally healthy people (60.61%). Nearly half of them (45.45%) have experienced some type of VR technology before. On average, the duration of testing an application in a virtual environment was approximately 16 minutes (ranging from 8 to 80 minutes). More detailed feedback from this research is described in our next paper (Voštinár et. al., 2020)

Here are some examples of environments and applications that were created within the course Virtual Reality or as final theses of students of applied informatics.



Figure 2 Arachnophobia VR application

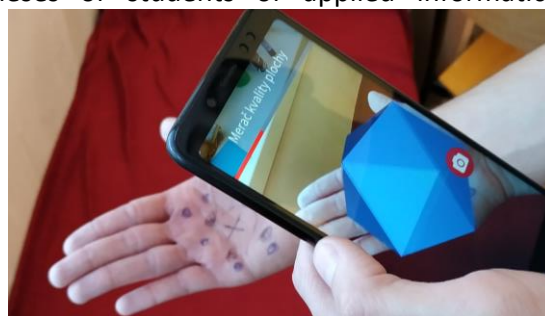


Figure 3 Platonic bodies AR application



Figure 4 Example of MR environment



Figure 5 Basketball VR application

DISCUSSION

We use the field of XR in education mostly because we are an educational institution, which wants to keep up with modern emerging technologies and has the ambition to closely link the process of education with practice. It is the education that supports our efforts to create applications for various areas. Today, XR applications for education transform the educational sector. The benefit of these technologies in education could be tremendous. We just have to grasp it well in our hands. We believe that XR will continue to transform education and the learning process itself.

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Assessment of Student's Perception on the Teaching Process

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Abstract

This paper focuses on evaluating students' perception of the opportunities offered by the higher education institution into which they are enrolled. The main purpose is to present the results obtained from the market research, the empirical experience and the evaluation of the statistical data recorded by the faculty website. The research is based on market research through questionnaires and in-depth interviews. Market research was conducted between 2015-2019, and the data are evaluated by comparison. The target group, used in the application of questionnaires, consists of students attending a technical university in Romania. The target group, used in the application of in-depth interview, consists of 10 professors who teach in the faculty. The results of the research show that the most important motivating factors are: teacher, teaching method, technology and infrastructure of the educational unit, and reputation of the university and the faculty. There is interest in research if students intend to pursue doctoral studies. At the end of the paper, an avatar of the student is presented based on the market research conducted. At the end of the research, the research conclusions and future research directions are presented.

Keywords

Student. Teaching. Learning Methods. Online Platforms. Motivation. Awareness. Research.

INTRODUCTION

The education system is a pillar of the national economy, it is important for the global sustainable development (Chen, & Howard, 2010). The legal framework of higher education is based on the related laws published at national level, according to the procedures for the recognition and accreditation of diplomas (Law 88/1993 modified by Law 144/1999). The preparation of students, after graduating, is at a high level. Students are prepared for the labor market. The feedback received from the employers emphasizes that the theoretical preparation of the students is at a high level. The practical training of the students must be improved (Draghici & Ivascu, 2016). Regarding the trends, however, if the perceptions of

the teachers and employers remain stable, the students have registered a depreciation in the last years. Higher education contributes to the development of skills and the development of skills. Currently, universities are facing the reality in which students choose to pursue a special career from the first years of university studies. Thus, the teachers adapt to these needs, and the teaching process implies to be improved annually by new techniques, practical applications, business interaction, teamwork, in order to develop stimuli that attract students. The motivating factors of the students change over time, as can be seen from the present study (Fazal-Ur-Rehman et al., 2012; Turi et al., 2017).

The paper is structured in 2 main directions: interviewing students to evaluate student perceptions and interviewing teachers to get feedback on the latest generations and their adaptability.

THE PARTICULARITIES OF HIGHER EDUCATION

The technical education has its particularities, Figure 1. Students in technical education have certain preferences for the teaching-learning process. The process of teaching has its particularities. The following is an inventory of the methods, typologies and methodologies used in higher technical education. It can be said that there is a bidirectional link between teacher, student, teaching materials and technology. In the whole didactic activity, the teacher must adapt to the needs and wishes of the student. The student sends feedback to the teacher through the annual evaluations that are carried out at the faculty level. The teacher adapts the teaching materials according to the feedback obtained (Draghici et al., 2016; Zeng et al., 2013). Teaching materials must incorporate the most innovative teaching methods. The student is influenced by the technological advance and sends feedback to the teacher. Thus between teacher, student, teaching material and technology there is a bidirectional relationship.

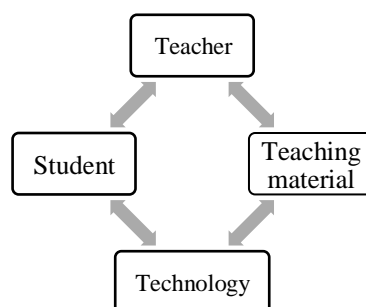


Figure 1: The teacher-student-teaching material-technology connection.

In terms of teaching methods can be identified: course material by dictation, discussion, question and answer, presentation (with IT tools), revision and lecturing (Hubalovsky, 2012; Izvercian et al., 2013). The characteristics of these teaching methods are:

- Course material by dictation - the teacher exposes the knowledge and information to the students. Students write down this knowledge. An efficient method, but time consuming.
- Discussion - session in which the teacher develops a series of discussion topics. Students become creative and their knowledge is verified.

- Question and answer - students ask a series of questions. The teacher answers the students' questions. The method is dynamic and highlights the knowledge accumulated by the students.
- Presentation (with IT tools) - use of information technology (IT) equipment to present a series of results or materials. It is an efficient method for the teacher, but the student becomes passive. Depending on the IT used it can become an attractive method. Materials need to be dynamic in order to be successful.
- Revision - verification of the information transmitted to identify the level of understanding of the basic elements. It is a constructive method for students, but it is time consuming.
- Lecturing – verbal transmission of knowledge and information to student. It is an efficient method, but students become passive.

From the perspective of the typologies of professor (Molnar, 2014; Morze et al., 2016) met in the technical universities, we can talk about:

- Initiator - the type of teacher who always initiates different activities.
- Organizer - the organization of the acquaintances, the information and the activities represents this typology.
- Tutor - the teacher who is always close to the student, being like a parent.
- Participant - participates in different courses, without major implications, being a good transmitter of information.
- Resource - a source of knowledge, without becoming a tutor or organizer.
- Correcting – the teacher corrects the deficiencies seen in students, does not involve as a tutor in advising students.
- Controller - constantly check the information transmitted.

Learning styles (Hubalovsky, 2012; Izvercian et al., 2013; Plevný & Gangur, 2016) defines the preferred means of receiving, processing, storage and updating of information and are formed through education.

- Visual - a student who visually absorbs and retains the information better if it is presented in pictures, diagrams and charts.
- Auditory - the student prefers to listen to what is presented during the teaching hours. The student responds best to voices, for example, in a lecture or group discussion. Hearing one's voice repeating something back to a tutor or trainer is also helpful.
- Kinesthetic - the student likes a physical experience. He likes a "hands-on" approach and responds correctly if he can experience the information transmitted. Students prefer learning if they touch and move. It also has two subchannels: kinesthetic (movement) and tactile (touch).

Models of communication in education (Morze et al., 2016) used in higher education are presented below:

- Same Time, Same Place - it is characterized by discussions, brainstorming. You can use the classrooms or online versions. Can be used: Skype, mural.co (online brainstorming), MindMeister, Adobe Connect, Diigo (<https://www.diigo.com/>), SharePoint, Cloud, wiki, Google Classroom, Inspire Reader, Wordle.
- Same Time, Different Place – it is characterized by lectures, workshop, file sharing. Can be used: Facebook, Twitter, Google Doc, WordPress, Kahoot, Scoopit, WordPress.
- Different Time, Same Place - it is characterized by researcher. We can use: Academia.edu, Google Search, Researchgate et al.
- Different Time, Different Place - it is characterized by review, assessment. We can use: Google Scholar, Blackboard Collaborate, PaperRater, Google Classroom et al.

MATERIALS AND METHOD

The research (Draghici & Ivascu, 2016) targeted two target groups: teachers and students. For student, market research was carried out over a period of four generations. For this research the questionnaire was used. The questionnaire is divided into four parts, Figure 2. Each year this questionnaire was applied to the students from year 2 of study. The information has been collected and is presented below. The respondents are the students of a technical university. I am women and men, between the ages of 20-22 years. The target group consists of 200 students. The questionnaire was applied using the faceto-face method.

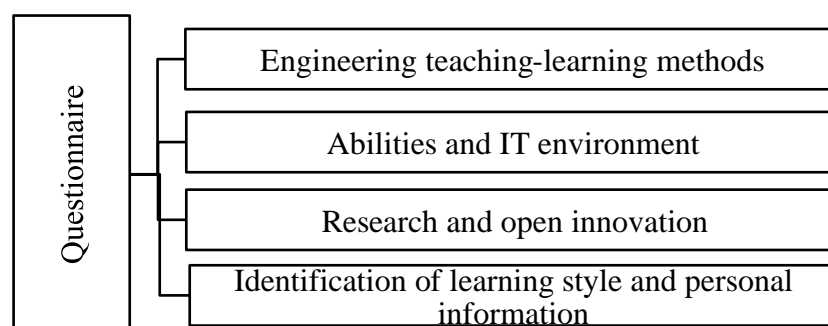


Figure 2: The teacher-student-teaching material-technology connection.

Market research for teachers was established 5 questions. The in-depth interview was used to gather as much information and interact very well. The directions followed in this research are presented in Table 1.

Table 1: Structure of the in-depth interview.

No.	Direction
1	Using a word describes the generation
2	Restructuring of teaching materials
3	Increasing the level of digitization
4	Involving students in research

RESULTS AND DISCUSSION

The results are presented on each side. The first part presents the information obtained from the application of the questionnaire.

A. Engineering teaching-learning

This section includes the evaluation of students' preferences over teaching methods, types of teachers and teaching techniques. From the perspective of the teacher's typology, a preference for the initiating teacher and tutor is observed over time (2015-2019 period), Table 2. The organizer is in the preferences of the students, registering a percentage of 23% in the last year. 9% of the respondents also appreciate the typology of the participating teacher (for the year 2018-2019).

Table 2: Teacher typology

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Teacher typology	Initiator	28%	32%	33%	35%
	Organizer	23%	20%	18%	23%
	Tutor	21%	25%	28%	30%
	Participant	11%	15%	10%	9%
	Resource	8%	4%	4%	1%
	Correcting	6%	2%	2%	1%
	Controller	3%	2%	5%	1%

From the perspective of interactive teaching-learning methods, one can observe an increasing tendency of the preference for Methods of teaching and interactive learning in group and Methods for problem solving by stimulating creativity. In contrast, Research methods in group recorded the lowest percentage in 2018/2019, 13%.

Table 3: Interactive teaching-learning methods

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Interactive teaching-learning methods	Methods of teaching and interactive learning in group	38.50%	40%	39%	40%
	Methods for problem solving by stimulating creativity	30.50%	35%	36%	35%
	Research methods in group	15.80%	10%	11%	12%
	I prefer individual learning	15.20%	15%	14%	13%

From the *interactive teaching-learning methods*, it can see a preference for *The course material by dictation* method. In the academic year 2018-2019 a percentage of 51% of respondents prefer this method. On the second place is the *Discussion* method, which shows a downward trend in recent university years.

Table 4: Interactive teaching-learning methods

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Teaching method	The course material by dictation	46.20%	45%	50%	51%
	Discussion	23%	20%	19%	18%
	Q&A	10%	9%	12%	13%
	Presentation (with IT tools)	11%	13%	11%	9%
	Revision	2%	3%	5%	6%
	Lecturing	7.80%	10%	3%	3%

B. Abilities and IT environment

This section includes the evaluation of the students' preferences over the communication methods based on their basic training (the profile of the high school graduate). Evaluating *models of communication in education* it can be observed that in recent years there has been a change of preference, Table 5. Between 2015-2017, respondents prefer the *Same Time, Same Place model* (35-40%), and in the last two years there is a preference for *Same Time, Different Place* (36-40%). This fact highlights the tendency of young people to change and the desire to meet new challenges, but the time remains the same.

Table 5: Interactive teaching-learning methods

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Models of communication in education	Same Time, Same Place	35%	45%	29%	27%
	Same Time, Different Place	18%	23%	36%	40%
	Different Time, Same Place	15%	17%	12%	11%
	Different Time, Different Place	32%	15%	23%	22%

From the *students' background* perspective, Table 6, it can be observed that the students of the university have a technical background, hence the links with the teaching methods appear. These typologies prefer static, obedient and systemic teaching methods. In the last year, 2018-2019, respondents registered 45% of the technical area and 23% of the economic area.

Table 6: Students' background

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Students' background	Technic	45%	51%	65%	45%
	Philology	8%	10%	12%	20%
	Natural Sciences	15%	19%	10%	12%
	Economic	32%	20%	13%	23%

C. Research and open innovation

This section presents the results obtained regarding the research, the involvement of the students in the research and their motivation. From the perspective of the *involvement of the students in the research*, Table 7, it can be observed that about 25% are involved and wish to continue to be involved. Respondents who have a preference for research will continue their studies in doctoral programs. In 2018-2019, it can be seen that 24% of respondents were involved in research, and 40% were involved and do not want to engage in more research.

Table 7: Involving students in research

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Research	I was involved in research	20%	22%	25%	24%
	I wasn't involved	35%	32%	11%	18%
	I was involved, but I don't like it	21%	20%	35%	40%
	I wasn't involved, but I want to do	24%	26%	29%	18%

When evaluating the *website*, Table 8, used by students it can be observed that the section dedicated to general information is the most used. This accessed page is followed by the journal page of the Faculty of Management. If we evaluate the number of visits of the website of the Faculty of Management (www.mpt.upt.ro), it is observed that it has 3,881 visitors of which are unique (for February).

Table 8: Official website

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Website	General information for students	40%	45%	48%	56%
	Research page	20%	8%	7%	3%
	Page for cultural events	10%	12%	14%	3%
	Faculty journal page	30%	35%	31%	38%

Summary					
Reported period	Month Feb 2020				
First visit	01 Feb 2020 - 00:20				
Last visit	29 Feb 2020 - 13:48				
	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Viewed traffic **	2,063	3,881 (1.88 visits/visitor)	9,676 (2.49 Pages/Visit)	58,846 (15.18 Hits/Visit)	32.01 GB (8646.34 KB/Visit)
Not viewed traffic **		9,064		26,104	5.06 GB

Figure 2: Website statistics for www.mpt.upt.ro

D. Identification of personal information

From the perspective of student's collaboration environment, Table 9, it can be observed that there is a preference for teaching staff of University, administrative staff and organizations. At the level of 2018-2019, there is a preference for teaching staff of University, registering a percentage of 29% of the respondents' preferences.

Table 9: Student's collaboration environment

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Student's collaboration environment	Students from University	10%	10%	9%	7%
	Teaching staff of University	33%	31%	28%	29%
	Administrative staff	10%	8%	11%	13%
	Experts	1%	3%	7%	9%
	Tutors (MOOC)	12%	9%	8%	8%
	Organisations	25%	21%	27%	28%
	Employers	9%	18%	10%	6%

At the beginning of the bachelor's degree studies, Table 10, it can be observed that students prefer visual meditation, being an easy and systemic one. Of the respondents, over 65% prefer this method. The next preference is for the auditory method.

Table 10: Learning styles

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
Learning styles	Visual	71%	66%	79%	69%
	Auditory	18%	17%	11%	14%
	Tactile	8.40%	13%	5%	7%
	Kinesthetic	2.60%	4%	5%	10%

Among the most important motivating factors are: teacher, teaching method, technology and infrastructure of the educational unit, and reputation of the university and the faculty, Table 11. Evaluating these factors over the period analyzed can be seen that the most important factor for students is the reputation of the university and the faculty.

Table 11: Motivational factors

Question	Type	2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
	Teacher	15%	15%	20%	18%
Motivational factors	Teaching method	16%	13%	11%	9%
	Attitude	10%	9%	13%	10%
	Rewards	11%	13%	1%	13%
	Technology and infrastructure of the educational unit	15%	14%	7%	18%
	Challenge	5%	5%	5%	5%
	Reputation of the university and the faculty	20%	19%	30%	22%
	Knowledge	5%	7%	10%	3%
	Colleague	3%	5%	3%	2%

Evaluating the results of the in-depth interviews, Table 12, with the 10 teachers, annually, during the studied period (2015-2019) the following can be systematized:

- Generations are dynamic and adapt to the environment. Currently, they are interested in innovative methods of global sustainability.
- Over 60% of teachers update their teaching materials annually. The level of digitization of teaching methods increases annually.
- The interest of the students for research, from the perspective of the teachers, has increased considerably in the last year. A percentage of 51% is reached due to the increased interest for doctoral studies in the field of Engineering and Management.
- Companies are increasingly involved in student training. Therefore, there are a number of opportunities to visit these companies.

Table 12: In-depth interview with teachers

In-depth interview		2015/ 2016	2016/ 2017	2017/ 2018	2018/ 2019
1	Using a word describes the generation	involved	social media	innovation	sustainability
2	Restructuring of teaching materials	60%	70%	87%	89%
3	Increasing the level of digitization	65%	71%	88%	85%
4	Involving students in research	30%	45%	36%	51%
5	Involving students in different company visits	21%	32%	34%	51%

Evaluating the results of the market research, the authors built a student avatar. This avatar interacts the factors, preferences and perceptions of the respondents.

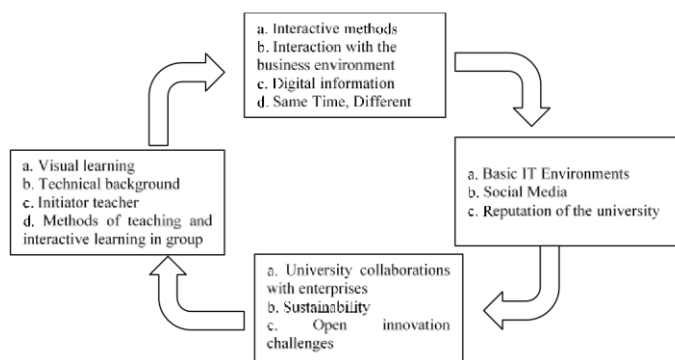


Figure 2: Profile of the technical university student

CONCLUSIONS AND DISCCUSION

The purpose of this study was to inventory the factors that contribute to student retention and to attract new candidates to our university. Research shows that students are connected to the demands of the environment and respond affirmatively to the challenges if they see a benefit. The cultural implications and extracurricular activities are minimal, but there is an increased interest for the research side. Teachers adapt to the demands of technological advancement and try to innovate every year. Following the study, we notice

that students prefer Initiator, Organizer and Tutor, from the perspective of the researched typologies. The evolution of perception has remained approximately the same throughout the four academic years. From the perspective of interaction, students prefer methods of teaching and interactive learning in groups and methods for problem solving by stimulating creativity. These methods have the advantage of stimulating interaction, creativity and involvement. Students prefer free debates and discussions on familiar topics. From the perspective of knowledge transmission methods, it can be seen that students prefer the course transmitted through dictation. Discussions are also appreciated because the level of knowledge required for a discussion is medium. Static questions and presentations are not appreciated due to the fact that students lose interest. These teaching methods are also dependent on environmental conditions. In the event of a pandemic, the teaching-learning system must be rethought and restructured. The methods, techniques and methodologies are different, and the information technology is fully involved.

ACKNOWLEDGEMENT

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Solving the Waste Problem by Modernizing the Secondary Education

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Abstract

By to Directive 2008/98/EC on waste, which is the basic EU waste management legislation, waste means any substance or object, which the holder discards, intends, or is required to discard. Unfortunately, we are currently linking waste to the global problems of humanity. Every year around 2 billion tonnes of municipal waste is collected worldwide. This amount will increase every year due to the growth of global population. Environmental education is one of the basic preventive tools of environmental protection. The basis of the submitted paper is to point out the possibilities of modernization of Environmental education through selected ICT tools in the topic of Waste in the teaching process. The aim of the paper is to introduce available mobile applications (Trash Out, Green Daily, Czech Zero Waste) to teachers and pupils of lower secondary education with the possibility of their application within the Environmental education. The result of this work is a model of environmental education for lower secondary education, which interconnects mobile learning, interdisciplinary learning, project-based learning and outdoor education in order to modernize and streamline the teaching of waste issues and make this issue more attractive to pupils. The content of education, which the model proposed by us, mediates, consists of 3 consecutive levels. Through them, pupils gradually become acquainted with the specific waste problem found in their immediate environment. Subsequently, they will become acquainted with the possible solutions (corrections) of this problem and also with the ways of preventing it.

Keywords

Waste. Environmental education. Outdoor education. Mobile learning. Project-based learning. Information and communication technologies. Illegal dumping. Separation, Zero waste.

INTRODUCTION

Waste. We all know this word and when mentioned, we all imagine something unnecessary that is no longer needed, and we want to get rid of it. By to Directive 2008/98/EC on waste, which is the basic EU waste management legislation, waste means any substance or object which the holder discards or intends or is required to discard. Unfortunately, we are currently linking waste to the global problems of humanity.

Every year around 2 billion tonnes of municipal waste is collected worldwide (data from 2016). This amount will increase every year due to the growth of global population. By 2050 mankind is expected to have produced up to 3.40 billion tons of waste

(<http://datatopics.worldbank.org/what-a-waste/>). On a global scale, we most often encounter the problem of plastic waste that accumulates in the oceans and eventually disintegrates into small particles known as microplastics (Tibbetts, 2015; Gross, 2015). These can be caught by hundreds of different organisms and can also affect human health through the food chain. Floating residues tend to accumulate in large ocean vortices (gyre), such as the Great Pacific Garbage Patch. According to WWF (2019), up to 80% of oceanic plastics are estimated to come from land-based sources, therefore not only the seaside countries are responsible for plastics in the oceans. Example being the Danube River, according to Lechner et al. (2014), through which 4.2 tonnes of plastic waste enters the Black Sea every day.

Plastics are not the only type of waste currently emerging as a global environmental problem. Other problematic types of waste include electrical waste (e-waste), which is produced in staggering quantities. Alabaster et al. (2013) and Heacock et al. (2016) consider e-waste the greatest threat to the environment. Grant et al. (2013) assess e-waste as dangerous not only for the environment but also for human health, because it contains a few hazardous components such as lead (Pb), mercury (Hg) and chromium (Cr). Food waste is also often mentioned worldwide. Approximately 1.3 billion groceries are wasted worldwide each year (FAO, 2013). According to Melikoglu et al. (2013), more than 95% of food waste ends up in landfills where it is converted into methane, carbon dioxide and other greenhouse gases under anaerobic conditions. Food waste therefore also has a catastrophic impact on the climate change. Recently because of the so-called Fast Fashion, a global problem related to textile and clothing waste is emerging. It is estimated that between 1996 and 2012, the amount of clothing bought per person in the EU increased by 40%, while in 2015 EU citizens bought 6.4 million tonnes of new clothing (12.66 kg per person) (<https://www.eea.europa.eu/>). More than half of the garments are not recycled and end up in mixed municipal waste and then sent to an incinerator or landfill after they are discarded.

Most commonly, municipal waste is disposed of by landfilling or incineration. However, in many parts of the Slovak Republic (SR), we can encounter illegal waste in illegal dumps. They consist mainly of municipal mixed waste from households, construction and bulky waste. The number of illegal dumps in the SR is estimated at 6000 – 8000. Such landfills pose a great risk to the environment and, of course, to human health (Boltižiar et al., 2016), causing not only aesthetic but also hygienic problems and waste of raw materials that could be recycled. Tasaki et al. (2007) consider raising waste disposal charges as one of the reasons for illegal landfills due to stricter waste treatment regulations in order to better protection of the environment.

To tackle the global waste problem, it is necessary to spend a lot of money and resources to improve the waste situation. At the same time, it is important to consider other means necessary to prevent more unnecessary waste to be generated. The basic preventive tools of environmental protection include environmental education. Its goal is the assessment of an environmental issue and any feasible solutions it may have; in that assessment problems are analysed systematically, not only as a theory of reality but also as an action strategy to be undertaken (Magnus et al., 1997).

Under the current educational conditions within the State Educational, the Program “Environmental Education” is a mandatory part of education and is implemented as a cross-cutting topic. Through it, it is possible to point out the seriousness of the waste issue and to influence pupils so that they get "engaged in activities aimed at protecting and improving

the environment and actively participating in the elimination of environmental pollution" (<http://www.statpedu.sk>). We believe that further education, knowledgeability and spreading of information on waste education is not only needed, but also necessary.

The basis of the submitted paper is to point out the possibilities of modernization of environmental education through selected ICT tools in the topic of Waste in the teaching process. The aim of the paper is to introduce available mobile applications to teachers and pupils of lower secondary education with the possibility of their application within the environmental education.

METHODS

In our view, modernization of environmental education concerns three interconnected areas: modernizing of the content of education, modernizing of the education process and modernization of the teaching aids and didactic technology.

Modernizing of the content of education

The issue of waste as a topic of environmental education can be demonstrated to pupils through the following basic areas: what is waste, types of waste, waste characteristics, history of waste origin, place of waste origin, how we handle waste, environmental problems related to waste, prevention and minimization of production of waste.

However, this content does not remain on a global, theoretical and impersonal level. It is linked to the pupils' daily lives and the environment that surrounds them directly. Pupils themselves discover the seriousness of the waste problem by mapping illegal landfills or littering (Earll et al., 2000; Valiente et al., 2020) and looking for solutions to address and prevent these problems.

Modernizing of the education process

We propose to use a combination of the following teaching approaches to implement the Waste issue in the teaching process within the secondary education:

- *Interdisciplinary learning* – Rowntree (1982) defines an interdisciplinary approach as an approach in which two or more disciplines come together, preferably in such a way that they interact. Interdisciplinary education according to Ivanitskaya et al. (2002) is characterized by the integration of multidisciplinary knowledge into the central theme in our case it is the issue of waste.
- *Project-based learning* – is a comprehensive perspective focused on teaching by engaging students in investigation. Within this framework, students pursue solutions to nontrivial problems by asking and refining questions, debating ideas, making predictions, designing plans and/or experiments, collecting and analysing data, drawing conclusions, communicating their ideas and findings to others, asking new questions, and creating artefacts (Blumenfeld et al., 1991).
- *Outdoor education* – is known as a method of developing knowledge, skills and attitudes concerning the world in which we live. It is an expression of the place where teaching takes place, but also of the topic to be taught (Ford, 1986).

The purpose of the outdoor activities is to give pupils out-of-classroom educational experiences involving direct contact with various environments. These experiences are intended to give pupils in-depth knowledge of environmental issues and to develop their self-confidence, environmental sensitivity, action skills, responsible action in nature, and their social relationships (Palmberg, Kuru, 2000).

Modernization of the teaching aids and didactic technology

The implementation of new technologies and practices into education currently represents the greatest support for the development of learner's cognitive and intellectual abilities (Balogh, Kucharik, 2019; Balogh, Koprda, 2014). Information and communication technology (ICT) is a key tool for the modernization of teaching aids and didactic technology. Stoffová (1998) considers computing, telecommunications, transmission, and organizational technology used for information processing to be ICT. It also includes software and organizational arrangements. Smitek (1998) explains ICT as methods, procedures and methods for collecting, storing, processing, verifying, evaluating, selecting, distributing and timely delivering the necessary information.

In our case, we mainly included mobile learning in the ICT group, which includes the use of mobile or wireless devices for learning purposes. Typical examples of devices used in mobile learning are mobile phones, smartphones, handheld computers, tablet computers, laptops or personal multimedia players (Kukulska-Hulme, Traxler, 2005).

The main applications that we use within our proposed mobile learning to teach the topic Waste include:

- *TrashOut* – is an environmental project that aims to locate all illegal dumps around the world. Since 2012, the Ministry of the Environment of the Slovak Republic (<http://www.minzp.sk>) has published on its website a new way of reporting the occurrence of illegal landfills in nature using the TrashOut mobile application (TrashOut, n.f.). TrashOut is a mobile application that is free to download for Android and iOS not only in Slovak, but also in other languages (Fig. 1). It was based on a worldwide initiative to locate and eliminate illegal landfills (<https://www.trashout.ngo/>). This form is considered very simple and effective. The main functions of the application are: easy reporting of illegal dumps, map of illegal dumps, anonymous reporting of illegal dumps, all check-ins can be synced, badges earned for activity and sign in with Facebook or email.
- *Green Daily* – free and downloadable application for both Android and iOS in Slovak language (EKOrast, o.z.) (Fig. 2). Since the system of sorting common waste is not uniform in Slovakia, the waste producer's application navigates to what colour of the waste bin it belongs in its municipality or city e.g. can, paper, glass, etc. At the same time, this simple application will offer the user the possibility to find the nearest place for the collection of specific waste in each municipality or town, such as medicines, electrical waste, old batteries, kitchen oil or construction waste. The application includes useful information and contact details for collection yards and other establishments or shops that take care of specific waste and ensure its consistent recycling. The application also includes a learning window that explains to the user why he should sort the waste and some interesting information. The application was prepared by a civic association as one of the projects for the public, companies, children, and youth in the field of environmental protection.

• **Czech Zero Waste** – is a free mobile application in Czech language created by girls who blog about life without waste (Czech Zero Waste) (Fig. 3). The application guides the user to meet the 40-day waste-free challenge. Every day, the user is given a new challenge that prompts him to live with less waste. Since checking the current status of the trash can, the user has moved on to perform day-to-day tasks, such as a shopping bag, a water bottle, less paper, a food bag, a waste-free drugstore, leaflets, food waste, etc. Each task explains its purpose and meaning. The user can document the fulfilment of tasks by photographing them and then sharing them on social networks. If a user fails to complete a task or it does not suit them on a given day, it is possible to postpone it and return to it later. Zero waste is a lifestyle that aims to reduce or prevent the amount of waste we produce under the five basic 5R rules: R - Refuse, R - Reduce, R - Reuse, R - Recycle, R - Rot (<http://www.zerowasteslovakia.sk/>).

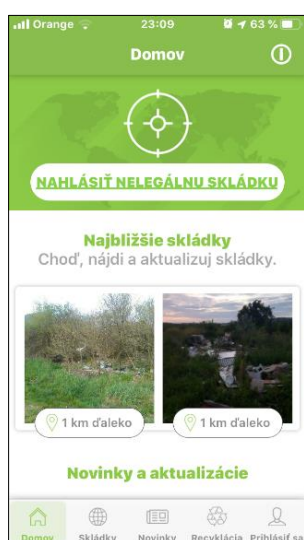


Figure 1: Free mobile application TrashOut for Android and iOS



Figure 2: Free mobile application Green Daily for Android and iOS

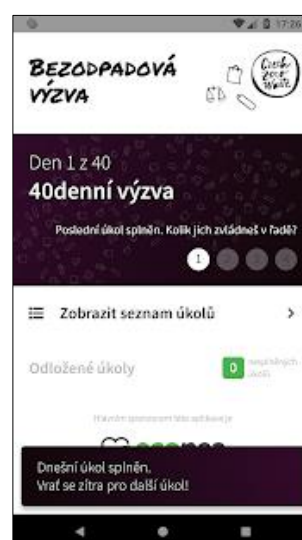


Figure 3: Free mobile application Czech Zero Waste for Android and iOS

Other ICTs that can be integrated into the training model we propose include GPS and GIS. We discussed them in more detail in our previous published papers (Zigová et al., 2018; Pucherová et al., 2019).

RESULTS

The result of this work is a model of environmental education for lower secondary education, which interconnects mobile learning, interdisciplinary learning, project-based learning and outdoor education in order to modernize and streamline the teaching of waste issues and make this issue more attractive to pupils.

The content of education, which the model we propose mediates, consists of three successive levels. Through them, pupils gradually become acquainted with the specific waste problem found in their immediate environment. Subsequently, they will become acquainted with the possible solutions (corrections) of this problem and also with the ways of preventing it.

Waste issues are a part of the education since the kindergartens. Pupils in lower secondary education, therefore, have a certain level of knowledge and habits. However, before execution of the model it is necessary to repeat the previously learned knowledge and habits. This level is shown in Fig. 4 as "level 0" and is represented by the key question: What do we know about waste and the problems that waste causes?

Level 1 – presents an analysis of the problem that waste poses directly in our communities and in close proximity. Attention is paid to illegal waste dumps and littering. This level is executed through outdoor education and represents the beginning of the work of pupil groups on their projects (within the project teaching). Pupils map illegal landfills directly in the field, using their mobile phones or tablets and using TrashOut to record individual landfills (Fig. 4).

After mapping the area, the result of this level is to report the occurrence of illegal dumping to the appropriate municipal or city authority or using the TrashOut a mobile application to generate an e-mail with all the necessary data. Subsequently, the data is also sent to the Ministry of Environment of SR or the relevant city that has expressed interest in cooperation (<https://www.enviroportal.sk/clanok/trashout-mapuje-negalne-skladky>). Since 2010, the Reference for Mayor platform has been increasingly used, through which citizens can report to the municipality categories of incentives and environmental problems, including "black dumps" (<https://www.odkazprestarostu.sk/>).

Within this level, it is possible to use various interdisciplinary relations by which pupils apply the previously learned knowledge and skills in acquiring and processing spatial data. For example mathematics – calculation of landfill area, expression of percentage of individual types of waste; informatics – creation of charts and graphs; geography – creation of analogue or digital map by GIS, surveying (positioning) of landfill by GPS; biology – description of habitat/ecosystem situated landfill; chemistry – landfill potential for chemical pollution of individual environmental compartments, etc.

Level 2 – is a continuation of work on pupil projects. Attention is focused on the prevention of illegal dumps. Pupils learn how to handle municipal waste, respectively how to separate out what we know to use as a secondary raw material in the recycling process from mixed municipal waste disposal by landfills. At the same time, pupils will learn to save natural resources, energy, and water by correct separation.

At this level, pupils use the Green Daily application, which is a suitable guide for the correct separation of municipal waste, respectively the possibility of using the collection yard (Fig. 4).

Level 3 – the longest lasting part of our model is the use of the mobile application Czech Zero Waste. Through the 40-day challenge included in this application, pupils learn to prevent waste production. As they say about zero waste, we apply voluntary modesty in pupils' lives and teach pupils to think before each purchase. This is changing their consumer

mindset and behaviour for the future. Pupils will understand that what they buy today will become waste tomorrow (Fig. 4).

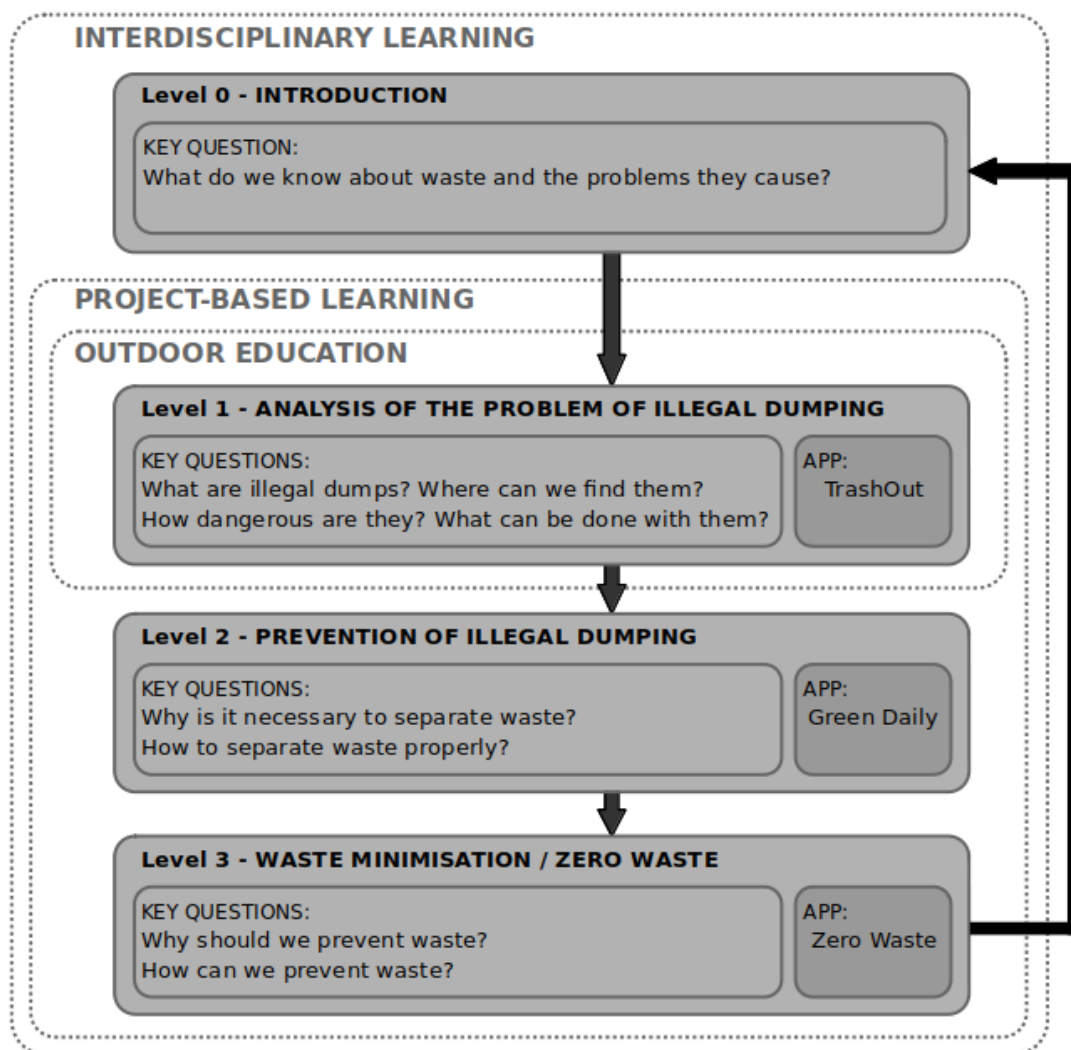


Figure 4: Scheme of the educational model with available mobile applications to teachers and pupils of lower secondary education with the possibility of their application within the environmental education

After the third level, the question raised in “level 0” can be reopened: What do we know about waste and the problems it causes? It is interesting to trace the shift in pupils' knowledge of skills and habits. The model can be continued by mapping other waste problems (for example, the mapping of the aforementioned littering). If interested, the project can be continued through peer education, which Shiner (1999) describes as the education of young people by young people. Pupils can share the experience gained by project teaching to classmates or younger pupils in the form of not only contact teaching, but also the use of ICT - for example by creating a short video about the progress and results of the mapping.

DISCUSSION

The topic of waste is currently discussed quite often. The economic development, production and changing market of human consumption have led to a surge in waste

worldwide over the last decades. Waste disposal harms the environment and poses a threat to human health. Therefore, there is a great deal of effort to reduce the total waste of each of us.

Education is very important to reduce waste production because education can change people's knowledge, attitudes, and behaviour towards waste management. Since 2009, the topic of waste has become a part of the state educational program for the first and second grades of primary schools and for eight-year grammar schools in the SR within the cross-sectional theme of Environmental Education. Within the 2 thematic areas Human Activities and Environmental Problems and Human Relation to the environment, pupils are acquainted with waste and ways of managing it, even with the example of a city or municipality, and as well as within the lifestyle of each of us (areas: waste and nature, principles and ways of waste management, ways of utilization and solution of waste management, types of waste, disposal, separation, recycling of waste, consumption of things, saving of natural resources and energy, impact on environment).

On one hand, we are trying to educate the younger generation, and on the other, the waste situation is not improving because we are increasing the amount of municipal waste per capita in Slovakia every year (Fig. 5). Compared to the average amount of municipal waste per capita in the EU (489 kg) and in individual EU countries, Slovakia is one of the countries with lower quantities, but landfilling predominates in waste management (61%) and thus the Slovak Republic ranks among the countries with a high share of landfilled waste. The EU has set itself the target of landfilling only 10% of municipal waste by 2035 (currently around 23.5%) (<https://www.europarl.europa.eu/>).

In these years the problem with waste disposal seems to be the biggest problem in waste management in Slovakia. Too much waste goes to landfills and their capacity is, of course, reduced. Pursuant to the legislation in force, the obligatory separate collection of paper, plastics, glass, and metals, later biodegradable waste and multi-layer composite materials based on cardboard was gradually introduced from 1 January 2010 in the Slovak Republic. All these commodities are prohibited from landfills in accordance with applicable waste legislation, it is forbidden to throw these into mixed waste, which is directly transported to the landfill. Although the share of separation is increasing every year, we are still relatively at a low level compared to EU countries.

One possibility is to change people's minds by avoiding or at least reducing waste.

The model proposed by us connects the worldwide topic of waste with modern pedagogical approaches, i.e. using mobile phones within ICT in teaching and with pupils' lives and their environment. In addition to the educational objectives that aim to raise pupils' environmental awareness, the model has the potential to develop a wide range of other skills and we agree with Belisle, Rosado (2007) active use of ICT develops skills associated with ICT.

Using interdisciplinary education, pupils develop interdisciplinary thinking, improve critical thinking skills, cognitive skills, and understand the relationships between different disciplines (Ivanitskaya et al., 2002). Project-based learning develops reasoning, problem-solving and communication skills (Barrows, Tamblyn, 1980).

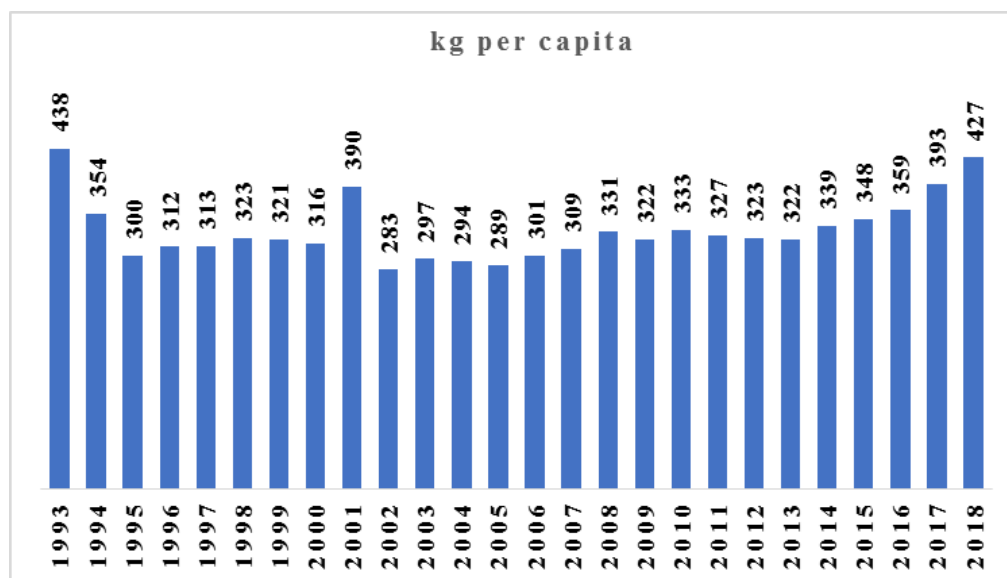


Figure 5: The amount of municipal waste per capita of the SR in the years 1993 – 2018
(<https://www.enviroportal.sk/spravy/kat21>)

According to Mergendoller et al. (2006) in project teaching, pupils acquire 21st-century skills such as collaboration, communication, critical thinking, creativity, language skills, innovation, global relationships, technology use and much more. Studies (Dresner, Gill, 1994; Palmberg, 1989) comparing pupils with experience in outdoor teaching with pupils without experience show that the difference between them is in the acquisition, improvement of action skills.

As a result, experienced learners were more confident in their activities, feeling safe without adult dependency (teachers), more committed to engaging, knowing their limits, and, positively, being spontaneous, open and willing to cooperate.

CONCLUSION

Waste production has its own history in human society. The current age has the attribute of a "consumer society" with typical redundant consumption. People often buy what they do not need and after a certain time, unnecessary things go to trashbins, containers, landfills or incinerators.

Every year, as the population grows, the economic activity of the population increases. Waste is generated in every part, so it is related not only to production but also to consumption. In this way, the so-called "human standard", which is also linked to increased waste production, is growing.

Many of these wastes can be recycled, many of them are destined for disposal, eg. to incinerators or to legal landfills, but a significant part of these wastes end up in places that are arbitrarily and in violation of several laws established by so-called "cultural person".

According to Hazra, Goel (2009) environmentally friendly management of municipal waste has become a global challenge due to limited natural resources, exponentially increasing population, rapid urbanization, and global industrialization.

We will certainly not be able to solve the waste problems within a day, but the way the environment is going to look in the future depends on our current behaviour and decision-making.

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- <https://europarl.europa.eu/>
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- <http://www.statpedu.sk/>
- <https://www.trashout.ngo/>
- <http://www.zerowasteslovakia.sk/>

Case Teaching Studies with the Use of Screencasting as a Supportive Element of Critical Thinking

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Abstract

In education, technological and social changes related to informatization of life and society require changes. Nowadays we deal with one of the actual worldwide problems called an overpressure of the informational world. The possible solution is critical thinking which is the skill that we present in our article. Our aim is to prepare pre-service Informatics teachers in critical thinking. Our idea is that when we prepare a teacher with critical thinking skill, he/she will be able to teach students critical thinking skills at primary or high school. We develop critical thinking by using the teaching case study to enhance pre-service Informatics teachers' skills. We collected six teaching case study, which we processed into case studies with the structure of AAA (annotation, analysis, alternation). We supplemented case studies by exercises focused not only on critical but also on creative thinking elaboration of the topic. In this paper, we present one of the teaching case study from our collection, Working with Table Data. The main element of the study is using screencasting to enhance learning with the focus on technology.

Keywords

Case teaching study. Screencasting. Critical thinking. Pre-service teacher.

INTRODUCTION

Nowadays, critical thinking is a global topic worldwide spread and developed. The development of information and communication technologies enables people to have easier access to a lot of information. The problem, which is still rising, is how to work with so much information, how to analyse, assess, evaluate them. The work with them requires critical thinking.

Critical Thinking

Critical thinking is one of the main, not yet resolved, pedagogical problems. A critically thinking person is an open-minded person, naturally curious, flexible, understanding diverse aspects, seeking arguments to formulate final decisions, rejecting shallowness, always considering proof before taking conclusions, no matter who carries them (Ruisel, 2005). Due to the study of prioritizing skills in more than 150 countries, the results are: more than 70 % of education system want to prioritize 6 cognitive skills, i.e. literacy, numeracy, communication, creativity, critical thinking and problem solving (Microsoft, 2018)

Halpern made a research whether critical thinking can be taught and learned (Halpern, 2003). Her results are that it is possible and she created a four-part model for teaching critical thinking skills consisted of encouragement of students' attitude, instruction in and practicing critical thinking skills, directing learning activities, monitoring and assessing thinking in Figure 6.

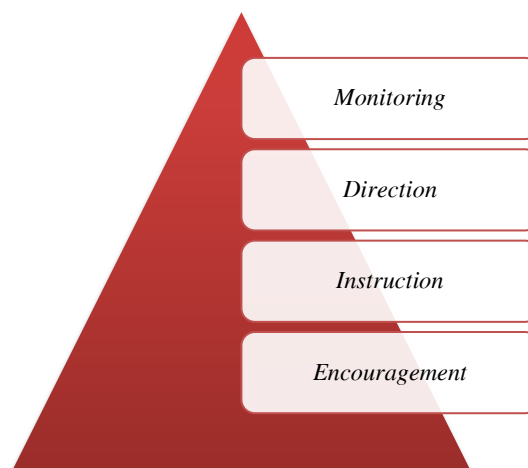


Figure 6 Model for teaching critical thinking skills

Screencasting as an Element of E-learning

The content of preparation of pre-service Informatics students is quickly changed. It is caused by the subject Informatics and digital era. Pre-service Informatics students as future teachers should be prepared not only for present technology but also for the future. Due to the fact we do not know what the future will look like, preparation is becoming harder. Informational or post-industrial period and the development of information and communication technology causes changes even in education. One of them is e-learning. We think that preparation of pre-service Informatics students should involve a creation of e-learning elements. One of them is screencasting which is described in this paper.

Screencasting

Screencasting is a digital movie in which the setting is partly or wholly a computer screen (Udell, 2005). These publishing desktop actions usually has an educational purpose, e.g. Khan Academy (Kopel, 2010). They are used as recorded actions along with narration for later presentation with asynchronous learning which is usually an attribute of e-learning. As Kopel says, they can present problem solving for later consideration.

We use screencasting for recording short pedagogical outputs in the preparation of future computer science teachers. Created records allow us to retrospectively analyze student performance and improve it. This is already happening during the creation of the record, when the student self-reflect his/her performance, as well as in a group of students discuss the performance in the finished record. We use the recorded pedagogical outputs as cases in case studies.

CASE TEACHING METHOD

Experience is a key element when preparing pre-service Informatics teachers. It is differentiated into own and mediated (Gavora, 2012). According to Gavora, it is the strongest factor affecting the teacher's motivation and it also has a positive effect on the teacher himself when teaching. The mediated experience is provided in Didactics of Informatics with the use of teaching case studies.

The case study is used as a teaching method for the development of higher thought processes (analysis, synthesis, evaluation, decision making). It is based on a case that has the potential to be educative for students. In the training of pre-service teachers, case studies of specific didactic situations from the teaching process can be effectively used to learn general didactic principles at higher cognitive levels constructively based on experience in solving an authentic case.

In this paper, we present the example of the case study implemented as a study material for pre-service Informatics teachers. In all teaching case studies we have chosen AAA methodology. It involves the following methodological steps in Figure 7: annotation, analysis, alternation (Janík, et al., 2016).

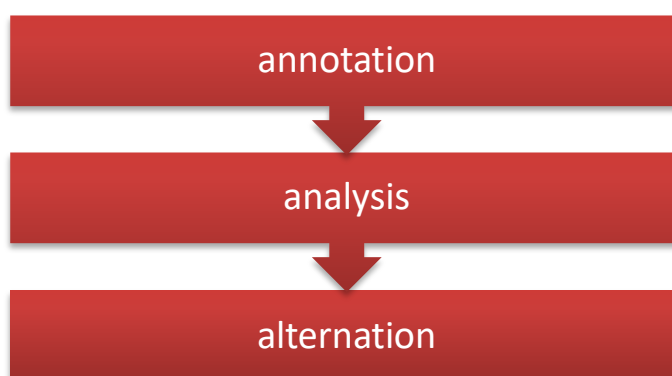


Figure 7 AAA methodology

These methodological steps are supporting critical thinking skills. First of them, annotation, is a brief description of the observed part, it is an analogy of the research description and contains the most important information about the course of the described situation. These are: the aim, the topic, the content of the lesson, the activity of the teacher and the subsequent activity of the students. The aim of the annotation is that the recipient (student) will be able to visualize the image of the observed part as a whole.

The second methodological part is analysis, a research interpretation that brings the characteristics of the observed situation regarding to the objectives of observation. We use it for identifying strategies for the development of critical thinking and evaluating the achievement of educational objectives.

Alternation as the third part of the AAA methodology is used for the recipient's thinking of the change, i.e. suggestions for improving, modifying or altering the lesson. The word alteration comes from Latin and it means a replacement that leads to a change in the value of a part or whole but does not change the meaning. Discussion is the commonly used method for alternation. It contains an evaluation of the quality of the analysed situation and a proposal for a change associated with the consideration of advantages and disadvantages.

It is an opportunity for the recipient to develop his own critical and creative suggestions so that he can use other teaching methods and practices that lead to an improvement of the lesson regarding to achieving educational objectives.

METHODS

We created a collection of six teaching case studies written in the AAA methodology line. In this paper, as an example from our collection we present a case study on working with table data. The case itself is an example of the application of the screencasting and is focused on developing the critical thinking.

The material for the case teaching study is two short videos created by the pre-service Informatics teachers. They solved the task by using the spreadsheet captured with a screencasting. There is a table with the data (some of them are incorrect) and the task is to formulate a problem and subsequently solve it. The analysis of the cases is aimed at answering the following questions:

1. What type of task is formulated?
2. What form and teaching method is used in the solution?
3. How do students solve the problem of incorrect data in the table?

RESULTS

Annotation

Students did not solve the designated task explicitly, but their task was to formulate a problem and subsequently solve it. The only specified part of the task was a table with data (Figure 3).

The World in the Pocket						
The survey was conducted by:		Patrik				
Date:		16.06.2010				
Name	Birth date	Gender	Height in cm	Chest in cm	Waist in cm	Favourite colour
Andrej Tref	23.11.1995	boy	163	8.9	79	grey
Janka Lovická	14.07.1998	girl	154	86	65	red
Milada Malá	27.10.1996	girl	161	94	74	blue
Emil Špún	18.09.1995	boy	72	93	75	green
Andrea Ferdenská	14.02.1992	girl	166	86	66	red
Janka Lovická	08.12.1997	girl	16.2	84	72	brown
Milan Retská	09.08.1997	girl	157	187	68	blue
Roman Jablčný	03.04.1996	boy	169	92	740	grey

Figure 8 Table with a survey's data. Source: (Kalaš, et al., 2009)

The table is taken from an attachment of student's book of Informatics called The First Book about Numbers and Tables from the series of student's books Creative Informatics for Primary Schools (Kalaš, and others, 2009). Original table is written in Slovak language, but we translated them to English for the purpose of this paper. There is involved a task assigned to the table designated on evaluating correctness of data in the table. The task is written as follows (p. 32):

“Designer company The World in the Pocket™ designs a top modern textile for teenagers. Therefore, they have made a survey at our school with students between 12 and 15 and ask for their favourite colours. Their survey worker Patrik is, however, inattentive and has made many mistakes. Your task is to find those mistakes.”

The students got only the table without the objective, and their task was to create their own task, where they have to use data in the given table in Figure 3. The task is divergent, because there are many possible solutions. The students were doing the task at home. For capturing the video, they used the Gaming panel of the Operating System MS Windows 10 or other software for capturing the output of the monitor. Created videos had length between 2:14 minutes (Case 1) to 7:22 minutes (Case 2). In the following lesson, there were all the videos presented and their solutions were discussed.

Analysis

In the first case, it was solved a simple and specific task with presenting the solution in the spreadsheet (Case 1). In the second case, there can be found a complex problem-solving task (Case 2). Both presented solutions are translated into English in this paper.

The student in the Case 1 was solving the task *“Sort data in tables from a shortest girl to a tallest boy.”* Solution is shown in Figure 4.

The World in the Pocket						
The survey was conducted by:		Patrik				
Date:		16.06.2010				
Name	Birth date	Gender	Height in cm	Chest in cm	Waist in cm	Favourite colour
Janka Lovická	08.12.1997	girl	162	84	72	brown
Janka Lovická	14.07.1998	girl	154	86	65	red
Milan Retská	09.08.1997	girl	157	187	68	blue
Milada Malá	27.10.1996	girl	161	94	74	blue
Andrea Ferdenská	14.02.1992	girl	166	86	66	red
Emil Špún	18.09.1995	boy	72	93	75	green
Andrej Tref	23.11.1995	boy	163	8.9	79	grey
Roman Jablčný	03.04.1996	boy	169	92	740	grey

Figure 9 Solution of the task in Case 1 The World in the Pocket 1

The record has been processed interested as a video tutorial: at the beginning, there was a greeting of the viewer, introduction about talker, in the end saying farewell to the viewer: *“That is all for today, see you soon.”* This kind of video could be a part of series of a video, where they might be simple functions of table calculator MS Excel explained. In this sample there is a multi-level sorting of data used, in the first level by the gender and in the second by height. The solution is short and straightforward. The student used:

- description of the solution,
- explanation of the solution.

The data about gender are text type, sorted descending lexicographically (from Z to A). Here he described the incorrect description *“We want to sort girls first and boys later. We know, D is first letter, then the CH. Well, we sort it from Z to A.”*

Content of data we are working with is totally ignored in the video. The solution is targeted only on technical problem without judging the information contained in the data.

The student in Case 2 formulated her task as following: “Create a graph showing the differences between boys and girls in their average heights and their average chest and waist sizes.” The solution is shown in Figure 5.

The World in the Pocket						
The survey was conducted by:			Patrik			
Date:			16.06.2010			
Name	Birth date	Gender	Height in cm	Chest in cm	Waist in cm	Favourite colour
Andrej Tref	23.11.1995	boy	163	89	79	grey
Janka Lovická	14.07.1998	girl	154	86	65	red
Milada Malá	27.10.1996	girl	161	94	74	blue
Emil Špún	18.09.1995	boy	172	93	75	green
Andrea Ferdenská	14.02.1992	girl	166	86	66	red
Janka Lovická	08.12.1997	girl	162	84	72	brown
Milan Retská	09.08.1997	girl	157	87	68	blue
Roman Jablčný	03.04.1996	boy	169	92	74	grey

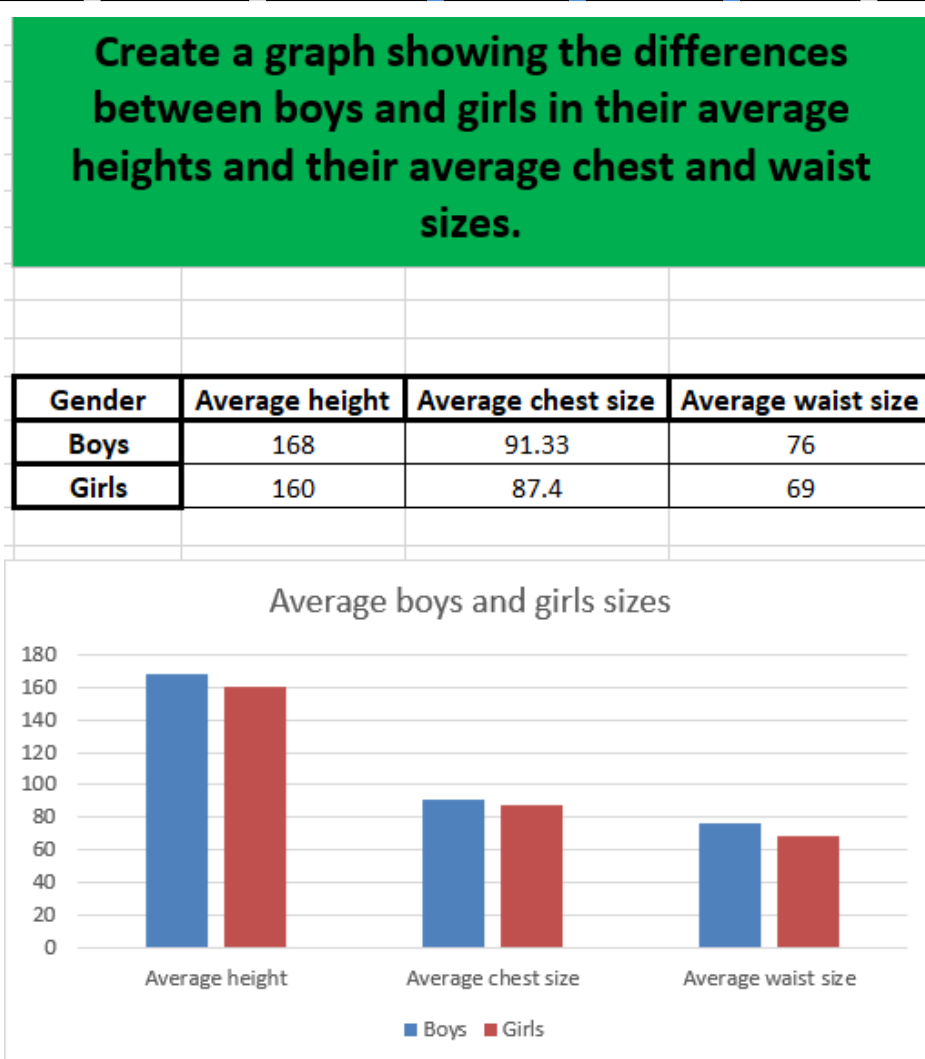


Figure 10 Solution to the task in Case 2 The World in the Pocket 2.

The task is complex, targeted on creative processing of data, gathering new info and their presentation, not the specific function of table calculator, as it has been in the previous case. The task introduces a meaningful problem, where the solution requires an active work

with data together with their meaning. Therefore, a student noticed some unreal data in the table and edited it to a realistic value. The solution uses the means to increase the clarity of teaching:

- writing the task to a significant text field with green colour allows pupils to sense, what is a task, throughout the whole solution,
- formatting of data with colourised underline helps differentiate data consisting of boys and girls. Blue colour for boys and red for girls correspond to established stereotypes.

The student used a method of problem solving. She asks questions, which help her to identify key steps in the solution (*"Which of the data do we need to complete the task?"* *"What types of graphs will be best for interpreting?"*) She comments and describe the procedure (*"I suggest to colour different data for boys and girls."* *"I created a supportive table."*) It is used the analogy (analogical solution for three categories of data: height, chest and waist), which supports a fixation of the topic.

Alternation

In the first solution of our objective (Case 1) the student solved their task generally, algorithmically. His solution is correct for any values of input data. The task, which consists of unrealistic input data, as in our case, is a great opportunity to improve even other competences of pupils. It is a pity not to use it and it is a mistake not to lead pupils to critical thinking when evaluating the results of the solution, even though the task is not explicitly focused on finding errors.

The possible alternation is:

- to add to the solution an interpretative conclusion of the final table (Figure 4), in which mistakes would be discovered in input data,
- or choose meaningful sample as an input, in this case fix input data as in Case 2 (Figure 5).

The default objective is from the textbook, where the task is included in annotation of the case study and focuses on improving the critical thinking. There are wrong data in the table that students have to find. The data in the task aren't specified by what method the mistakes should be found. Whereby there aren't many data, it is possible to do it by reviewing data in every cell of table without automation, not by the computing methods. In terms of Informatics objectives, it is more valuable if mistakes can be discovered by automation of processed data.

Numeric data in the table can be imaged with a bar chart. Source data are gradually changed from the column with height, to columns with data of chest and waist. Individual graphs are in Figure 6. In the graphic representation of data, it can be found some values that differ from others:

- By height: Emil Špún and Janka Lovická,
- By chest: Andrej Tref and Milan Retska,
- By waist: Roman Jablčný.

We can critically control them in the table and correct. With wrong chest and waist data, we discover mistakes even in the name of the pupil – the girl has a boy's first name.

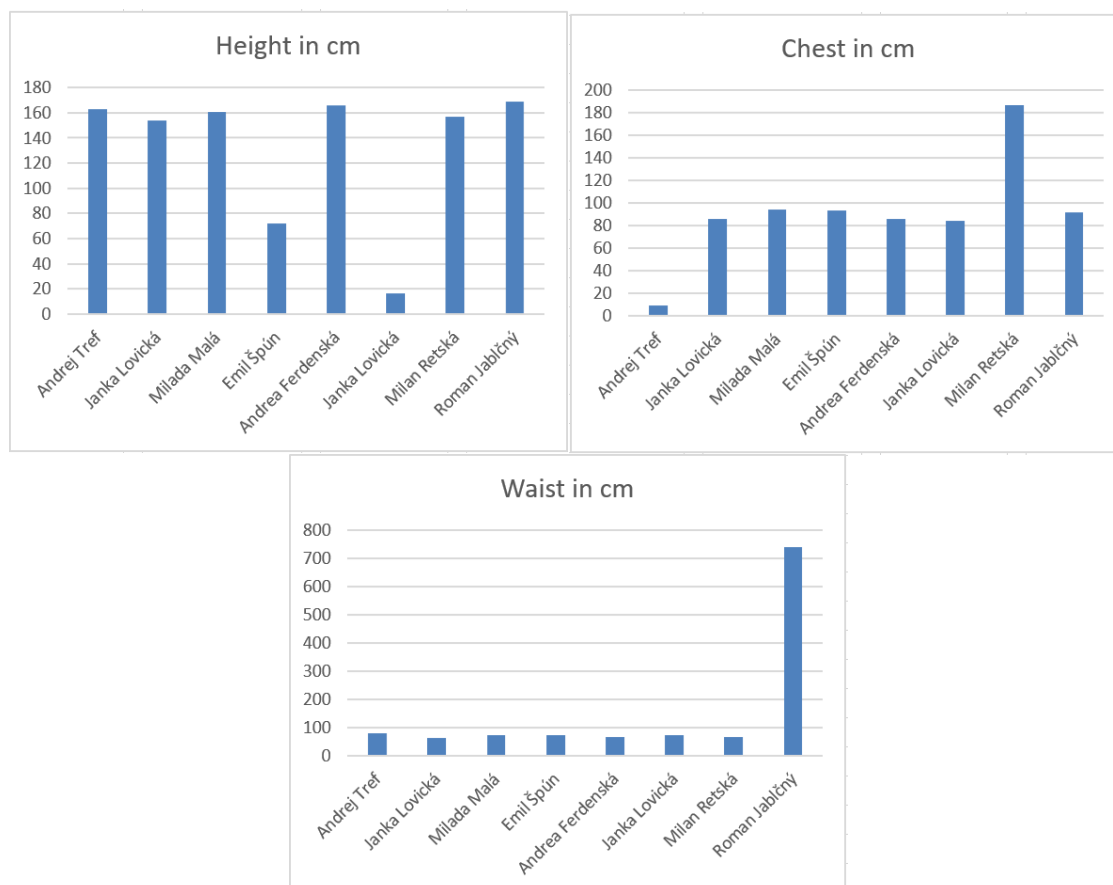


Figure 11 Solution to The World in the Pocket 3 (alternation)

Exercises

- Describe the mistake which the student did in the description about lexicographic sorting of data. Try to suggest a correct formulation.
- Find all mistakes with data in the table.
- Create your own task with these data in the table.

DISCUSSION

The evaluation and comparison of the case studies 1, 2 and the designed alternation with respect to the questions we focused on answering in our case study, are shown in Table 1.

The two cases and the designed alternation represent a diverse sample of types of tasks, forms and methods of teaching and the way of working with incorrect data. Therefore, they are a suitable material for processing in a case study intended for didactic training of pre-service Informatics teachers.

Table 1 Comparison of the case studies

		Case 1	Case 2	Alternation
<i>What type of task is formulated?</i>	Complexity of the task	Simple task of multilevel sorting	Complex problem task	Critical evaluation of the result of a simple task
	Meaningfulness of the task	No	Yes	Yes
	Level of learning objectives	Knowledge	Analysis, Synthesis	Application, Analysis, Evaluation
<i>What form and teaching method is used in the solution?</i>	Form of presentation	Video tutorial	Solution demonstration	Solution demonstration
	Teaching method	Instructions	Explanation	Inquiry
<i>How is solved the problem of incorrect data in the table?</i>	Handling of incorrect data	Ignoring	Editing	Inclusion to the task

CONCLUSION

Teaching case study contributes to linking theory with practice in preparing pre-service teachers. The didactic outputs of pre-service Informatics teachers recorded by screencasting technology are the source of authentic examples of didactic problems, by which students gain specific experience with the application of theoretical knowledge of didactics in teaching practice.

Learning by studying specific cases involves higher cognitive functions - analysis, evaluation and creativity. The creation of a record of pedagogical output using screencasting technology is an opportunity for students to reflect on their performance. At the beginning, when solving a case (screencasting record), interesting didactic phenomena are initially identified, analysed and evaluated from different didactic aspects, and then, alternative solutions of the problems identified and evaluated in the analysis are creatively proposed. Such teaching significantly supports the development of critical thinking in analysing and evaluating case study, and evaluation and the development of creative thinking in designing appropriate alternations.

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Students' Utilization of Mobile Devices with Regards to Learning Mathematics Compared in Central Europe and Indonesia

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Abstract

Nowadays, using mobile technologies for younger generations is becoming an everyday reality. Smartphones and tablets combined with mobile Internet are easily accessible to students and are a part of their everyday life. Mobile devices allow university students to use new methods and forms of learning in mathematical courses. The questions are, can they tap into this potential by knowing the relevant online learning resources, platforms and applications, and are they motivated to integrate mobile devices into their mathematical learning processes? We looked for answers to these problems in the previously realized quantitative researches with more than a thousand respondents of the Czech Republic, Slovakia, Hungary and Romania. In this study, we compared the possibilities and habits of students in Central Europe and Indonesia. In this analysis, the opinions of students on using mobile technologies in math education were identified in the frame of concrete courses of mathematics at each cooperating university. Answers from proposed questionnaires were processed by descriptive and inductive statistical methods according to the considered research questions. Conclusions proved the declared assumptions as significantly satisfying, as was particularly estimated. Our research suggests that the topic is critical so we must pay particular attention to future research, including for other countries.

Keywords

Mobile Technologies. Mathematics Education. Mobile Applications for Education. Quantitative Research.

INTRODUCTION

Mobile devices enable university students to develop innovative learning methods. The question is that can they take advantage of these potentials, do they know the relevant online curriculums, platforms and applications and do they have incentive for integrating mobile devices in their math learning process (Korenova & Veress-Bagyi, 2018).

In the frame of higher education, mobile technologies can be considered as a significant and essential part of the lives of nowadays students. According to theories in sociology, people born after 2000 can be classified as members of the so-called *Generation Z*. Authors Joanne G. Sujansky and Jan Ferri-Reed claim in their book entitled *Keeping the Millennials*, that the current generation of young people is able to do multiple things at the same time, e.g. watch television while working on a laptop, listen to an iPod while chatting or texting messages etc. (Sujansky & Ferri-Reed, 2009).

The young of today do not strictly differentiate between virtual and real experience and often want to have fun alongside work or learning. Today there is a wide range of mobile applications which can be used by students to learn math, and which offer the opportunity to use e-learning support through LMS, alongside with learning materials available as e-books, provided by many Universities. Nowadays, the Neumann Galaxy lives together with the Gutenberg Galaxy. Both printed books and mobile devices are applied. The question often arises: in which proportion should they be used by teachers and by students? We believe in the learner-centred pedagogy and we analyse this question from the student side. We are focusing on the types of mobile learning and talking about the change of mathematics learning (Korenova & Veress-Bagyi, 2018).

In the previously realized quantitative research (Korenova et.al., 2019) with 782 respondents of the Czech Republic, Slovakia, Hungary and Romania; the utilization of mobile technologies was analysed and presented in (Korenova et.al., 2019). In this previous analysis, opinions of students on using the mobile technologies in math education were identified in the frame of concrete courses of mathematics at each cooperating university. Answers from proposed questionnaires were processed by descriptive and inductive statistical methods according to the considered research questions. Conclusions proved the declared assumptions as significantly satisfying, as was particularly estimated.

Indonesia is a developing country located in Southeast Asia region with more than 265 million population. According to the Kemp's survey (2019) the vast majority of the adult population (91%) in Indonesia owned at least a mobile device; most of it is a smartphone (60%). The use of mobile devices in this country is mostly for accessing the Internet spending more than 8 hours and 30 minute daily in average. No figure on mobile devices usage for studying in this survey.

Mobile devices are an emerging tool for learning and delivering instruction in the last couple decades. The devices including smartphones, tablets, Personal Data Assistances (PDAs) or might be laptops and desktop computers have influenced the teaching and learning processes particularly in higher education level. It is common nowadays in Indonesian university instructions for having blended or distance learning facilitated by avant-garde technologies. Likewise, university students' learning methods, styles, and preferences are turning into digital ways. Reading a digital textbook through mobile devices, for instance, is now more preferable than reading it in the printed version.

Nevertheless, it is debatable in Indonesia whether university students could use their smartphones or tablets in the classroom during conducted lessons. In some cases, students are not allowed by their lecturers to use any technological devices during the lesson. However, in other cases, the lecturers encourage students to utilising their devices to figure out learning materials or resources. Hence, it could be said that the situation is depending on the lecturer who teaches them in the classroom owing to each of them have different preferences as well as policies. Some lecturers, particularly the junior one, were usually encouraging students to use a variety of learning applications accessible through smartphones or tablets. In addition to this, lecturers attempted to use games by using Kahoot!, Quiziiz, Seesaw, and other game platforms to motivate and enhance students' engagement in classroom activities. Meanwhile, still many courses are taught traditionally by lecture integrated with minimum advanced technologies or applications. Using a laptop connected to the presentation screen is what commonly happened in the classroom daily.

In Indonesia, studies about mobile devices usage among university students have been conducted for various objectives. Pratama (2018) investigated the daily mobile devices use among university students with focus on time spend and ownership. More comprehensively, Soegoto (2019) investigated reasons of buying a smartphone, spending hours, activities, frequently accessed applications, and behavior effects of using a smartphone. Savitri and Akhiriyah (2017) were studying about the use of smartphone and its apps for learning English. Others studied around the issues of addiction, dependency, adoption, intention to use, and usability. However, most of the studies are solely conducted in one country without any comparison to another country.

THEORETICAL ASPECTS

According to OECD (2005), "if we want students to become smarter than a smartphone, we need to think harder about the pedagogies we are using to teach them. Technology can amplify great teaching but great technology cannot replace poor teaching" (p. 4).

Today's students' needs were identified in six areas. These are the followings: sharism, shifting identities, border crossing, literacies beyond print, a culture of gaming and a culture of bricoleurs. In details, you don't need to hide information. You do not have to be in a single role. You do not have to stay in one place. You do not have to learn the tools, it is enough to use them. There is no need to be motivated, only to give room for learning. There is no need for a rigid curriculum, but rather a tangible experience (Korenova, 2015).

During mathematics courses, students can use digital technologies in various ways: 1) during numerical calculations so they can concentrate on the solution of the problem itself; 2) for visualisation, modelling and simulation of problems and thus to obtain such a graphical representation of the problem which pushes them towards a solution; 3) as a source of educational materials e.g. e-books or videos, interactive educational materials; 4) drilling exercises, a student can make use of electronic working sheets or e-tests to evaluate himself; 5) they can use applications, such as: Geogebra, GeoMatech, 3D Geometry, Wolfram Alpha, PhotoMath etc.; and watching videos about problem solving (Korenova, 2015).

ONLINE MATH RESOURCES

Separated in two categories, in the first part, you can read about searching platforms such as GeogGebra Materials, GeoGebraBook, GEOMATECH project and Planeta Vedomosti project as well. In the second part, several of the students' favourite applications are presented.

GEOMATECH (<http://geomatech.hu>) is a highlighted project in the Hungarian public education the goal of which is to have students like math and the other science subjects. This is an online and interactive curriculum website, which can be used as digital math textbook too. The curriculum portal is based on the GeoGebra software, which provides the potential for making interactive learning material. We can say that GEOMATECH is more than GeoGebra because it gives a frame to GeoGebra applet. Every exercise contains both the description of the problem and of the usage of GeoGebra applet. We can easily search among subjects by choosing the class and the material, which we want to see.

Planeta Vedomosti (<http://planetavedomosti.iedu.sk>) is a Slovakian, free of charge website. It contains a number of professionally made material for mathematics like videos, electronic worksheets and tests which are grouped together according to the curriculum topics for students and teachers alike. The content of this site covers a large part of both elementary and secondary school mathematics but also includes some topics for university students. It is accessible on computers and interactive boards but unfortunately only a part of these is available on smartphones.

Mathematics applications

1. **GeoGebra** has now four apps for iOS and seven apps for Android. We present the most often used ones of them. GeoGebra Graphing Calculator easy to utilize for graph functions, solve equations, find special points of functions. GeoGebra Geometry easily construct triangles, drag points, draw parallel lines, and intersect circles. GeoGebra Classic is applicable for solving math problems, graph functions, create geometric constructions, do statistics and calculus. A first version of GeoGebra Augmented Reality app was launched in 2017 only for iOS platforms, but this is under construction. With this app, the developers would like to explore the potential of AR for learning and teaching mathematics.

2. **Wolfram Alpha** is an education tool, which can give answer for almost everything which is needed in the secondary school. This is a tool, which calculates the math problems and answers the questions. These possibilities are free of charge but there are some potential, which you can get only in paid Pro version. For instance, if you want to upload a photo with math problem the solution of this is only possible in version Pro. Wolfram Alpha has apps for iPad, iPhone, Android, Windows Phone and Tablet and Kindle fire.

3. **Photo Math** is a free 2D AR app for Android and iOS. We point our camera toward a math problem and Photomath will show the result with a detailed step-by-step instruction. What is really exciting about it is that this app contains handwriting recognition. We tried it and the result was excellent. PhotoMath, also named camera calculator, makes math problems easy to solve and everyone is motivated to continue this "game".

There are many other applications in this segment of education but we just focused on the well-known and used ones.

M-learning in Central Europe region and Indonesia

We studied the M-learning current situation in Slovak, Hungarian and Romanian universities. At the present, nearly all schools make use of some kind of digital technologies in education. Digitaliada (<http://digitaliada.ro>) has been a special program for rural areas digital math education in Romania since 2016. The project covers 30 secondary schools from the countryside, this means 3400 students and 82 teachers. The site of Digitaliada is a platform for collecting new online materials in this theme as well.

The most active Hungarian blog is TanárBlog (<http://tanarblog.hu>) made by Prievara Tibor and Nádori Gergely. This blog is an almost daily updated site with actual and exciting content about the Hungarian digital education. Essentially it is a teacher blog as its name shows, where the authors share their teaching experience in M-learning too, but unfortunately only in Hungarian. Prievara has also created a new electronic evaluation system which is used by other teachers. The ICT Association in Hungary (<http://ivsz.hu/en/>) is concentrating on the education and digital skills in schools with Program for promoting digital education and The Digital Thematic Week.

There are many projects, domestic and foreign, which are focusing on pilot introduction of M-learning to schools. In Slovakia, there are currently two such projects that can be found under the following links: <http://www.skolanadotyky.sk> and <http://www.digiskola.sk>. The former project, "school by touch", was an initiative from private companies, which supplied ten schools with interactive whiteboards and tablets for every pupil in a classroom.

There is a prominent project of the Ministry of Education and Culture in 2011 called e-Sabak for promoting the use of tablets in Indonesian schools, especially those located in rural areas. The aim of this project is providing tablets for schools' learning systems that enable students and teachers using it as a learning tool and resources, learning interaction medium, learning management system, and learning evaluation tool. However, e-Sabak is currently only used as a learning resource replacing books (Warsihna et al., 2015). This project now is called Buku Sekolah Elektronik or electronic school books.

There are no specific learning applications commonly used by university students in Indonesia. What is common and happening that universities were developing their own online learning system or application by using a learning management system (LMS) platform. Students' learning activities and interaction with lecturers and peers synchronously or asynchronously are conducted in the developed system. Moodle could be said as the most popular LMS used to develop an online learning environment in Indonesian universities. Moreover, others are using Edmodo, Google Classroom, and edX. Additionally, some universities were also developing massive open online courses (MOOCs).

STATISTICAL ANALYSIS WITH REGARDS TO COUNTRIES (EUROPEAN / ASIAN)

Using the Euclidian type of a similarity measure, the cluster analysis obtained the conclusion (Figure 1) in favor of diversification of Indonesian characteristics in comparison with other European countries. The cluster analysis was provided according to the Table 1, respectively Figure 2.

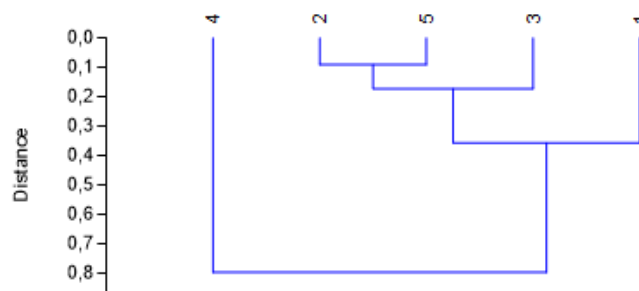


Figure 1 Achieved Cluster Analysis of Countries' Characteristics Based on Using Mobile Technologies in Education (1 – Slovakia, 2 – The Czech Republic, 3 – Hungary, 4 – Indonesia, 5 – Romania)

Table 1: Data in Form of Means Prepared for Cluster Analysis Based on Possibilities of Using Mobile Technologies in Education

Item	Country of Study	Using Smartphone or Tablet in Education	Teacher's Approach of Using Smartphone or Tablet in Education
1	Slovakia	1.18	1.73
2	Czech Republic	1.18	2.14
3	Hungary	1.11	1.97
4	Indonesia	1.00	1.21
5	Romania	1.09	2.13

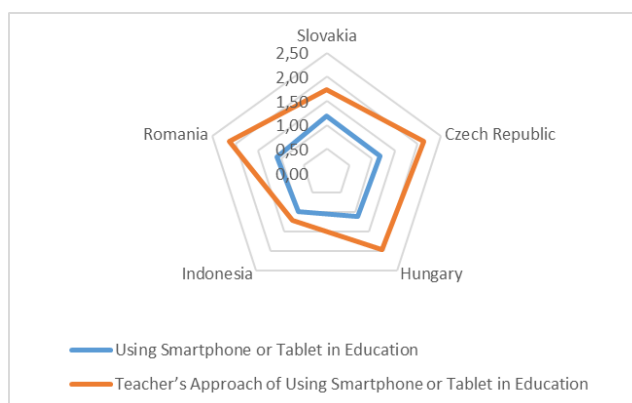


Fig. 2 Possibilities of Using Mobile Technologies in Education According to Countries

In the quantitative educational research, the following testing hypotheses (Hendl, 2014; Vaclavik et al., 2019) have been frequently seen. Additionally, in contingency tables (Table 2 – 5), appearance of observed phenomenons in the form of absolute frequencies is a background for application of method Chi-squared (Hendl, 2014; Barot and Krpec, 2019).

Following hypotheses were established and than tested using by the particular contingency table on the significance level 0.05 in the statistical software IBM SPSS Statistics version 26.

Hypothesis 1H₀: There are not statistically significant dependences between country of study and field of study, in which the mobile technologies can be used.

Hypothesis 1H₁: There are statistically significant dependences between country of study and field of study, in which the mobile technologies can be used.

Table 2: Contingency Table Constructed with Regards to Country of Study and Field of Study

Country of Studies	Economical Sciences (Digital Humanities Engineering (Mathematics, Marketing, Economics, (Arts, Social Technique, Biology, Chemistry, Management, Company Sciences, Informatics, Medical) Management, Tourism)
Slovakia	152129
Czech Republic	1201
Hungary	23050120
Indonesia	455531
Romania	8028102

Due to $p\text{-value } p = 1.0005 \times 10^{-102} < 0.05$, the zero hypothesis is rejected in favour of the alternative hypothesis on the significance level 0.05 using the Chi-Squared test ($DF = 8, \chi^2 = 499.29$). Therefore, there are statistically significant dependences between country of study and field of study, in which the mobile technologies can be used.

Hypothesis 2H₀: There are not statistical significant dependences between country of study and gender of respondents, which can use the mobile technologies in education.

Hypothesis 2H₁: There are statistical significant dependences between country of study and gender of respondents, which can use the mobile technologies in education.

Table 3: Contingency Table Constructed with Regards to Country of Study and Gender

Country of Studies	Male	Female
Slovakia	23	213
Czech Republic	1	21
Hungary	170	230
Indonesia	32	99
Romania	101	109

Respecting $p\text{-value } p = 1.5067 \times 10^{-22} < 0.05$, the zero hypothesis is rejected in favour of the alternative hypothesis on the significance level 0.05 using the Chi-Squared test ($DF = 4, \chi^2 = 108.52$). Therefore, there are statistically significant dependences between country of study and gender of respondents, which can use the mobile technologies in education.

Hypothesis 3H₀: There are not statistically significant dependences between country of study and frequency of using the mobile technologies in education.

Hypothesis 3H₁: There are statistically significant dependences between country of study and frequency of using the mobile technologies in education.

Table 4: Contingency Table Constructed with Regards to Country of Study and Using Smartphone or Tablet in Education

Country of Studies	Yes	Not
Slovakia	185	51
Czech Republic	18	4
Hungary	357	43
Indonesia	131	0
Romania	191	19

Due to p-value $p = 1.3585 \times 10^{-8} < 0.05$, the zero hypothesis is rejected in favour of the alternative hypothesis on the significance level 0.05 using the Chi-Squared test ($DF = 4, \chi^2 = 42.43$). Therefore, there are statistically significant dependences between country of study and frequency of using the mobile technologies in education.

DISCUSSION

In the quantitative research, relations between two selected topics were analyzed. Particularly, the analysis was based on identification of dependences between utilization of mobile technologies in math education and technical background of students. On the sample of 1124 respondents, which were the university students of the Czech Republic, Slovakia, Hungary Romania and Indonesia; these consequences were tested. The quantitative research was focused on testing hypotheses, which were bounded on the considered research questions.

The following conclusions were determined. There are not statistically significant dependences of teacher's approach of using a smartphone or a tablet in education on having a smartphone or a tablet. There are statistically significant dependences of using the tablet or the smartphone on type of equipment. There are not statistically significant dependences of using the tablet or the smartphone on having the desktop computer. There are statistically significant dependences of appearance of Wi-Fi connection at university on having a smartphone or a tablet. There are statistically significant dependences of using the tablet or the smartphone on appearance of Wi-Fi connection at university. There are statistically significant dependences of utilization of Internet mobile connection on having a smartphone or a tablet. There are statistically significant dependences of using the tablet or the smartphone on utilization of Internet mobile connection. All these obtained and identified conclusions were considered on the significance level 0.05. Due to achieved result can be claimed, that the technical background of students has a significant influence on the utilization of proposed type of devices of students.

In this article we searched the answer for the question that in which proportion do university students use mobile devices in their learning process, especially in mobile math learning and what is their opinion about the utilisation of these devices in learning? For this purpose we establish a few lists about the university students' activities on their mobile devices. One list is about the possible online daily activities, the other is about online practices belong to learning and finally about math applications used by them. These lists were put in questionnaires made in Slovakian, Hungarian, Czech and Indonesian language and spread both in Hungary and Slovakia, in the Transylvanian part of Romania and Indonesia.

CONCLUSION

We obtained several interesting results. In the quantitative research, relations between three particular topics were analyzed. The analysis was based on identification of dependences between utilization of mobile technologies, gender and field of studies in math education with regards to the comparison between Central Europe and Indonesia. On the sample of 1124 respondents, which were the university students of the Czech Republic, Slovakia, Hungary Romania and Indonesia; these consequences were tested. The quantitative research was focused on testing hypotheses, which were bounded on the considered research questions. The following conclusions were determined. There are statistically significant dependences between country of study and field of study, in which the mobile technologies can be used. There are statistically significant dependences between country of study and gender of respondents, which can use the mobile technologies in education. There are statistically significant dependences between country of study and frequency of using the mobile technologies in education.

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Development of University-Industry Centre of Biomedical and Medical Informatics

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Abstract

Biomedical and Medical Informatics (BMI) belongs to the rapidly growing interdisciplinary field which aims at implementation of digital technologies in all aspects of healthcare. Due to rapid development and integration of information and communication technologies into all areas of human life, it is expected that demands for experts in this area will grow in the coming years. This fact should be reflected by higher education institutions to develop new interdisciplinary study programs that educate specialists that have knowledge of medical and biomedical terminology, understand the current issues of biomedical research and have a strong background in informatics and digital technologies. European universities have reflected this reality and have begun to offer study programs in the area of BMI. In Slovakia, this fact has been reflected by Faculty of Management Science and Informatics of University of Zilina, which opened a master study program on BMI in September 2019. To support this program and grasp the best practices of European universities offering BMI-related study programs, University of Zilina prepared and coordinate Erasmus+ project bringing together universities and industrial partners from nine countries of the European Union. The aim of the project is to create a university-industry centre in BMI with an online portal covering current challenges in BMI and containing teaching materials for courses related to BMI. The portal will be available for free to students of partner universities as well as other universities and practitioners interested in BMI and will support not only regular learning but also distance learning in BMI.

Keywords

Biomedical Informatics. Electronic Healthcare. Interdisciplinary Studies. Knowledge Alliances. Learning Systems. Medical Informatics.

INTRODUCTION

During the last years, Information and Communication Technologies (ICTs) have become an integral part of human lives. They can be found in industry, offices, homes, and others. An important economic sector, where the relevance of ICTs increases very fast, is healthcare. This fact can also be recognized in several resolutions of World Health Assembly (WHA) approved in the last 20 years (WHO, 2020). For example, resolution WHA58.28 on eHealth approved in 2005 recognizes the potential of eHealth (the use of ICT for health) to strengthen health systems and improve quality, safety and access to healthcare (WHO, 2005; 2020). Resolution WHA66.24 from May 2013 expands the previous one by the need for health data standardization in order to achieve a secure, timely and accurate exchange of data for health decision-making (WHO, 2013). Another resolution WHA71.7 on Digital health, which was approved in 2018, emphasizes that digital technologies including ICT and mobile technologies play one of the major roles in health promotion and disease prevention by improving the accessibility, quality and affordability of health services (WHO, 2018). According to these documents of World Health Organization (WHO), digital technologies have become an integral part of medicine and will play a significant role in achieving universal health coverage. This fact has resulted in the promotion of Biomedical and Medical Informatics (BMI).

According to Bernstam, Smith and Johnson (2010), BMI is the interdisciplinary study of the design, development, adoption and application of ICT-based innovations in healthcare services delivery, management and planning. It deals with the resources, devices, and methods required to optimize the acquisition, storage, retrieval, and use of information in health and biomedicine. BMI tools include computers, clinical guidelines, formal medical terminologies, and information and communication systems, among others. It is an emerging field for decades due to the rapid advances in biomedical, medical, and ICT sectors (Mihalas et al., 2014). Successful BMI research has resulted in the development of innovative technology-supported techniques, diagnostic and therapeutic methods leading to radical changes and enhancement of healthcare delivery (Sligo et al., 2017). Further growth in this interdisciplinary area calls for a pool of high-quality experts. This requires the development of new study programs and modernization of curricula of existing programs, which enable to educate specialists that are able to communicate with physicians, nurses and employers of biomedical laboratories to develop software for processing and analysis of medical and biomedical data, to design, implement and manage complex healthcare information systems, to create systems for support of decision-making in medicine, and to understand data produced by various medical and biomedical devices. This fact is reflected by universities among the whole European Union (EU). In Slovakia, it is reflected by Faculty of Management Science and Informatics of University of Zilina, which has offered from September 2019 a new study program named as Biomedical Informatics (Macekova, Kvassay and Zaitseva, 2019). During preparing this program, members of the faculty established cooperation with other EU universities and companies dealing with BMI and prepared a joint Erasmus+ project which aims at creating a Centre of BMI (CeBMI), whose main part will be an online portal supporting free access to teaching materials intended for the main courses of BMI.

The delivery of BMI training programmes in universities have to be a joint cooperative effort of medical and technical universities, which will be facilitated through the CeBMI. Within the project, a shared online BMI repository will be created by all core project

partners, i.e. technical and medical universities for the delivery of BMI courses. Companies involved in the project will be able to promote their own products, e.g. medical and biomedical applications or various hardware and software medical solutions, and provide in-house technology training for academic staff. Universities will be able to increase the quality of BMI related educational programs. The joint academic-industrial research collaboration will be conducted by academic and industrial partners. The CeBMI will provide ICT tools and open educational resources for ICT-enabled pedagogic approaches to increase effectiveness in education delivery and enhancing learning experience. The CeBMI will develop a research-informed curriculum with vital inputs from the industries. Even though developing such a curriculum is challenging, it could be realized through an international and interdisciplinary joint collaborative effort of medical and technical universities as well as industrial technology providers. So, the main goals of this paper are to summarize the current state in teaching biomedical informatics, present results of analysis of the study programs connecting medicine, engineering and informatics in Slovakia, justify the need for the CeBMI and present the key requirements on the portal developed within the CeBMI.

STATUS OF BIOMEDICAL AND MEDICAL INFORMATICS

According to Mihalas et al. (2014), medical informatics or biomedical informatics has been developed across western countries for more than fifty years. With respect to Bernstam, Smith and Johnson (2010) and American Medical Informatics Association (AMIA, 2020), it is an interdisciplinary field that deals with the effective use of biomedical data, information, and knowledge to support decision-making in biomedicine and medicine, whose main goal is to improve human health. Sometimes, it can be referred to as a part of a similar area known as biomedical engineering. However, it is important to note that the key difference between BMI and biomedical engineering is a fact that BMI focus on processing and analysis of various data produced in medicine and biomedicine using computer technology, while the main focus of biomedical engineering is the development of hardware solutions to understand, modify, or control biological (e.g. human) systems by applying electrical, chemical, optical, mechanical, and other engineering principles (Bronzino, 2012). Another term that is closely related to BMI is bioinformatics. According to Claverie and Notredame (2006), it can be defined as the computational branch of molecular biology since it deals with the development of algorithms, methods and software solutions for processing of biological data. In this context, it can also be viewed as a branch of BMI.

Although WHO recognized ICT and all digital technologies as an important tool for achieving universal health coverage (WHO, 2020) at the beginning of the 21-st century, some works of Mihalas et al. (2014) or Polašek and Kern (2012) imply that BMI has existed in western countries for more than half of a century. This has resulted in the development of various study programs dealing with BMI in many European countries that are also recognized by European Federation for Medical Informatics (EFMI, 2020a), which promotes research and development in medical informatics and encourage high standards in education in medical informatics across Europe (EFMI, 2020b). According to EFMI (2020a), most European countries, including Czechia, have several study programs on medical informatics, health informatics, biomedical informatics, bioinformatics or biomedical engineering. However, no information about Slovakia is currently provided at webpages of EFMI. Because of that, we analysed study programs provided by Slovak universities. The

analysis was performed based on data provided by PortalVS.sk (<https://www.portalvs.sk/>) and by finding all programs that contains in their names key phrases, which are in Slovak “bio” (for biology), “med”, “lek” (for medicine), “zdr” (for health), “klini” (for clinical), “ort”, “prot” (for orthotics and prosthetics), “digi” (for “digital”), “dát”, “big” (for data and big data). After that we identified the study programs whose names pointed to the correlation between informatics, electrical or mechanical engineering and medicine or biomedicine. Finally, we inspected webpages of each of the identified universities and checked whether the university offers the found program and whether its content really coincides with applications of engineering or informatics in medicine or biomedicine. Based on this analysis, we found that just three universities offer technically oriented biomedical programs (Table 1). Furthermore, before 2019, there was only one study program dealing with processing of biomedical data (Bioinformatics at Comenius University in Bratislava) and no program on education of specialists in the development of complex software solutions for needs of BMI. Because of that, Faculty of Management Science and Informatics of University of Zilina has tried to fill in the gap and open the study program on Biomedical Informatics in September 2019. Now, it tries to support it by development of the CeBMI.

Table 1: Study programs combining engineering with medicine and biomedicine in Slovakia.

University	Faculty	English and Slovak name of study program	Level	Source
Comenius University in Bratislava	Faculty of Mathematics, Physics and Informatics	Biomedical Physics (Biomedicínska fyzika)	Bc.	https://fmph.uniba.sk/studium/programy/biomedicinska-fyzika/
		Biomedical Physics (Biomedicínska fyzika)	MSc.	https://fmph.uniba.sk/studium/magisterske-studium/biomedicinska-fyzika/
		Bioinformatics (Bioinformatika)	Bc.	https://fmph.uniba.sk/studium/programy/bioinformatika/
Technical University of Košice	Faculty of Mechanical Engineering	Prosthetics and Orthotics (Protetika a ortotika)	Bc.	https://www.sjf.tuke.sk/uc-hadzac/studijne-programy/bakalarske-studium/71-protetika-a-ortotika
		Biomedical Engineering (Biomedicínske inžinierstvo)	MSc.	https://www.sjf.tuke.sk/uc-hadzac/studijne-programy/inzinierske-studium/80-biomedicinske-inzinierstvo
University of Zilina	Faculty of Electrical Engineering and Information Technology	Biomedical Engineering (Biomedicínske inžinierstvo)	Bc.	https://www.uniza.sk/index.php/studijne-programy-info-bc?oblast=1
		Biomedical Engineering (Biomedicínske inžinierstvo)	MSc.	https://www.uniza.sk/index.php/studijne-programy-info-ing?oblast=2
	Faculty of Management Science and Informatics	Biomedical Informatics (Biomedicínska informatika)	MSc.	https://www.uniza.sk/index.php/studijne-programy-info-ing?oblast=2

Online Portals Related to Teaching Biomedical and Medical Informatics

As mentioned above, BMI is a complex and interdisciplinary area that needs diverse yet complementary knowledge, expertise and competences in medicine, biomedicine and informatics. BMI curricula for health professionals must include statistics, knowledge discovery, image processing, telecommunication networks, system reliability and safety, augmented reality, virtual reality, data science, etc. All these represent various domains of informatics. BMI curricula have to be developed based on innovative and multidisciplinary approaches to teaching and learning. According to Pinho, Franco and Mendes (2018), all these goals can be satisfied through an online portal that incorporates necessary tools to facilitate easy and quick creation of new or modernization of existing curricula and programs so that they will be adaptive to dynamic changing needs of the BMI domain and will reflect the real labour market demands. Such a portal should include a repository of lectures' texts and presentations, a list of practical tasks for labs, multimedia sources for home works, etc. Due to specifics of BMI, the portal should also incorporate tools for data analysis based on R, Python, Matlab, SaS, and others.

Several portals partially matching the requirements introduced above currently exist, but they are primarily aimed at academic staff and students of medical universities. For example, medical universities can use the following online resources:

- MedEdPortal (<https://www.mededportal.org/>) – open-access journal and online repository containing teaching and learning resources used in the health professions published by Association of American Medical Colleges (AAMC), which represents 171 accredited United States and Canadian medical schools (AAMC, 2020);
- OnlineMedEd (<https://onlinemeded.org/>) – online portal containing teaching materials for students of medicine;
- Health Education Assets Library (HEAL) (<https://mwdl.org/collections/HealthEducationAssetsLibraryHEAL.php>) – a digital library providing access to several thousands of videoclips, animations, presentations, and audio files supporting education in healthcare published by University of Utah – Spencer S. Eccles Health Sciences Library;
- PubMed (<https://www.ncbi.nlm.nih.gov/pubmed/>) – a free resource supporting the search of biomedical and life sciences literature managed by the United States National Institutes of Health's National Library of Medicine, which belongs to the leading repositories of medical information (DeBakey, 1991).

However, the analysis of these and other resources showed that they cannot be used for engineers since the knowledge of students in medical and technical universities in both ICT and medicine is significantly different (Kim, 2019). This calls for the development of new resources in BMI for the technical universities. These resources should be stored at an online portal that will be an addition to existing resources to improve the background in BMI education for all specialisations. Furthermore, as Klaassen (2018) and Kim (2019) state, the resources should be developed in a way that supports interdisciplinary education in BMI, which makes easier future communication between computer and software engineers and analytics, doctors and nurses. For these purposes, it is important to develop the portal for supporting BMI teaching as a common project of technical and medical universities as well as partners from the industry. Such a concept celebrates great success in the development

of the Multimedia Educational Resource for Learning and Online Teaching (MERLOT) (<http://www.merlot.org/>), which represents an online repository of learning resources managed by international consortium of higher education institutions, industrial partners and individuals (McMartin, 2009). Furthermore, according to Sheffield (2006), MERLOT belongs together with MedEdPortal and HEAL to the most effective online portals containing information about healthcare. During the development and creation of the portal, we can also build on the experiences and results of the Medical Faculties Network in Slovakia and Czechia (MEFANET) (<http://www.mefanet.cz/>). These and other portals can be used as a source of knowledge helpful in the development of the portal related to BMI issues developed as an integral part of the CeBMI.

CENTRE OF BIOMEDICAL AND MEDICAL INFORMATICS

The principal goal of the project led by University of Zilina is the creation of multidisciplinary teaching and research CeBMI. According to the current state in teaching BMI summarized above, the key part of the centre will be an online portal that provides (a) innovative embedded tools for easy and quick development of new curricula and update of existing curricula on BMI; (b) a rich virtual environment cross-fertilisation of ideas, knowledge exchange, transfer and co-creation. The portal will be developed in a cloud-based platform in order to cater for concurrent users and also for scalability purposes in order to accommodate for a foreseeable increase in student numbers in the near future. The project partners will fill in the portal with teaching materials and modules prepared by them. All these materials will be available to the users of the portal, who are teachers and students of the partner universities as well as other educational institutions interested in BMI. Based on the analysis of the existing portals mentioned above, we decided that the CeBMI portal will include the functionalities presented below.

- *The BMI-repository and educational resources* that will include teaching materials and current BMI-related scientific as well as research findings. The repository will have a thematic module structure. Access to the repository will be provided via free online registration. Registered members will be able to upload additional teaching resources approved by the administrators of the portal. These BMI materials will be additional reading resources or references for students and other users of the portal.
- *The dissemination section* will publish partners' relevant publications and also provide links to open-access BMI-related journals. This facility is to provide easy access to the latest BMI state-of-the-art, research findings, challenges and best practices in BMI teaching.
- *The news* will provide information on latest developments and trends in BMI curricula, technologies, techniques, and approaches, job vacancies, events, projects, and advertisements of new ICT products for medicine and biomedicine.
- *The discussion forum* will provide a virtual environment for knowledge exchange and transfer, best practice sharing, etc. It will be one of the main communicative means amongst the project partners and the public.

The CeBMI will involve representatives of medical, technical universities/faculties, companies and enterprises as registered users. The aims of the CeBMI are:

- using new instruments and technologies in the form of a portal for easy creation of new as well as multidisciplinary BMI-related curricula and modification of existing curricula;
- collating synergised BMI-related theoretical and practical knowledge;
- support of national and international cooperation;
- support of cross-sectoral cooperation between the academic staff of universities and enterprises, which will help students develop entrepreneurship mind-set and entrepreneurial skills. Such cooperation will also stimulate the flow and exchange of knowledge between academia and the industries;
- involvement of industrial experts in students' educational process;
- exposing academic staff to real and actual BMI-related application problems. Academics will help bring the academic, research and theoretical dimension to these problems.

All these goals will support the new study program on Biomedical Informatics opened in September 2019 at the Faculty of Management Science and Informatics of University of Zilina and allow other universities to modify and further improve their own curricula dealing with BMI.

Partners

The interdisciplinary approach of BMI requires a unique combination of skills and experience that can only be provided by the best scientists of various European countries. The project gathers a group of high-profile experts from BMI, informatics and medical fields of various European countries such as Germany, Italy, Slovenia, and the United Kingdom in case of BMI, Bulgaria, Slovakia, and Spain in case of informatics and Czechia and Finland in case of medicine.

The project consortium includes partners that have different specialisations and expertise in BMI that is necessary for the development of a multidisciplinary portal resource and to provide a wide range of BMI-related consultancy services via the CeBMI. More precisely, the project consortium is composed of the next educational institutions:

- University of Zilina from Slovakia with specialization in data mining, medical decision support systems, system safety and reliability,
- Leeds Beckett University from the United Kingdom with a focus on knowledge discovery and telecommunication,
- Peter L. Reichertz Institute for Medical Informatics of the Technical University of Braunschweig from Germany, which is one of the leading medical informatics institutes in Germany and worldwide with specialization in image processing, healthcare information systems, and telecommunication,
- Università Campus Bio-Medico di Roma from Italy dealing with big data, machine learning, image and video processing and analysis,
- Universidad Rey Juan Carlos from Spain dealing with knowledge discovery, medical decision support systems, and medical simulation,
- University of Oulu from Finland which has very good knowledge in properties and characteristics of healthcare information systems and general medical background,

- Universitat de Valencia from Spain focusing on medical statistics and ethical, legal, and social issues of eHealth,
- University of Ostrava from Czechia with the background in medicine, protection of healthcare data, and ethical, legal, and social issues of healthcare information systems,
- and the following industry partners:
- TELESIG Ltd. from Bulgaria dealing with the development of tools for biometrics analysis in mobile applications and security of information systems,
- STAPRO Slovensko from Slovakia, which is the Slovak leader in the development of hospital information systems,
- Dr. Guido Kaufmann e.K. from Germany dealing with quality control,
- Bioanim from Slovenia focusing on applications for virtual reality,
- Hospital of Zilina from Slovakia which belongs to the main hospital in the Northwest Slovakia.

It is worth noting that all university representatives who are involved in the project are also active BMI researchers and their research will be fed into research-informed teaching and also the development of high-quality teaching materials that are of excellent high-quality international standards. This is important for the provision and delivery of excellent quality education that will meet the demands of the labour market.

Courses

The previous description of the project partners indicates they cover a wide range of knowledge in BMI. Based on their experiences, research activities, and educational abilities they agreed on the development of the courses dealing with the following topics:

- image and signal processing,
- medical simulation,
- data mining,
- reliability, safety, and security,
- telemedicine and hospital information systems,
- artificial intelligence in decision making support,
- educational software in virtual reality,
- medical statistics and medicine for engineers.

All these courses will be developed within the project, and they will be accessible without any fee not only to the project partners but also to other partners interested in BMI. It is worth noting that the courses try to cover most of the topics related to BMI according to Shortliffe and Cimino (2014), which is inspired by a Stanford University (SU) training program focusing on various aspects of BMI (SU, 2020).

CONCLUSION

As we presented in this paper, BMI is a well-recognized interdisciplinary field in western countries. According to our research, no study program on this problematic was offered by Slovak universities till the year 2019. Faculty of Management Science and Informatics of University of Zilina has tried to fill in this gap by its new study program entitled Biomedical Informatics. To support this program by grasping experiences and skills of some of the European well-recognized experts in BMI, we proposed to develop the CeBMI, which should cover medical and technical universities as well as companies dealing with BMI to provide a breeding ground for further development of BMI in Slovakia and other countries of EU. The main part of the CeBMI will be the online portal containing various teaching materials and learning resources to support BMI teaching. According to our analysis of some of the similar portals, the main benefit of the portal managed by the CeBMI will be its focus on students of technical universities since most of the existing portals are primarily aimed at students of medical universities. Furthermore, the participation of medical universities in the project will allow developing materials in such a way that they can be used not only by computer scientists but can also be used as a source of additional technical knowledge for graduates of medical universities, which can be a great support for interdisciplinary education in BMI. The current progress in the implementation of the project and development of the portal can be watched at the project homepage <http://cebmi.fri.uniza.sk/>.

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Remote Experiments as Virtual Labs?

Examples with Pendulum

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Abstract

The contribution presents the technology and examples of real remote and virtual experiments that contain pendulum. This experiment topic has played an important role in the history of time measurement and understanding gravity, therefore it is still included in school curricula and lab assignments. We present a new real remotely controlled physics experiment that is available at any time, from anywhere, and for everyone and that can be linked with virtual experiments (simulations). The real remote experiment technology is based on our universal “iSES Remote Lab SDK” platform as well as other 18 remote labs available online. This SDK, which is used for easy creation of new remote experiments even by non-programmers, is also described.

In the introduction, we recall first PC-aided experiments with pendulum, their features, technology, and outcomes. Then we describe our new real remote experiment. It offers opportunity for an experimental study of several dependencies between experimental parameters like period vs. deflection or period vs. length, with a goal to determine the experimental value of local gravity acceleration g . Our real remote labs may be accessed with common web browsers, they feature live video of the experimental setup and a possibility to record and download own experimental data for further processing with dedicated software. Furthermore, first outcomes of the WorldPendulum (WP@ELAB) Project are discussed. The project aims to create and publish 20 identical online pendulum remote experiments worldwide in order to study the dependence of the gravity value g on latitude.

Keywords

Remote Laboratory. Virtual Laboratory. Pendulum. ISES Remote Lab SDK. Gravity of Earth. Projekt WP@ELAB

INTRODUCTION

History of pendulums

Galileo Galilei is considered to be the first scientist who studied pendulums experimentally (around 1582 by the swinging motion of a chandelier in the Pisa Cathedral). He also found that the period is independent of the mass of the pendulum and proportional to the square root of the length of the pendulum. He measured time using his heartbeats because no precise clocks were available. Later he proposed to use pendulum clocks for precise time measurement. The idea was realised after Galileo's death. Historicians believe that pendulums had been used in the 1st century in China as a simple seismographs. Also Leonardo da Vinci is the author of many drawings of pendulums as timekeeping applications.

The first pendulum clock was constructed in 1656 by the Dutch scientist Christiaan Huygens. Best accuracy achieved was around 15 seconds of drift per day. In 1671 French astronomer Jean Richer found during his expedition from Paris to Cayenne in French-Guyana that pendulum clock was 2,5 minutes per day slower at Cayenne than at Paris. He concluded that the force of gravity was lower at Cayenne. The study of this dependency in school setting is also the goal of the WP@ELAB Project. Due to the dependence of period on temperature, air pressure and the influence of air friction on the pendulum movement as well, pendulum clocks have been replaced with cheap and available quartz crystal oscillator clocks since 1927.

First remotely controlled pendulum

Real remote labs became part of experimental physics education many years ago. First remote labs were described in (Aktan, B., Bohus, C., Crowl, L., Shor, M. H., 1996). Probably the most significant contribution concerning remote pendulum was the German project World Pendulum (Gröber, S., Vetter, M., Eckert, B., Jodl, H.-J., 2007). Here several identical pendulum experiments were offered online, enabling the study of the dependence of gravity on latitude and height above sea level. These pendulums were situated in:

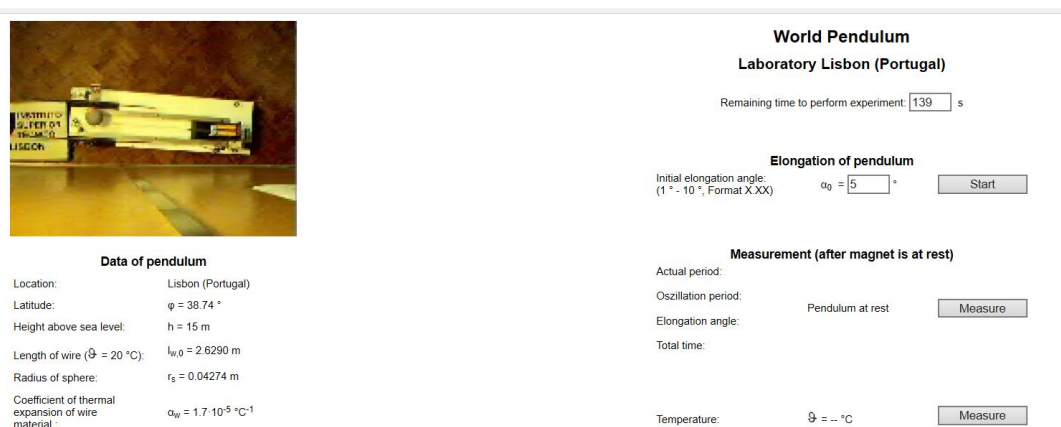
1. Germany (Kaisersesch, latitude: N50.23°, 455 m above sea level)
2. Germany (Hermannsburg, N52.83°, 55 m)
3. Italy (Napoli, N40.83°, 6 m)
4. Yemen (Aden, N12.80°, 25 m)
5. Latvia (Riga, N66,93°, 11 m).

German pendulums consisted of a steel sphere, a wire and a precision suspension. Their length 2,7 m corresponded to a pendulum period of one second. The initialization of oscillation was realized with movable electromagnet on a sledge moving on tracks. After the electromagnet is switched off, the sphere is released to oscillate. An important part of the experimental setup is a photogate to measure period of the pendulum to determine the

Earth's gravitational acceleration g . Accuracy of time measurements around 0.1 ms was determined using the sampling frequency of counters connected to the optical gate. The deflection of pendulum could not be measured in order to decide whether oscillations are harmonic. It was only possible to set the initial angle of deflection, afterwards the time period of the pendulum could be measured. The experimental value of local gravity acceleration g was determined with corrections considering temperature dependence of the length so the temperature had to be measured, too. Two items of assignment were:

1. Measurement of the Earth's gravity acceleration at one of the five locations in the model of the physical pendulum.
2. Measurement of the dependence of the swing period of the pendulum on the initial angle of deflection.

Unfortunately, the control web page (see Figure 1) is not available anymore because it was based on Java applets, which required JAVA SE 6.0 Runtime environment (JRE) available from the Oracle Java archive (nowadays with security vulnerabilities and many warnings that make remote measurement impossible).



World Pendulum
Laboratory Lisbon (Portugal)

Remaining time to perform experiment: 139 s

Elongation of pendulum
Initial elongation angle: $\alpha_0 = 5^\circ$ (1° - 10°, Format X.XX)

Measurement (after magnet is at rest)
Actual period:
Oscillation period:
Elongation angle: Pendulum at rest
Total time:
Temperature: $\vartheta = \dots^\circ\text{C}$

Data of pendulum
Location: Lisbon (Portugal)
Latitude: $\varphi = 38.74^\circ$
Height above sea level: $h = 15\text{ m}$
Length of wire ($\vartheta = 20^\circ\text{C}$): $l_{w,0} = 2.6290\text{ m}$
Radius of sphere: $r_s = 0.04274\text{ m}$
Coefficient of thermal expansion of wire material: $\alpha_w = 1.7 \cdot 10^{-5} \text{ }^\circ\text{C}^{-1}$

Figure 1: Control web interface of World Pendulum in Lisbon laboratory, 2007
(http://rcl-munich.informatik.unibw-muenchen.de/worldpendulum/eng/lab_lissabon.htm)

The German (later also Portuguese) World Pendulum remotely controlled experiments (RCLs) were created in 2007 and unfortunately were not upgraded to be accessible by smartphones in the following years. Their live video quality was poor. However, we must appreciate their first successful experimental study of the dependence of gravity on latitude using remote measurement over the Internet.

Pendulum in Trnava (Slovak Republic)

The other significant contribution was the Slovak remote pendulum (Schauer, F., Majerčík, P., 2009). It was created in 2009 and situated in the University of Trnava. It was based on the ISES platform (E-laboratory Project, 2002) and contactless reading of angle deflection using two dynamometers (see Figure 2 A). The swing period of pendulum could be measured with an optical gate. The actual measurement of the deflection angle from dynamometer readings was challenging. (Schauer, F., Majerčík, P., 2009).

The control web interface (see Figure 2 B) was based on the software development kit "iSES Remote Lab SDK", see (Lustig, F., Dvorak, J., Kuriscak, P., Brom, P., 2016) that is

described further below. It involves control objects (buttons, sliders), display objects (graphs, values), experimental data recorder and downloader and live video stream of the oscillator and its initialization mechanism.

The items of assignment were:

1. Determination of the local gravitational acceleration.
2. Study of the dependence of swing period on initial angle of deflection.
3. Determination of kinetic, potential, and total mechanical energy.
4. Study of damping caused by air friction.

Unfortunately, this remote lab is not online any more as of time of the publication.

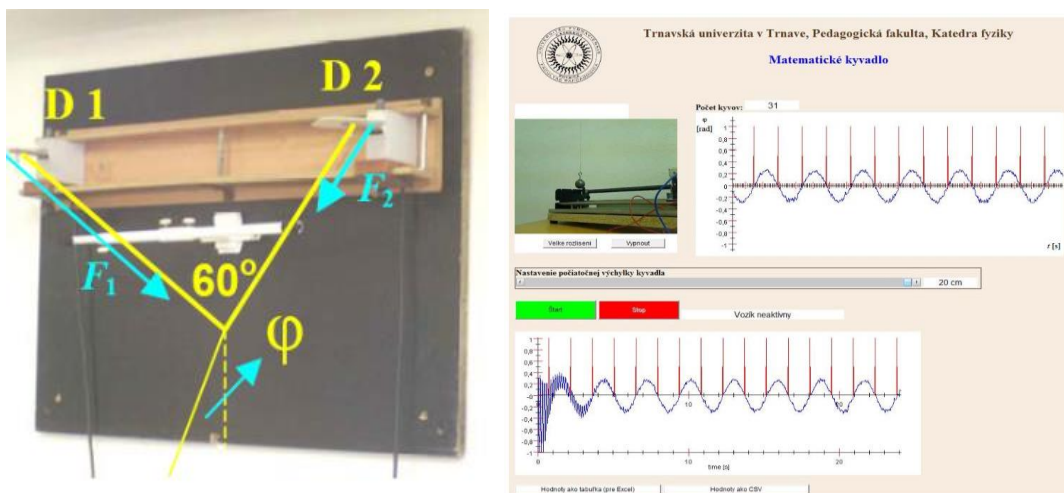


Figure 2: A: Pendulum - detailed view on experimental setup with two dynamometers (D1, D2) for determination of angle deflection of the pendulum.

B: Control web interface of the remote laboratory experiment Pendulum in the University of Trnava (Slovak Republic), offline at the time of the publication.

Pendulum in the new project World Pendulum WP@ELAB

A successor to German and Lisbon (Gröber, S., Vetter, M., Eckert, B., Jodl, H.-J., 2007) pendulum project has formed in 2019 – World Pendulum Alliance (Santos, Fernandes et al., 2019). It is a federated initiative of several universities devoted to create a network of pendulums at various latitudes with the objective of mapping local gravity differences at different locations. The constellation will consist of 20 primary experiments (with basically the same hardware parameters as the original German one) and 120 secondary experiments to be deployed in partner universities in the following years. Most of the installations should be eventually located in South America.

All experiments are supposed to be accessible remotely by high-school or university students, allowing them to perform various educational activities. Since so many installations were planned to be deployed, a careful IT infrastructure design had to be implemented. The data flow from individual experiments (through RESTful API) would be restricted to a private VPN and centralised in servers located in Lisbon. Those servers will expose the controls and measured data to the outside world through websockets according to the Smart-Device Specification. This will allow the WPA experiments to be accessible

using the already available GoLabz (www.golabz.eu) and Graasp (www.graasp.eu) framework as well as through its own portal.

In addition to remote experiments, a few MOOCs will be deployed. Educational content will go beyond the basic pendulum experiment and will include energetic balances and oscillation damping, tidal studies and variations of pendulum period with latitude, altitude, pendulum length etc.

The real overarching goal of this project is to promote cooperation between physics education institutions in Europe and South America. Teams from Europe are in process of visiting South American universities and disseminating the technical and educational knowledge required to install, maintain and use the pendulum constellation. South American universities are being supported in creating a science dissemination centers and cooperating with local smaller educational institutions, spreading the project reach even further. The project is still in the development phase as of writing of this contribution.

Pure simulated virtual pendulum laboratories

There are also a virtual on-line pendulum experiments, which should be noted here. Well-known collection of physical applets (PhET) containing over 150 virtual experiments offers a pendulum at:

http://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html

Another applet collection (Walter-Fendt) also provides a pendulum simulation at:

https://www.walter-fendt.de/html5/phen/pendulum_en.htm

Our team has previously proposed a connection of e-text, virtual and remote experiments under the “integrated e-learning” strategy (Schauer, F., Ožvoldová, M., Lustig, F., 2009).

METHODS – OUR PENDULUM EXPERIMENT

Pendulum in Prague (Czech Republic)

One of the more elaborate remote experiments with pendulum is located in our laboratory at Faculty of Mathematics and Physics of Charles University in Prague. The experiment has been just recently launched (2019), is fully functional and non-stop accessible using standard browser at: <http://kdt-40.karlov.mff.cuni.cz>.

Experimental design

This remote experiment presents a pendulum with variable length (possibly the only one currently online worldwide). It is equipped with two stepper motors, one controlling the length, the other one setting the initial deflection (See Figure 3). Pendulum period is measured using a photogate, deflection is measured using water-based potentiometer (this provides significantly decreased friction). Under the ball, there is a small water reservoir with two electrodes. These electrodes are connected to a constant voltage. A miniature needle is attached to the pendulum ball, touching the water surface. Because the whole pathway up the pendulum pivot is conductive, one can measure the instantaneous deflection by measuring the voltage between the pivot point and one of the electrodes.

The experimental setup is monitored by two cameras that provide additional feedback to the users inside the controlling web interface. The interface itself displays real-time graphs of deflection and photogate signal. Users can trigger a data recording session and later download measured values as a CSV file or display them within an html table. They can later process the measured data in their own software.

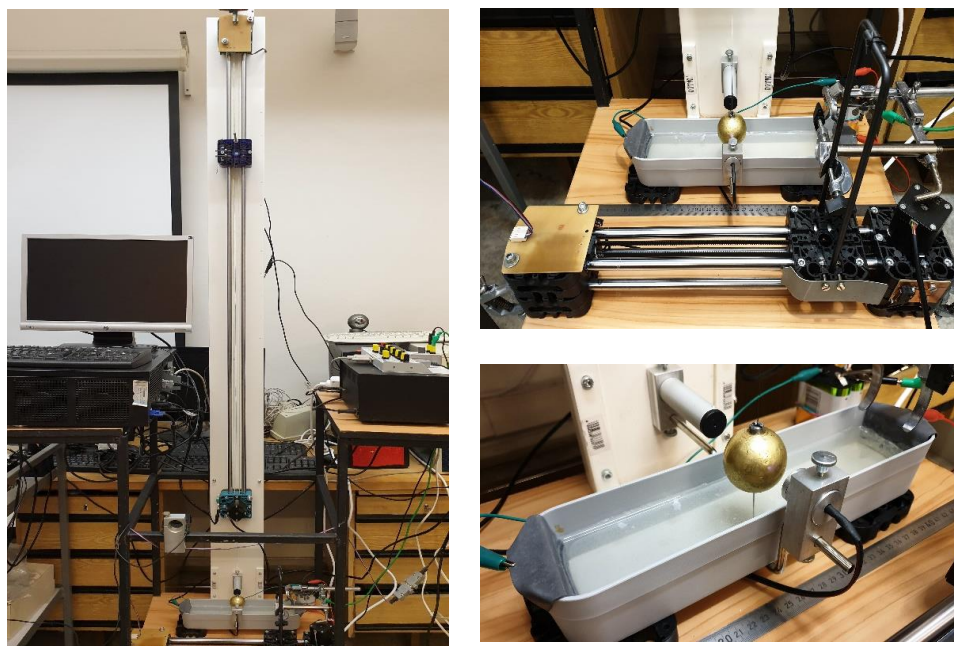


Figure 3: Arrangement of pendulum in Prague (Czech Republic, 2019). Image on the left shows an overview of the whole experimental setup. In its center, an adjustable pendulum length (1.6 m to 0.8 m) mechanism can be seen. In the top right image, there is a pendulum ball with photogate and a motorised initial deflection mechanism (9.5 or 6.5 cm). Bottom right image displays a detail view of the water-based potentiometer.

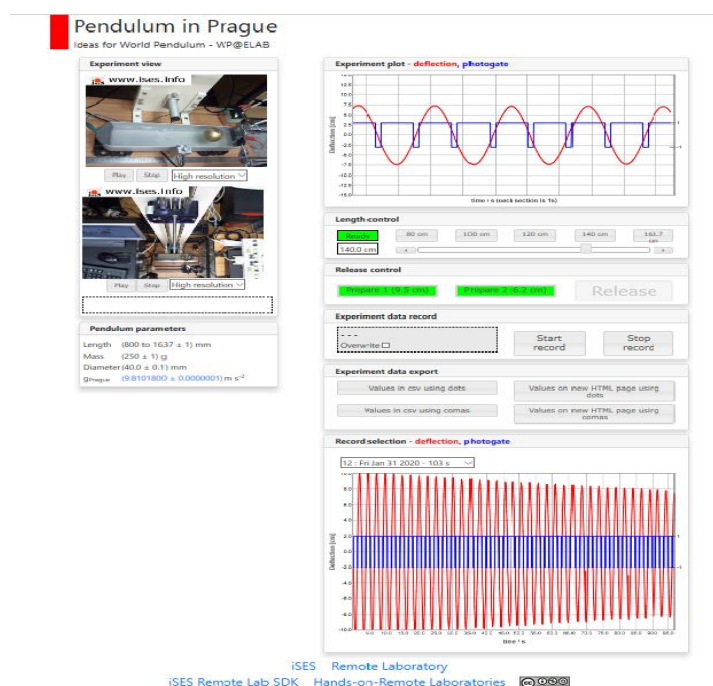


Figure 4: Control web interface of the remote laboratory experiment Pendulum at the Charles University of Prague (Czech Republic, 2019). (<http://kdt-40.karlov.mff.cuni.cz>).

Software architecture

We have built a software kit of “iSES Remote Lab SDK”, described in detail in (Lustig, F., Dvorak, J., Kuriscak, P., Brom, P., 2016). This software kit is originally developed for iSES measurement hardware (Schauer, F., Kuřitka, I., Lustig, F., 2006) but also has a support for Arduino boards.

Server-side part of a remote experiment consists of experimental hardware connected to a dedicated computer, which runs *MeasureServer* and *ImageServer* applications. *MeasureServer* provides two-way communication with the hardware, while *ImageServer* creates a video stream captured by a webcam. As the real-time data connection is realized using the WebSocket technology, a *web server* (e.g. free *NGINX*) must also be installed and running. In most of our experimental setups the web server runs on the same dedicated computer and serves both user interface in a form of webpage and relays the WebSocket connection to the MeasureServer. Clients connect to the experiment through regular web browsers. Client browser has to support JavaScript and WebSocket technologies. These are however standard features of all modern browsers in most devices and are required by various other internet applications. In case the WebSocket protocol is not supported on client side, connection automatically switches to HTTP fallback so that measurement is still possible, although with degraded performance.

In Figure 4, you can see the web interface of the remote Pendulum in Prague. It is built in JavaScript, therefore it's possible to use it even with mobile devices.

We have prepared a library of approx. 20 JavaScript components (widgets). Widgets are highly configurable and provide many thoroughly documented options, which are available by default and which allow even non-programmers to build a complex measuring and controlling interface with data and video transfer. Among built-in features, users have

access to real-time spline interpolation, simple processing, export of data in various formats, graphical output and other sophisticated functionality. User interface widgets are mostly based on JQuery and few other freely available JavaScript libraries that are distributed together with the SDK. By using these standard elements, the user interface visual design is also highly customizable. Web-page developers are able to alter the default design using standard methods (mostly CSS) to fit the webpage in which the interface is embedded. Widgets cover all standard interface elements that are needed for design and control of the experiment.

For non-experienced experiment designers we have prepared a Collection of pre-built simple experiments such as remote analogue record of one quantity (e.g. temperature), remote analogue control of one channel (e.g. switch relay), remote control of digital inputs and outputs, time dependence of two or more quantities, XY dependence of input and output quantities, data record, data export, WEB camera stream etc. The examples have the simplest possible code and mostly use default settings for all the components. These simple interfaces can be arbitrarily merged and combined so even beginners are able to rapidly develop complex interfaces. They can immediately control their own remote experiments via mobile phone or tablet. This set of examples can be accessed online on (E-laboratory Project, 2002). Many experiments also contain an assignment, e-texts with the theory, and examples of data processing.

Educational goals of our remote experiment Pendulum

The possibility to set and change the pendulum length, its initial angle of deflection and to easily record and download experimental data offers interesting labwork with advanced statistical and graphical data processing for students. Properties and physics of pendulum may be studied using variety of dedicated software (MS Excel or similar spreadsheet processors, gnuplot, etc). Users may perform their remote measurements of these dependencies:

1. Swing period T of the pendulum versus its length l .
2. Swing period T of the pendulum versus (initial) angle of deflection α .

The swing period T can be determined simply from the optical gate signal or sophisticatedly using a harmonic function fit of voltage readings from the water-based potentiometer. Within advanced graphical processing using the model function

$$T = T(l) = 2\pi \sqrt{\frac{l + c}{g}}$$

students may verify that period T is proportional to the square root of the pendulum length l . Moreover, they can determine two parameters with physical meaning: the local gravity acceleration g and (probably positive small) length correction c considering the true rotational axis position of the pendulum oscillations and the systematic error of the length reading (in fact, only the changes, differences of l are set and known absolutely). Sample graphical processing of the first dependence can be found in the Figure 5 (see section Results). The local gravitational acceleration is then one of the fitted parameters.

Another educational approach to pendulum experiment is presented in (Beňačka, J., 2009) which gives a power series solution to the pendulum equation that enables to investigate the system in a purely analytical way.

RESULTS

Measurement was performed for 5 various pendulum lengths. The period was determined from the optical gate signal as the average value of 3 measurements with estimated error – see the results in the Table 1 and graph in the Figure 5.

Table 1: Sample results of the measurement and processing.

Pendulum length [cm]	Period (with error) [s]	Final fit parameters with asymptotic standard error determined by Gnuplot
163.7	2.566(3)	Model function: $T(l) = 2\pi \sqrt{\frac{l+c}{g}}$ Local gravity acceleration: $g = (980.4 \pm 2.3) \text{ cm}\cdot\text{s}^{-2}$ Length correction: $c = (0.01 \pm 0.28) \text{ cm}$
140.0	2.374(3)	
120.0	2.200(3)	
100.0	2.007(2)	
80.0	1.794(2)	

In separate set of measurements we have confirmed that the presence of friction does not introduce a measurement error greater than the one introduced by the photo-gate sampling rate.

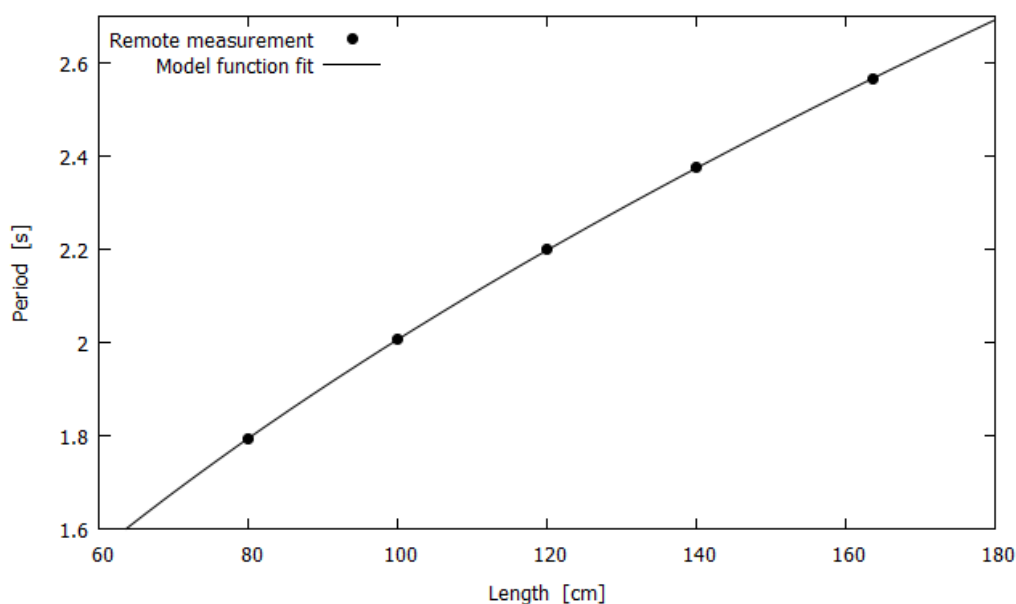


Figure 5: Model function fit of 5 average values ($n = 3$) of the pendulum period with goal to determine local gravity acceleration g using scientific freeware Gnuplot.

DISCUSSION

In our view, the main appeal of virtual laboratories is their easy on-line accessibility, rather than their pure simulated nature. In this perspective, remote experiments offer

almost the same on-line convenience, while preserving real-life intricacies of experimental measurements such as noise or the need of proper operation of the equipment.

In our other works we have also attempted to extend remote experiments in the opposite direction by proposing a “hands-on-remote” philosophy (Lustig, F., Brom, P., Kuriščák, P., Dvořák, J., 2018), which integrates hands-on experiments in the classroom with a later possibility of accessing the hardware remotely.

CONCLUSION

In this contribution we have reviewed a remote and virtual experiment technologies involving a pendulum. We have presented our unique experimental setup with variable pendulum length, its detailed software architecture (based on iSES Remote Lab SDK) and sample measurement results.

ACKNOWLEDGEMENT

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Digital Competences in Pupils from Secondary Mechanical Engineering Schools and Their View on the Usage of Digital Technologies in Teaching and Learning

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Abstract

The study is focused on the analysis of secondary schools of engineering students' opinions on their equipment with specific tools for digital control of production processes, use of the tools by teachers of vocational subjects, application of students' already acquired digital competences in learning and their assessment of schools' contribution of to their further development. The survey took place at the end of 2019 at two secondary schools of engineering with a sample consisting of 316 students. The analysis produced the following outcomes. Only more than one-third of students consider the school facilities as good and very good with as a large share cannot asses them. Most students rate the use of digital technology by vocational subject teachers as sufficient up to maximum. Nearly half of the students considered the possibility of applying their digital skills as sufficient, but nearly a third of the students feel that these options are limited or very limited. Almost 60% of students consider the school's contribution to the development of their digital competences to be quite significant or very significant, but 40% consider it to be small or very small. Final year students are more critical in their assessments of school facilities, the use of digital technologies by teachers, possibilities to apply their digital competences in learning, and the contribution of schools to the development of their digital competences than lower grade students.

Keywords

Secondary Mechanical Engineering Schools. Digital Competence. Use of Digital Competences in Teaching and Learning. Digital Technology Equipment.

INTRODUCTION

The importance of digital literacy on the labour market has been discussed in a report by the Czech Statistical Office “Výběrové šetření pracovních sil (Sample survey of the workforce)” (ČSÚ, 2018), which points out the increase in the demand for services connected with ICT technologies, which presents a certain challenge to revise the national curricula and school education programmes, especially at secondary vocational schools with technical (for example, mechanical engineering) specialisation.

Concerning the trends and requirements on the majority of professions, the Czech Republic has also accepted the Digital Education Strategy up to 2020 (MŠMT, 2014), reacted to the constant development of digital technologies and intends to gradually introduce modern technologies in teaching and learning. Its main aims are to open education to new methods and ways of teaching and learning using digital technologies, to improve pupils' competences as regards working with information and digital technologies and to develop pupils' information critical thinking.

Nowadays, digital competences are an integral part of key competences (EU Recommendation, 2006) and, especially recently, there is a great number of their definitions and the optimum combination for the general public (DigComp 2.1), for certain territories (Australian Workforce Digital Skills Framework) and for certain ages or professions (DigCompEdu, DiCTE, UNESCO ICT Competency Framework for Teachers).

The early investigations of the introduction of digital technologies and their gradual development in teaching and learning primarily dealt with the computer equipment used by schools, pupils and their families. Later on, analyses were focusing on the frequency of their usage in teaching and learning in general or in particular subjects, the duration of their usage in the classroom or their usage in various teaching strategies. In recent years, the general interest in the usage of digital technologies in teaching and learning has been extended to include the effects of using digital technologies, both to acquire digital competences as well as to reach the subject and personal development objectives.

Digital competences represent a set of knowledge, skills, abilities, attitudes and values which are needed for the self-confident, critical and creative usage of digital technologies at work, in our profession, in learning, in our free time and also in our social life. Recommendation of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning. „Digital competences are understood as transversal key competences which enable to acquire other key competences and they are connected with many skills of the 21st century, which every citizen should have to be able to play an active role in society and on the labour market” (MŠMT, 2014, p. 11). The definition of digital literacy has been specified by Růžicková (2018) who explains that it is “a term used to describe a set of skills, attitudes, values and knowledge which enable people to use digital technologies critically, safely and creatively at work and in their free time” (Růžicková et al., 2018, p. 4).

ANALYSES AND MONITORING OF THE USAGE OF DIGITAL TECHNOLOGIES IN TEACHING AND LEARNING

Digital technology equipment

International comparisons in the field of ICT (information and communication technologies) can be provided by the index of ICT accessibility in schools, which was created based on questions from the PISA 2015 survey, which were presented to pupils in questionnaires. They were evaluating the accessibility of individual ICT elements in schools. The index states that the higher the value of the country, the higher the number of ICT tools accessible in schools in the given country. In international comparisons, the Czech Republic ranked below the international average, which is 6.09 points. The value of the index for the Czech Republic is 5.71 points. Australia obtained the highest value of the ICT accessibility index (7.63 points), by contrast, Japan ranked lowest (4.01 points) (Brusenbauch Meislová et al., 2018a, p. 39). After the secondary analyses of the PISA 2015 survey, it has been concluded that schools where the ICT equipment is available to every teacher achieve better results than schools with less accessibility to the ICT equipment (Brusenbauch Meislová et al., 2018a, p. 11).

Pupils who have their table for learning, mobile phone, Internet connection and share a PC achieve a statistically significantly higher score in Mathematics than pupils who do not have these sources at home. Last but not least, it is important to mention that pupils who have their PC have, by contrast, a statistically significantly worse score than pupils who do not have their PC (Brusenbauch Meislová et al., 2018a, p. 17).

Teachers' usage of digital technologies

ICT are currently a common part of everyday life and their potential has been used in various fields, including schools and education. Despite the apparent potential that ICT offer, not only from the perspective of making the teaching and learning more attractive for pupils but also from the perspective of effectiveness in education, current studies dealing with the impact of ICT on teaching and learning do not concur and individual pieces of research do not bring unequivocal conclusions in the sense that the usage of ICT should always have a positive impact on pupils. Some studies conclude that moderate usage of ICT elements when doing homework is associated with a positive effect on pupils' results. However, if ICT elements are freely available for pupils and they are rather used for entertainment, their effect on the final score in the test on mathematical and natural sciences literacy will be rather negative (Brusenbauch Meislová et al., 2018a, p. 38).

A thematic study by the Czech School Inspectorate suggested that a positive relationship between ICT and pupil's success rate does not automatically mean the highest frequency of ICT usage in teaching and learning and vice versa, an absolute non-usage. The middle ground would be ideal, that is to say, a moderate usage of ICT in teaching and learning and pupils' preparation at home (CSI, 2016). A similar recent survey by the Czech School Inspectorate (2019) for the school year 2018/2019 states that the field of digital technologies have been fully included in the development concept at more than 70% of secondary schools visited during the thematic inspection activity. Even though, at approximately three-fourths of secondary schools, the majority of teachers are aware of the ICT potential to increase the quality of education and also more and more teachers include these technical means into their teaching, only one-fourth of teachers from the visited

schools consider themselves to be confident and methodically competent when using ICT. As for the specific use of digital technologies in teaching and learning, secondary schools mainly focus on various teaching and learning activities (66%) including project teaching and learning, less on the complex integration of digital technologies into the teaching and learning process and on the exploration of new and effective approaches (33%). Although pupils were able to use ICT rather autonomously, their active participation (apart from ICT classes) was demanded quite rarely. By contrast, the use of ICT for teachers' presentations prevailed. The analysis of the ICT usage in schools did not find that schools use the quality of the ICT equipment, teachers' experience with the ICT usage in teaching and learning or methodical integration of ICT into all subjects and into the improvement of culture to attract new students, in other words, to support pupils' decision to choose the given secondary school.

During the analyses of results of didactic tests and answers from the questionnaire in the PISA 2015 survey, it has been interesting to find that the Internet usage in the classroom has a rather negative effect on the final score in the testing of Natural Sciences literacy in schools with a higher average socioeconomic status, as for schools with lower socioeconomic status, the relation between the Internet usage and pupils' scores is rather positive (but not statistically significant). The most important issue is the way how the didactic potential of the Internet and ICT, in general, and related teachers' digital competences are used. The ICT use can be recommended to schools with pupils with lower average socioeconomic status (due to the positive association with the final score), however, the way how ICT is used in the classroom should be taken into consideration (negative associations) in schools with pupils with higher socioeconomic status. It is necessary to always reasonably and suitably adjust the ICT usage: who uses the ICT in the classroom (teacher vs. pupils), the type of school, the subject (Mathematics vs. Natural Sciences) (Brusenbauch Meislová et al., 2018a, p. 38).

Computers with the Internet are a common standard in the majority of schools, and they offer a huge potential for the usage in teaching and learning. What can prove to be problematic in this context is the factor of teachers, or more precisely, their sceptical attitude to modern technologies or the lack of methodical competences and skills for the effective ICT usage in teaching. Especially older teachers can be afraid of using ICT, due to the lack of knowledge and awareness about the possibilities which this technology can offer. It is often because of their inability to keep up with the technological development. Nonetheless, it is not an unsolvable factor because, similarly to everyday life, we can face the technological progress in schools by teachers' further education which would primarily focus on the ICT field.

It has been proven that the ICT usage can improve the quality of teaching, it especially enables better activation of pupils or it improves the explanation and effectiveness of teaching. However, it is necessary that the school and also the teachers can create such an environment for teaching and learning where different forms of ICT are used so that pupils willingly participate in the instruction. Nevertheless, a situation when the ICT elements are used unnecessarily or completely uselessly cannot be accepted (Brusenbauch Meislová et al., 2018).

Pupils who use a PC or a tablet for homework such as searching for and reading information for a maximum of 30 minutes per day can reach a higher score in the test of

reading literacy than pupils who do not use a PC or a tablet for the above-mentioned purposes at all or those who use it for more than 30 minutes per day (Brusenbauch Meislová et al., 2019, p. 11)

Only 14 countries, including the Czech Republic, cover the specific criteria concerning digital education in their external frameworks for the evaluation of schools. In these education systems, assessors are required to consider various aspects of digital education, including how digital technologies are integrated into teaching and learning processes or into the school management or whether the quality of the IT infrastructure meets the required standards (Bourgeois, Birch a Davydovskaia, 2019).

Possibilities of how to use pupils' digital competences in teaching and learning

The topic of the usage of digital technologies by pupils in schools has been in the shadows as far as the research is concerned, which has favoured its usage by teachers instead. However, there appear to be interesting connections between the two subjects. While the ICT usage by teachers during teaching has a positive effect on the final score from Mathematics and Natural Sciences (even though this result is not completely conclusive given the methodological problems), the frequent usage of ICT tools by pupils in the classroom is associated with negative effects on the final score from Mathematics and Natural Sciences (Brusenbauch Meislová et al., 2018b, p. 10).

The use of ICT tools by pupils is demonstrated by another variable from the InspIS system - pupils working with the Internet or learning software in the classroom. It appears that the more frequent use of ICT tools in the classroom in the given school, the worse score from the Mathematics test. The highest value of the negative coefficient has been noted in pupils from schools where the headmaster answered that ICT is used by pupils in almost every lesson.

A certain possibility how to use pupils' digital competences in teaching and learning is to "support students in developing the ability to critically and independently assess the quality of digital and online materials" (European Commission, 2016, p. 20).

School contribution to the development of pupils' digital competences

It is not possible to rely on the effects of informal incidental learning of children and pupils how to use digital tools, but it is necessary to cultivate digital literacy, including digital needs in a purposeful, thoughtful and systemic manner (MŠMT, 2014 and MPSV, 2018). In reference to previous documents, the European Commission emphasises this fact by stating that "the training and education systems must be fit for the digital age" (European Commission, 2018).

In the Czech Republic, the concept of the development of digital competences has been currently fundamentally changing. However, the present approach - where the education area of Information and Communication Technologies at primary schools and the majority of the education area of Informatics and Information Technologies (grammar schools) and Information and Communication Technologies Education (secondary vocational schools) mainly focused on the ability to work with ICT and information as a basis for usage in other education areas/fields - is unsustainable because of the fact that the majority of teachers of other subjects do not feel the responsibility to develop the ability to apply pupils' knowledge, skills and attitudes gained in this subjects. It is necessary to emphasise that the field of Informatics has its own goals, their importance increases and the basis which it can

offer to other fields changes. It is directed more towards the basic principles of information processing and the ability to apply informatics processes when dealing with non-informatics problems. The new approach is based on the integration of the development of digital and informatics competences into curricula in all education areas. The field of Informatics will be preserved and, at the same time, educational aims and content of other fields of education in the curriculum framework will be updated to explicitly include the development of abilities to work with information and digital technologies and alternatively, new topics according to how the development of digital technologies influenced the content, functioning and methods of their original fields. Digital literacy will be described as a whole in the curriculum framework - a set of competences (see the definition of digital literacy) where every education field contributes to the construction of their foundations in a binding manner, and they are developed by application in various contexts of school work.

We suppose that the use of the digital needs of young individuals on the next level of education can be an important factor influencing their choice of the field of study or a particular school. Connecting studies and subsequently professional life can be viewed as a certain part of the "digital attitude" (Gekara, et. al, 2019), since the results of secondary analyses in international surveys ICILS 2013 and PISA 2012 showed that Czech pupils use a computer for their leisure purposes over proportionally in the international comparison, even most frequently from all the OECD countries (CSI, 2016, p. 2). The PISA survey found that Czech 15-year-old pupils spend 120 minutes per day online with technologies and even up to 150 minutes at weekends. It has also pointed out that pupils who use a tablet or a laptop at school also use these tools for school purposes more often than their peers who use a desktop computer at school. Paradoxically, it has found that pupils from less successful schools use a computer for various purposes more frequently compared to pupils from very successful schools. These differences are slightly higher in grammar schools (pupils aged 10-15) than in primary schools.

The question is whether - given how much time children spend using digital technologies outside school - the school contribution is bigger or smaller than the contribution of children's informal learning from using them from an early age. In any case, every school should assess digital literacy of its pupils, which accelerates very much, and adapt the use of technologies accordingly. Czech schools already significantly suffer from boredom and the lack of pupils' interest in learning.

The level of digital competences and its (auto)diagnosis

The thematic report of the Czech School Inspectorate (2018) in the school year 2016/2017 summarises the result of their investigation: The expected success rate in the test of information literacy was set at 67% (pupils who correctly solved more than three-fifths of questions). While primary school pupils did not reach this level more often (63%), pupils from secondary schools with the maturita school-leaving exam got closely under this level (66%). Pupils from grammar schools reached the average success rate in the test 71.1% (with 58% girls) and pupils from technical fields of study (including mechanical engineering and engineering production) 67.5% (with 13% girls)

The self-assessment of digital skills in companies and its comparison with the declared degree of their need by companies brought interesting results. In 116 companies participating in the survey, the highest correspondence between available skills and required skills was in the area of the social media use, cloud computing and mobile

technology. By contrast, the highest differences are in the area of the Internet of things, digital security and corporate networks (UNESCO, Education sector, 2018).

What can quite reliably show the results of the self-assessment of one's own digital skills is the so-called level of students' confidence in their digital competences. Team Deloitte and IpsosMORI commissioned by the European Commission worked with this construct when carrying out the 2nd Survey of Schools: ICT in Education (European Commission, 2019). Five researched areas of digital competence were the same as in the DigComp framework and included information and data literacy, communication and collaboration, digital content creation, safety and problem-solving. The selection of data for pupils from Czech secondary schools (ISCED 3) presented the following results on the scale 1 to 4 (where 1 = not all, 2 = a little, 3 = somewhat, and 4 = a lot):

- in the area of Safety, the average value for Czech pupils was 3.09 and for the EU 2.86
- in the area of Communication and collaboration, the average value for Czech pupils was 3.38 and for the EU 3.26
- in the area of Information and data literacy, the average value for Czech pupils was 3.31 and for the EU 3.04
- in the area of Problem-solving, the average value for Czech pupils was 2.67 and for the EU 2.65
- in the area of Digital content creation, the average value for Czech pupils was 2.78 and for the EU 2.74

In all five areas, Czech pupils declared a slightly higher level of confidence in their digital competences than the EU average. Pupils are most confident in the area of Communication and collaboration and least confident in the area of Problem-solving.

RESEARCH

The research on a sample of pupils from two secondary schools studying mechanical engineering in the Moravian-Silesian Region in the Czech Republic was carried out at the end of 2019. Using the questionnaire survey, we collected data from 320 respondents who attended all four years of study. The majority of respondents were boys (98.13%), which is usual in these fields. Four scaling items were selected for this study.

- In my opinion, the school where I am studying is equipped with technology enabling digital control of production processes: (offered answers) a) wholly insufficiently, b) insufficiently, c) I cannot say, d) well, and e) very well (Question 36).
- Teachers of vocational mechanical engineering subjects use the potential of digital technologies (offered answers): a) insufficiently, b) to a small extent, c) sufficiently, d) to a large extent, and e) maximally (Question 37).
- The possibilities to use my current ICT skills in learning are: (offered answers) a) very limited, b) limited, c) sufficient, d) significant, and e) very welcome and supported (Question 38).

- In my opinion, the secondary school where I am studying contributed to the development of my digital competences (offered answers): a) very little, b) a little, c) quite significantly, d) significantly, and e) very significantly (Question 39).

There were data available about pupils' gender and year of studies.

The research aimed to find answers to the following research questions:

- According to pupils, how well-equipped is the school with technology enabling digital control of production processes?
- According to pupils, to what extent do teachers of vocational mechanical engineering subjects use the potential of digital technologies?
- To what extent can pupils use their current ICT skills in learning at the given secondary school?
- According to pupils, to what extent has the secondary school where they are studying contributed to the development of their digital competences?
- Are pupils' answers influenced by their year of studies?

RESULTS

The data was processed using the MS Excel spreadsheet. The results are shown in the figures (graphs) and tables below.

Figure 1 shows that 37% of students cannot assess the school's facilities. 41.8% of students consider them to be good or very good, and only 21% of students rate them as insufficient or wholly insufficient. The relatively high proportion of 'I cannot assess' answers can be interpreted in two ways. The first may be based on pupils' less experience in using these technologies in teaching or practice. The second one may be based on the pupils' limited orientation on current processes of digitisation of engineering production.

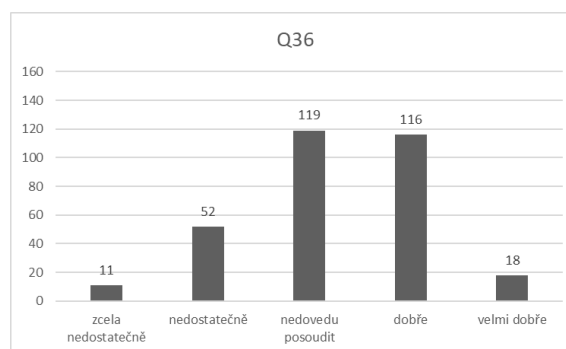


Figure 1: Students' opinions on the school's digital equipment for production process control

Source: own

A year-by-year view (Figure 2) confirms that the number of pupils who cannot assess the school's digital equipment was decreasing with advancing years of study (from 47.3% in the first year to 39.7% in the second year, 28.3% in the third year to 32.9% in the fourth year). Gradually, students became more critical of school facilities. 43% of students rated

positively in the first year, 50% in the second year, 44.6% in the third year and 34.2% in the fourth year).

The finding is illustrated in Figure 2 by a quantified average value, which gradually decreases from the first to the fourth year. Another outcome is that the diversity of responses increases with the year of study and this may be a reflection of the fact that the curriculum of the study program does not include criteria for assessing the state of digitisation of engineering production, and students are unable to find a common benchmark for expressing their views.

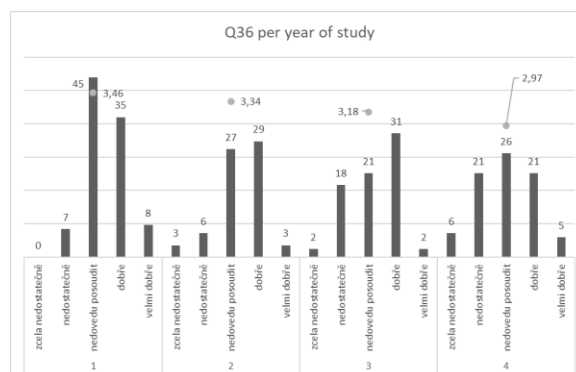


Figure 2: Students' opinions per year of study on the equipment of the school with digital equipment for production process control

Source: own

The question of whether the teachers of technical engineering subjects fully exploited the possibilities of digital technologies was answered positively by the most of students (85% of students) with their distribution being slightly sloped to the right positively (Figure 3).

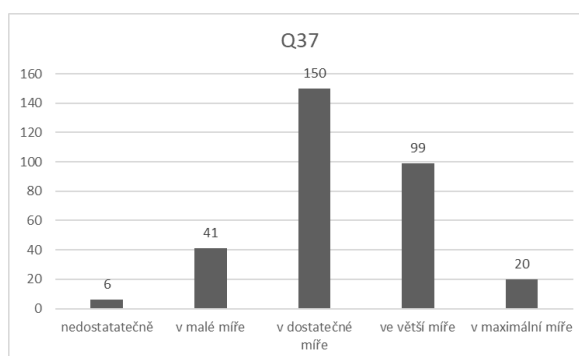


Figure 3: Students' opinions on the use of digital technologies in learning

Source: own

The final average of the responses increases year after year, but a significant decline can be seen in the fourth year, but all results can be viewed as above average (Figure 4). The fourth year of study assessment can be explained by the behavioural aspects of the last grade.

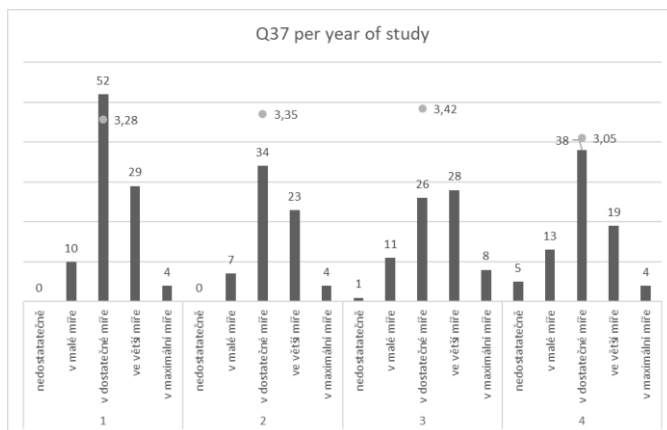


Figure 4: Students' opinions per year of study on the use of digital technologies in learning

Source: own

Possibilities of using digital skills in learning are considered mostly as sufficient by the students (46.8%). The distribution almost entirely follows the more pointed normal distribution (Figure 5). However, nearly a third of students (30%) considers the options as limited or very limited. By broadening the use of experiential learning in secondary schools, more space could be created for individual or group student activities in which students themselves would decide on digital technologies application.

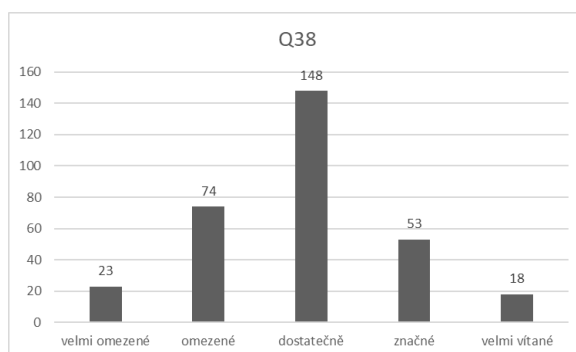


Figure 5: Students' opinions on the possibility of applying their current digital skills in learning

Source: own

The distribution of the sample per year of study brings interesting results. In the first and second year, the distribution of answers is perfectly normal, with the highest average score of 3.04. In the second year, the most significant number of students (7 in total) evaluated the use of their skills as appreciated and supported. On the other hand, in the fourth year, there were the most students (11 in total) who rated these options as very limited. In the following years, a decrease in the average value was found, and the possibilities of applying their digital competences in education were evaluated more negatively by students (Figure 6).

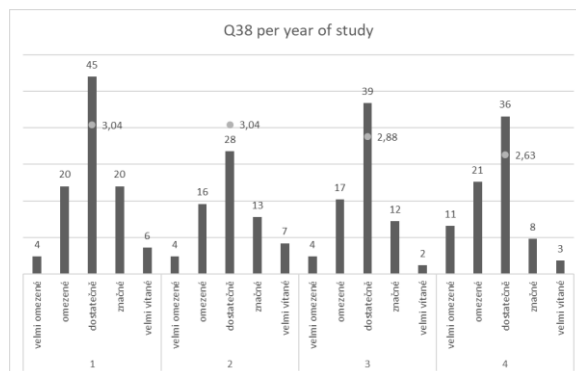


Figure 6: Students' opinions per year of study on the possibility of applying their current digital skills in learning

Source: own

The subjective evaluation of the contribution of the secondary school to the development of students' digital competences can be divided into significant and insignificant ones (Figure 7). 59.5% of students, which is a positive figure, consider it to be quite significant, significant and very significant. However, 40.5% of students consider the contribution of school to be small or very small. The advent of high school generation, born after 2000, sometimes referred to as "digital children", is likely to explain this finding. From an early age, children working with mobile technologies will require a different, probably more demanding and more in-depth approach to information shaping and digital thinking.

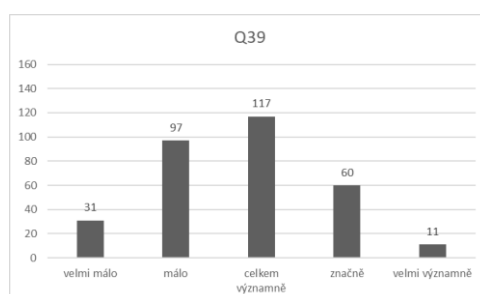


Figure 7: Students' opinions on the school's contribution to the development of their digital competences

Source: own

A gradual decline in the average evaluation of a school's contribution to the development of a student's digital technology with an increasing year may be a warning (Figure 8). In the fourth year, out of a total of 76 students, none of them found that "the school had developed significantly" their digital competence.

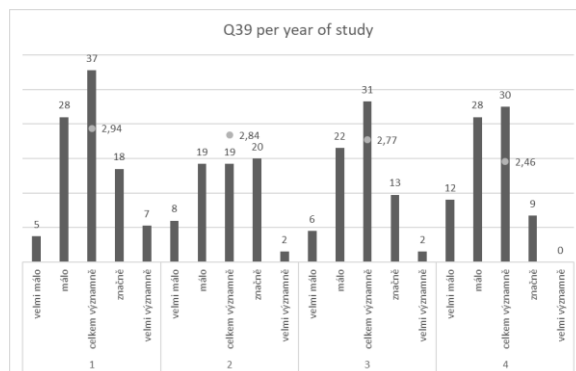


Figure 8: Students' opinions per year on the school's contribution to the development of their digital competences

Source: own

DISCUSSION AND CONCLUSION

The results of the analysis of the four items of the questionnaire assigned to students of secondary engineering schools were difficult to discuss due to the absence of similar research findings. The level of school facilities is usually learnt by questioning the school management, not students, and mostly non-specifically, with no relation to the field of study. In our case, digital technology was bound to use in engineering production and comparable data cannot be found. A similar statement also applies to the choice of responses to an item determining the level of use of digital technologies by teachers in vocational education. The interviewees are, in most cases, teachers, not their students. It would certainly be interesting to find a research finding on this matter that would be fed by questions to teachers and their pupils in parallel.

Only a third of students consider school facilities to be good and highly equipped, and a large proportion of students cannot judge them.

Most students rate the use of digital technology by vocational subject teachers as sufficient up to maximum.

Nearly half of the students considered the possibilities to apply their digital skills as sufficient, but nearly a third of the students felt that these possibilities were limited or very limited.

Almost 60% of students consider the school's contribution to the development of their digital competences to be quite significant or very significant, but 40% of students consider this contribution to be small or very small.

Final year students are more critical in their assessments of school facilities, the use of digital technologies by teachers, the ability to apply their digital competencies in learning, and the contribution of schools to the development of their digital competences than lower grade students.

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Collaborating Networks in the Cloud Supported by Experience-Oriented Devices

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Abstract

The prevalence of the Internet and the proliferation of digital devices have impacted all aspects of life including the labour market and the educational system. However, not only the processes change, but the required competences are transformed as well. Therefore both students and teachers have to adapt to the respective changes. In the era of digital paradigm shift the success and effectiveness of the education effort depend on teachers' ability to meet the demands of the information-based society and being knowledgeable and capable of applying the network-based instruction methods. While previous educational theories were not suitable to describe the digital lesson or learning process, the latest trend, connectivism, integrates those features that are applicable to the current teaching and learning effort. Furthermore, it facilitates collaboration, known as interactive social activity aimed at building knowledge for the purpose of solving a given problem. While the Web 2.0 and cloud-based solutions support new options of collaboration, there are differences regarding the popularity and penetration of such devices. Our study introduces the most important and informative results of related programs promoting the activation of students, and the basic features of selected applications facilitating the realization of the three main goals of web 2.0-based systems, sharing, collaboration and the formation of on-line communities.

Keywords

Collaboration. ICT, BYOD. Web 2.0. Cloud-Based Services

THE TRANSFORMATION OF THE EDUCATION SYSTEM

The growing prevalence of the Internet and the increasing popularity of mobile communication technologies have impacted all aspects of life (Prensky, 2001; Molnár, 2013) including the labour market and the educational system (López-Pérez et al, 2011). Such changes are determined by economic and technological factors (Benedek, 2016; Beetham - Sharpe, 2013). Consequently, active members of society have to be equipped with new skills and aptitudes meeting the requirements of the information-based society. In an increasingly

network-oriented world high level digital competences (Berki, 2019) become indispensable along with professionalism, cooperation (Schrauf, 2019), problem solving skills, and digital security and well-being implying the ability of critical thinking and the knowledge related to the production and processing of electronic content (Roschelle & Teasley, 1995) (Dillenbourg, 1996) (Molnár, 2013).

Due to the digital paradigm change the technological achievements are becoming integrated in the education process (Simonics, 2016). Thus the learning habits are changing as multimodality, intensifying use of technology, the formation of individual learning paths and the need for instant feedback becomes the norm (Sass - Bodnár, 2017). These changes have imposed an added burden on the teaching profession as educators not only have to keep up with the quickly changing educational materials, but are compelled to meet the demands of the information-based society. Furthermore, it is the teachers' responsibility to help students to acquire such professional and modern, up-to-date knowledge enabling them to adapt to the respective changes (Köpeczi-Bócz, 2007). The effectiveness and success of the education process depends on personal circumstances (Gogh-Kovari, 2019) as all actors in the education sphere are required to possess an user-level proficiency of ICT devices, and content-related requirements have to be fulfilled implying the accessibility of appropriate, sufficient and good quality digital educational materials (Török, 2014). In order to fulfil these conditions adequate, technology-based teaching methods, including collaboration are indispensable (Jambor, 2019).

THE THEORETICAL BACKGROUND OF COLLABORATION

Since the middle of the 20th century several learning theories have emerged (Virág, 2013). While each of them contain features that can be relevant to the current teaching and learning process, none of them can fully describe the characteristics of learning in the digital age. Behaviourism emphasizes the importance of reinforcement in boosting the motivation and commitment of the learner, while cognitivism implies an active, consciously designed learning process. Furthermore, constructivism prioritises the learner's personality and interests. Connectivism (Siemens, 2005), unlike, the previous trends, is organically connected to digitalized learning. The term "trend" in this case is a more than a mere coincidence, since professional debates have taken place until the present day concerning whether connectivism is a learning theory or simply a pedagogical perspective (Kurzweil, 2006). No matter which category the given approach belongs to, it takes the phenomenon of information explosion to consideration along with the need to explore the authenticity of information sources. It considers learning as a process embedded into a different activity and emphasizes the network-based aspect and possibility of information exchange via various devices. Accordingly, knowledge can be described as a network, while learning implies a network arrangement activity resulting from interaction with one's environment (Rainie, 2012).

Such a learning theory model can provide an adequate basis for collaboration. The concept of collaboration originates in the 1990s (Hunya, 2008), from the launching of the CSILE project (Computer Supported International Learning Environment) (Francisti & Balogh, 2019), implying a knowledge construction process aimed at solving a given problem or performing a specific task. Accordingly, the determination of the objectives was up to the learners, who had to continuously adapt to the actual circumstances, and assignments

leading to a greater identification with the respective problem or task. Obviously the fulfilment of the given objectives requires the presence and help of the teacher. The specific output of collaborative learning will be the new material, approach (Silverman, 2005), methodology, or solution elaborated jointly or via a shared effort of the learning community engaged in fulfilling the given task (Daradoumis, 2006). The resulting knowledge has a social aspect leading to the concept of collaborative knowledge construction implying that knowledge is formed as a result of interaction, shared understanding and interpretation (Stahl, 2006) (Scardamalia - Bereiter, 1994). According to a study by Strijbos, Martens and associates, intragroup interaction has two basic principles. The principle of mutual dependence shows as to what extent the academic progress of individual students depends on the effort of other group members (a high rate indicates the growth of group cohesion). Individual accountability represents the responsibility of the specific students regarding the given work phases and its correlation with the overall group performance (Gunawardena, 1997). During online collaboration the teacher plays the role of a tutor, monitors and supports the individual and group activity, offers constructive criticism, and provides positive reinforcement while maintaining and increasing the motivation of the learner (Kovari, 2019). The resulting networked individualism gives rise to persons and learners capable of navigating in networks and attaining greater freedom during the learning process. Such a situation provides an opportunity for the formation of individual learning paths supported by the availability of a wide selection of devices implying a new type of help in task solution (Farkas, 2018).

APPLICATIONS AND PROGRAMS FACILITATING COLLABORATION

Micro-research concerning Web 2.0 applications supporting collaboration

Digital web 2.0 and cloud-based solutions facilitate collaboration whose effectiveness has been discussed in several publications. Below we introduce those research results which can be optimally applied during student and teacher interaction. It can hardly be disputed that the globalization of knowledge production led to such a high amount of information, which cannot be handled effectively without digital devices or data bases. Web 2.0 users are not primarily involved in the creation of content, rather they contribute to the formation of an information system in which content can be shaped continuously. Furthermore, working on and sharing their tasks in one location, both learner and teacher are integral parts of such systems. Tags editable freely by the participants help the categorization of information. Tags are crucial components of the system as not only they provide information about the scope of interest of the users, but function as markers of a connection network formed between the respective individuals. Another tendency is the increased importance and value of situation and experience-based learning, along with the personalization of information acquisition (Cress – Kimmerle, 2008). The transformation of the previously one-directional communication into a bi-directional process resulted in the formation and proliferation of a written and at the same time readable web culture (Hargreaves, 2015). Personalized learning environments (Attwell, 2007) enable users to meet the requirements of the information society along with the development of self-regulated learning strategies. Consequently, instead of assuming the passive role of the receiver, students become creative participants in the learning process (Blees- Rittberger, 2009). These tendencies clearly delineate the three pillars of Web 2.0 educational systems:

sharing, collaboration, and formation of on-line communities. Our empirical research explored, how familiar members of the education profession are with the most frequently applied programs designed to boost the activity level of the learner. Below we introduce the responses related to three applications assuring the efficiency and success of the learning process. These applications can be simultaneously used both by teacher and learner and many students can have access to them free of charge. As Diagram 1 indicates the most frequently used or most popular program is the Kahoot which was applied by 74,4% of the respondents, that is 174 out of 234, while 11 persons (4,7% of the sample) regularly rely on it on a daily basis. Two respondents have even delivered training to or assisted their colleagues in using this application. This quiz program is suitable for assessing the knowledge of students either as a warm-up or closure of the lesson in a competitive, game-like atmosphere via assigning points based upon the speed of answering the given questions. Another popular application as shown in Diagram 2 is the Mentimeter tested by 109 people, that is 46,6% of the respondents. Moreover, 32,1% or 75 respondents have heard about it, or saw other pedagogues using it. 50 respondents or 21,4% of the sample haven't heard about it, and there were no participants who would use it regularly on a daily basis or helped colleagues regarding its use. While the Mentimeter is capable of displaying responses in real time and compose word clouds or diagrams, this function is hidden. in order to avoid influencing the testing process in any way. The third application we focused on was the Socrative on-line questionnaire providing feedback in real time as well. The system is capable of providing brief explanations to the questions which include multiple choice, true or false, or short answers. The application can be used by groups as the progress of a team is shown by virtual figures thereby providing a gaming or competitive atmosphere in a community context. Despite such advantages this application is not widely used. Diagram 3 reveals that 206 respondents, that is 88% of the sample, haven't tried it and only 3%, that is, 7 persons have registered and attempted to use the program.

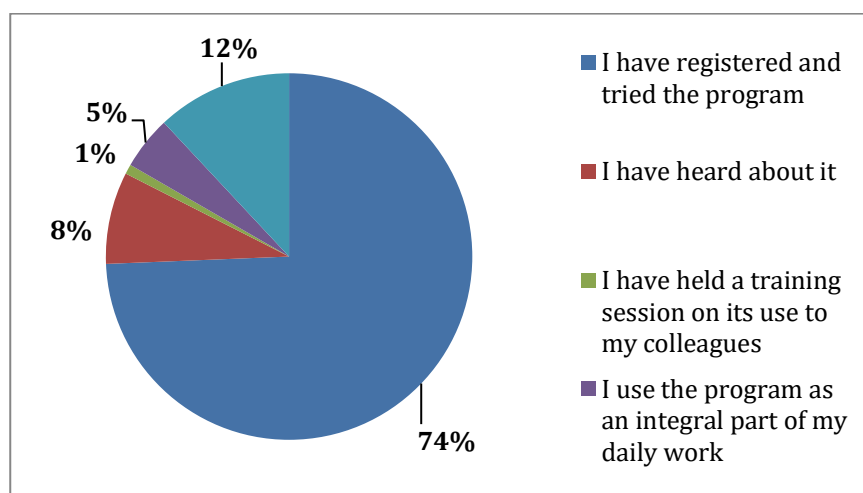


Diagram 1: Familiarity with applications supporting the learning process - Kahoot (author's own compilation).

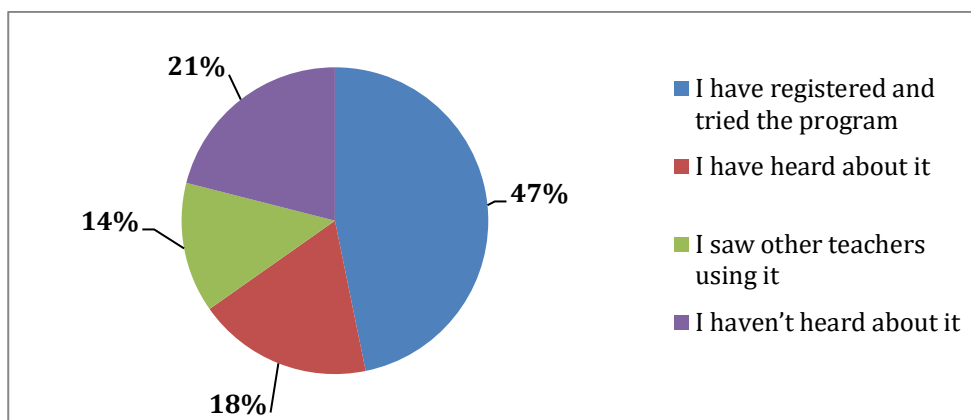


Diagram 2: Familiarity with applications supporting the learning process - Mentimeter (author's own compilation).

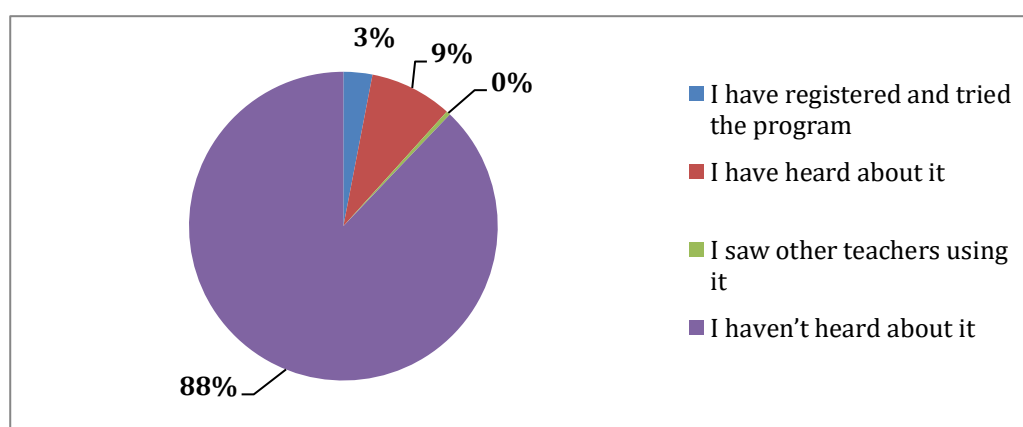


Diagram 3: Familiarity with applications supporting the learning process - Socrative (author's own compilation).

Below we introduce further applications reflecting the three basic principles of the Web 2.0 learning effort, namely sharing, collaboration, and community formation.

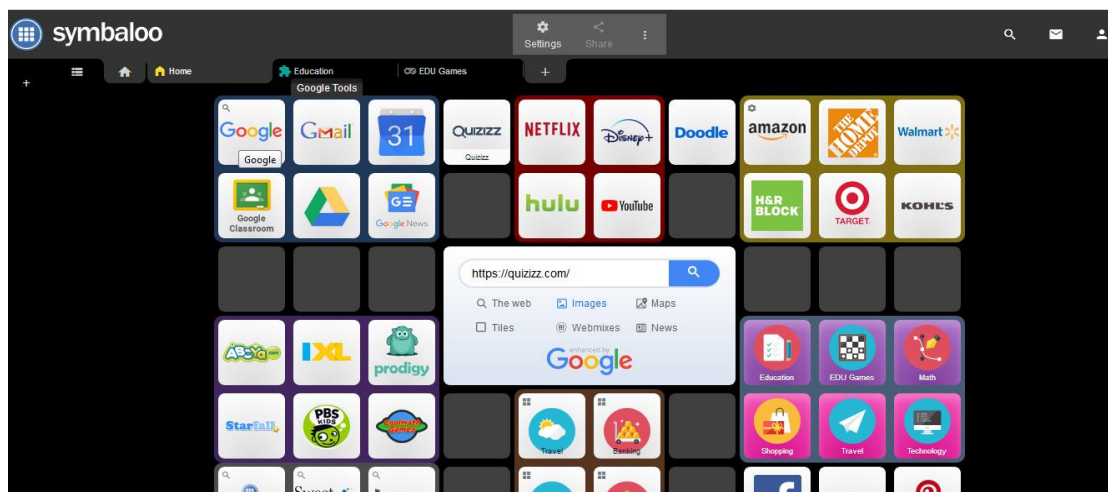
Additional cloud-based applications utilizing the user's own device

Symbollo

During the informatics classes of the current academic year I relied on the Symbollo system. The Symbollo is an Internet-based bookmark collection or a website collecting links (Picture 1). A website can be included via the administration surface and can be marked by small icons, subtitles, or placed on a grid.

Advantages:

- the given website can be viewed without registration,
- spares the work of either dictating or writing numerous links on the board,
- separate webpages can be established with DNS control.



Picture 1: Symbaloo, author's own screenshot.

Google Classroom

The Google Classroom is an LMS scheme similar to the Moodle system (Balogh & Kucharik, 2019). It is primarily used for giving and collecting in-class assignments and homework during Informatics lessons. Students entering the system with their g-mail address access the shared course wall. Depending on the given setting the teacher or even students can place educational materials, links, YouTube videos, or Google Drive files on the wall (Picture 2). We can create locations where students can place their work even according to a set calendar schedule. The uploaded works can be evaluated and the given points will appear on the students' surface as well.

Advantages:

- there is no need for a separate server
- it is integrated with the own application of the Google (Drive, Forms, etc.)
- it can be integrated with more and more applications, i.e Quizizz.



Picture 2: The surface of the Google Classroom, author's own screenshot

Description of a lesson

I attempted to use the most approaches possible. One class was started with frontal instruction as I demonstrated the setting options of the WORD paragraphs. Accordingly, I projected my screen on the students' machines by the help of the Veyon, marked the most important information by the ZoomIt, then span the WheelDecide, and I picked the student. I asked the student to repeat and explain the given settings and options, (to me and the class) which were projected on the board. I paid special attention to errors and inaccuracies during the discussion of the oral report, for which I assigned a red mark or 1 point as indicated in the ClassDojo. After that the students completed a new Quizziz test whose link was found in the Classroom. The test included 10 questions and the answers were projected on the board. This way the group or the students could monitor their progress and could see the rate of right and wrong answers even in case of real conditions. If someone achieved 100% on the test, the given reward was indicated in the ClassDojo. In the next segment of the class we applied the previously learned theories. Accordingly, I uploaded the tasks in the Classroom and the relevant source files could be downloaded from the Classroom as well. The completed assignments had to be uploaded into the Classroom. In the closing segment I span the Wheel of Fortune of the WheelDecide and picked a student whose work was projected on to the screen while the class discussed the appropriate solutions. Finally, I assigned the homework, which had to be solved and uploaded into the Classroom or could be done in form of a test on the Quizziz. I uploaded my evaluations of the students' in-class work as besides the numerical marks I included textual explanations as well. The Classroom also provided a summary table, which provided significant help during the determination of the students' monthly marks. In the following section we introduce a developmental scheme optimal for the easy to learn mobile telephone-based applications enabling the teacher to create a program facilitating and monitoring the acquisition of educational materials. What's more, the previously described quiz production programs can be programmed further and games can be developed as well.

Quickapp application builder for Android operation systems

The use of the web-based Quickapp service is free of charge. During registration a Google e-mail address is needed and the system is ready for use. Later the program can be accessed by a Facebook identifier as well



Picture 6: Quickapp, author's own screenshot.

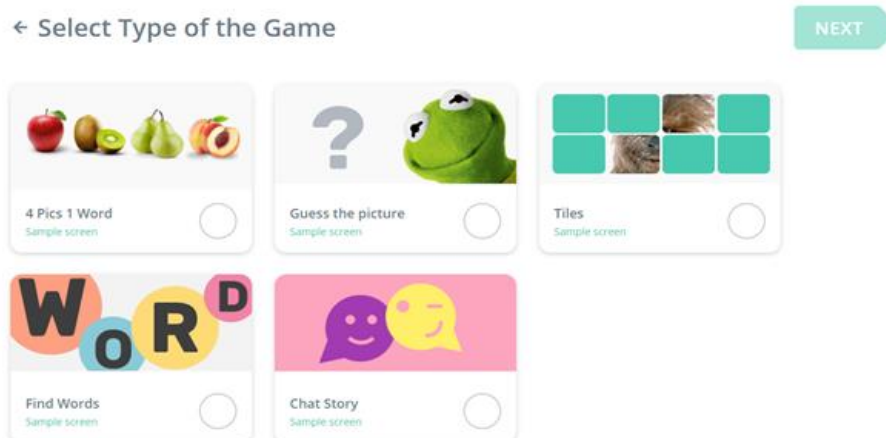
Our first application can be prepared after clicking on the "Create new game" icon (Picture 6) as shown above.

The completed application can be modified by a click on the small pencil icon. The existing applications can be edited, deleted, duplicated, or hidden by the points at the end of the row (Picture 7).

NAME	VERSION	GAME TYPE	NEW USERS	SESSIONS	ADMOB REVENUE	ACTIONS
 New Game	—	Guess the Picture	0	0	—	GO   

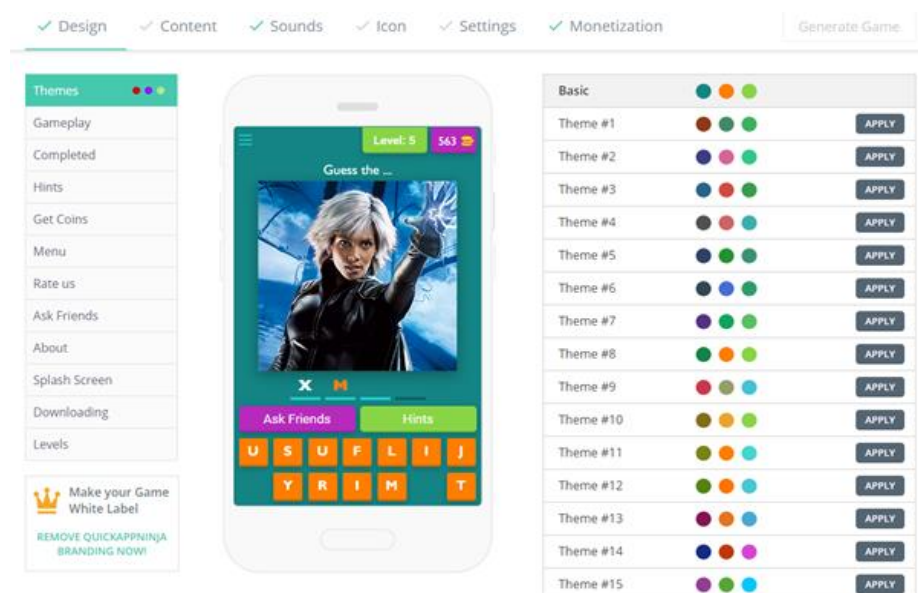
Picture 7: Options provided by the Quickapp, author's own screenshot.

Building a new game program:



Picture 8: Task selection options, author's own screenshot

Clicking on the above images, the type of the game can be selected (Picture 8). The respective game types can include a "4 pictures 1 word" format, general word or image search as the tiles have to be turned so that the player can find the given words or expressions. The application can be edited after clicking on the "Next" button.



Picture 9: The design surface of the application, author's own screenshot.

The display or look of the game can be adjusted at the design page (Picture 9). Accordingly, all aspects of the game including theme, topic, game surface, colour of the buttons can be modified. Frequently, only the matching of colour schemes is required. In

order for the text to follow the Hungarian punctuation we can select the language of the game on the "Content" page.

The size of the pictures or images uploaded via dragging can range between 400x400 and 600x600 pixels. The length of each question is 25 letters and the ANSWER cannot contain more than 14 letters. Only the following symbols can be used in the QUESTION field: letters from A to Z, or a-z, digits from 0-9, full stop (.), comma (,), hyphen (-), question mark (?), colon (:), semicolon (;), star (*). The questions indicate what information the players have to find, among them the "name of a famous person," or "the capital of a country." We can create games with at least 48 levels. New questions are automatically presented, as we only have to provide additional content.

SUMMARY

Our essay described how the educational system changes due to the prevalence of the achievements of modern technology and their integration in a school environment. While becoming familiar with and learning to use ICT devices can take up a substantial amount of time for pedagogues, we believe it is important to get to know such systems as they enable learners to become more efficient in acquiring competences required by the changes of the labour market. Consequently, the application of ICT devices and the accompanying teaching and learning methodology should not be viewed as a burden imposed by the information society, but as a new option to create a fully student-centred learning process (Balogh, 2006) (Horvath-Sudar, 2018) (Horvath, 2019). This would also mean the elimination of previous spatial and temporal obstacles and potential infrastructural problems hindering the efficiency of teaching and learning. Virtually all students have mobile communication devices with a tremendous potential for learning both in the classroom and at home. Teachers should be encouraged to use such devices in order to increase student motivation and boost participation or activity levels. We introduced a selection of applications successfully used in the education process. Accordingly we can establish a virtual classroom with the Goggle Classroom integrating the Google Forms capable of monitoring the acquisition level of theoretical knowledge. The Quizziz provides an ideal solution to control the fulfilment of home assignments not necessarily in real time. The Symballo can help in the collection of relevant webpages and the Doodle program can be used to schedule the given tasks. The digitalized teacher can choose from several options and can expand their arsenal with applications designed on one's own mobile phone. All the above mentioned options are connected with modern mobile communication devices leading to interactive, attention-evoking collaboration (Katona-Kővári, 2018a; 2018b) and experience oriented learning. Our experiences confirm that the abovementioned approaches will help in the maximisation of benefits and achieving the level of efficiency recognized by educational researchers. Additionally, such solutions will be instrumental in preparing our students to meet the challenges and perform tasks imposed by the labour market of the future.

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Assessing the Effectiveness of an Electronic Course: A Practical Experience Review

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Abstract

The paper describes the practical experience of an e-course effectiveness assessment. The described e-course for master and Ph.D. students of pedagogical education particularly aimed at promoting students' e-learning and network collaboration experience, increasing students' involvement through the development and implementation of various projects in joint work, identifying current problems in the professional field and finding ways to solve them. The assessment procedure included several steps. The effectiveness of the D. Keller's ARCS model used in developing the course was tested. For that, students' perception of their successful learning was revealed with the help of an entrance and a final questionnaire. The results allowed to propose recommendations on an e-course design and key assessment criteria – a course objectives, design, students' previous learning experience of e-learning (b-learning), students' digital content preferences, and learning outcomes.

Keywords

Assessment. Electronic Course. Blended Learning. Information Behaviour, Higher Education.

INTRODUCTION

The process of professional training in the global context flexibly responds to the new demands of the emerging digital society. It strives to meet the complex challenges of the foreseeable future: to create new conditions for updating a training content, to change forms of educational practices and interactions, to improve the educational management process, to optimise the processes of adaptation to the new realities of life. Global systemic changes in the development of society and the sphere of professional training can be traced at the level of world trends and challenges reflected in the numerous information resources and documents. The answers to the challenges of digitalisation on the global scale are the concepts of Smart University (Fernandez-Carames, 2019; Serdyukova, 2019), STEM education (Siverling 2019), MOOCs and digital learning platforms (Turčáni, 2017), adaptive e-learning systems (Clark, 2020). Besides, predictive competency models are proposed by IFTF - Institute for the Future (Future Work Skills, 2011), the European SELFIE project for digital education in schools, the Digital Competence Framework for Educators – DigCompEdu (Redecker, 2017), the International Society for Technology in Education (ISTE) and others. In Russia, the main legislative acts and information resources in this area are the

Program for the Development of the Digital Economy in the Russian Federation, the Development Strategy of the Information Society in Russia, the National Project "Education" 2018-2024, the Atlas of Emerging Jobs, the study "Russia 2025: resetting the talent balance", the Education Foresight 2035, etc.

The listed legislative acts, information resources, and projects focus on the importance of several professionally significant skills for the near future: cognitive skills (e.g. adaptability, solving non-standard tasks), social and behavioural skills (e.g. intercultural interaction, communication), and digital skills. Demanded skills largely depend on the progress of information and communication technologies that are rapidly changing our world. The principle of new professional objectives is not possible without the use of new information tools. The modern educational process becomes multilevel, technological, open, mobile, continuous, interactive, variable, problem-based, and ambiguous. Thus, professional training for the digital society should include educational activities in the digital (electronic) environment to gain e-learning and network collaboration experience. ICT tools, e.g., social media, increase students' involvement through the development and implementation of various projects in joint work, identifying current problems in the professional field, and finding ways to solve them.

To achieve these effects, the team of academic teachers and researchers from the Chair of Digital Education, the Herzen University of Russia, has been conducting experimental work for several years to introduce an elective electronic course "Social Media in Education" for master and Ph.D. students of "Pedagogical Education" programme. The course is implemented in a blended learning paradigm, for 6 weeks, 72 hours. Along with developing digital content for the course and facilitating students' activities, the issues of assessing the course effectiveness remain important (Drlik, 2014). In this paper, we will try to offer practical experience in evaluating the effectiveness of an e-course.

RESEARCH PROBLEM

E-learning course design: main approaches

Before evaluating an electronic course, it is necessary to give a general description of the main idea of its design. The electronic course "Social Media in Education" was created in LMS Moodle as an open e-learning environment system. The informational aspect of such an open system can be characterised as its ability to exchange and interact with environmental entities and other systems based on unified methods, tools, protocols, and interfaces. For the course, we used such general properties of an open information system as extensibility (scalability), mobility (portability), interoperability (ability to interact with other systems), friendly user interaction, in particular, an easy control - driveability. It is important to ensure the invariance of an open e-learning environment system together with the evolution of its digital resources, particularly, changes of presentation formats and internal organisation of data, changes of data storage environment, changes of users' requirements and emergence of new categories of users, changes of the data distribution order and user access methods.

Following the psychodidactic approach, as well as the authors' typology of digital educational resources (Noskova, 2017) an electronic course should comprise three types of digital educational resources: digital content (information resources), digital resources for

the organisation of interactions and communication (communication resources), and digital resources for the educational and cognitive activities management (management resources).

Information resources of the course are presented in the format of video lectures, voiced multimedia presentations, videos, collections of hyperlinks to open Internet resources, a series of problematic questions, assignments, methodological recommendations for completing assignments and assessment criteria, files with additional information, various graphics (visualisation and infographics). Thus, these resources made it possible to achieve several important learning objectives - acquiring new knowledge, accessing additional reference information, providing a practical component of training, and monitoring students' activities. Communication resources provide users' interactions in a discussion forum. Management resources include express polls, reflective questionnaires, and assignments.

E-learning course design: management and facilitation model

At the initial stages of the electronic course elaboration, students' reflection on their educational behaviour strategies within an e-course was studied (Noskova, 2019). This preliminary research showed that indicators of insufficient readiness for self-guided work within b-learning are preferences for feedback mainly from a teacher, little use of peer assessment advantages and knowledge exchange with peers, insufficient level of self-control, and planning of own activities. Therefore, when developing digital content, the listed features were taken into account, and the aspect of strengthening horizontal feedbacks (between students) was further enhanced by the possibilities of building a knowledge-sharing community based on social media (communication resources and management resources in the course). The model of management and facilitation within the e-course is presented in Figure 1.

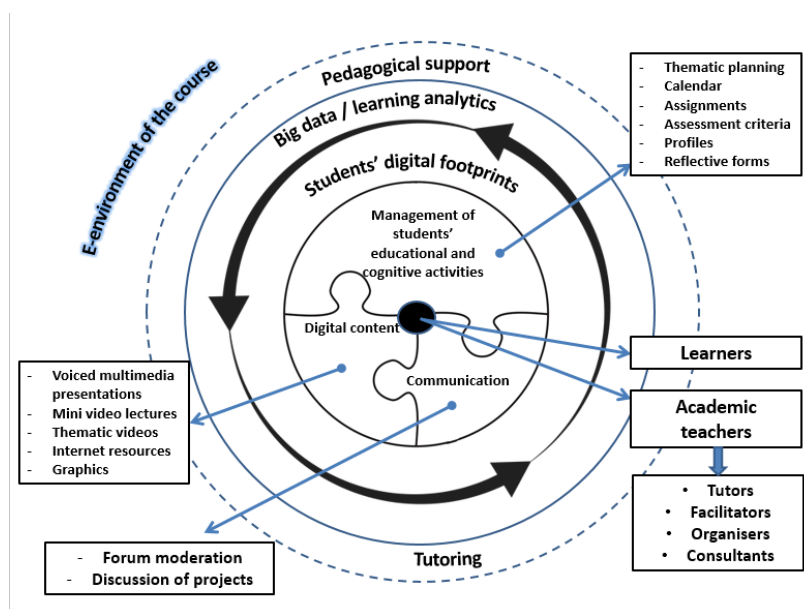


Figure 1: Management and facilitation within the e-course.

Source: own work

In the process of mastering the course, each student develops a project - a media channel (using the means of social media) that aims at reaching certain professional objectives. The result of the training is the creation of such innovative educational practices. The course was developed and supported by five academic teachers who created digital content, moderated the course, and provided students with individual support and advice on the course content acquisition and on the individual project development. Teachers acted as tutors, facilitators, organising, and directing the educational activity of participants. A forum was created for the interactions and solution of emerging issues and difficulties; learners and teachers could communicate with each other, ask questions, and participate in thematic discussions.

The main topics of the course are practically oriented and problem-based: Why is the popularity of social media growing? Why do we need social media in education? How to organise educational interaction based on social media? How to manage interaction in the educational media channel? Why is media competency important? How to analyse the achieved effects and to improve a media resource? Each thematic section is organised and provided by the following structure:

- Motivation and goal-setting component (problematic issue, educational situation);
- Information - content on the topic (video lectures, voiced multimedia presentations, videos, graphic materials - infographics, diagrams, tables, mind maps; recommended information sources);
- Communication (network discussions of problematic issues on the forum);
- Practical activities (a series of multidirectional variable tasks);
- Control and evaluation component (evaluating criteria, an electronic journal of progress, reflective polls, questionnaires, tests, self-assessment, and peer assessment tasks; final presentation of projects as a summative form of control).

RESEARCH METHODOLOGY

Testing the effectiveness of the D. Keller's ARCS model

The experimental work involved testing the effectiveness of the D. Keller's ARCS model (attention, relevance, confidence, satisfaction) used in developing the course, which includes four components of successful learning (Keller, 2010).

The "attention" component was implemented through continuous formative assessment in the course. The "relevance" component means demonstration of the importance of the material being studied, not general and formal theoretical aspects, but understandable and clear explanations - why this information is important for study and how it can be immediately put into practice. Tasks offer solutions to problems as close as possible to real ones. The "confidence" component means that teachers of the course and peers maintain the confidence of students that they are successfully moving forward in the acquisition of the material and take real steps in the development of their projects. This is achieved by providing redundant information materials that students learn following their preferences, but at the same time, students know that they can count on the help of the teacher and other students. This is facilitated by the availability of feedback (through both chat and forum on the course website, and by e-mail). The last component of the Keller model is "satisfaction" from the work done. The opportunity to present an information

product at different stages of its development, to express one's own opinion makes it possible to mark students' progress in the current mode, and to recommend advisable corrections. This type of interaction also allows to feel the specifics of social media, to focus on the fact that representatives of generation Y and Z are sensitive to feedback.

To identify the characteristics of students' perception of their successful learning while undertaking the e-course, an entrance and a final questionnaire were proposed. For the analysis, 12 main variables were identified as indicators of students' successful learning (variables and questions are presented in Table 1.

Table 1: Entrance and final questionnaires - ARCS model.

Variables	Entrance questions (Relate to the 5-point scale)	Final questions (Yes/No)
<i>Attention</i>		
Orientation to the maximum score.	I will regularly monitor my score in the e- journal.	I regularly monitored my score in the e-journal.
Orientation to the position in the rating.	I need to see and compare my peers' grades.	I regularly followed my peers' grades accumulation.
Focus on reflection (need for feedback).	The teacher's comments on my assignments are important to me.	Comments and notes in the e-journal helped to overcome problems with assignments.
<i>Relevance</i>		
Awareness of the practical importance of educational content for solving professional problems.	The importance of ICT for your future profession.	Do you plan to use the knowledge gained in the classroom in your upcoming professional activities?
Awareness of the practical importance of educational content for solving educational problems.	The importance of ICT for your learning.	Do you plan to use the knowledge gained in the classroom in your upcoming learning?
ICT skills level.	Your ICT skills level.	Have you improved your ICT skills level?
Interest to ICT (educational content).	Your interest in ICT.	Has your interest in ICT increased?
<i>Confidence</i>		
Comfort of individual work.	I usually complete assignments individually.	I was comfortable completing assignments individually.
Comfort of group work,	When doing assignments, I would like to see how other students perform them.	I was comfortable completing assignments in-group.
Initiative and creativity.	When doing assignments, I try to be creative.	I tried to perform additional tasks that required creativity.
<i>Satisfaction</i>		
Self-organisation, time-management.	I try to complete my tasks on time.	I usually completed my tasks on time.
Awareness of an information product (project) value.	I believe that my information product (final project) will demonstrate and improve the acquired skills.	While developing an information product, it was possible to identify the strengths and weaknesses of the acquired skills.

In total, 150 master degree students took part in the e-course, and they all answered to the proposed questionnaires. Answers of the respondents were analysed in several directions: a statistical analysis of the entrance and final questionnaires was made (correlation analysis), and the percentage indicators of positive answers were compared for the selected variables of the two response arrays.

RESEARCH RESULTS

Effectiveness of the D. Keller's ARCS model

Figure 2 shows that differences were found in the responses of students to the proposed questionnaires at the initial and final stages of training.

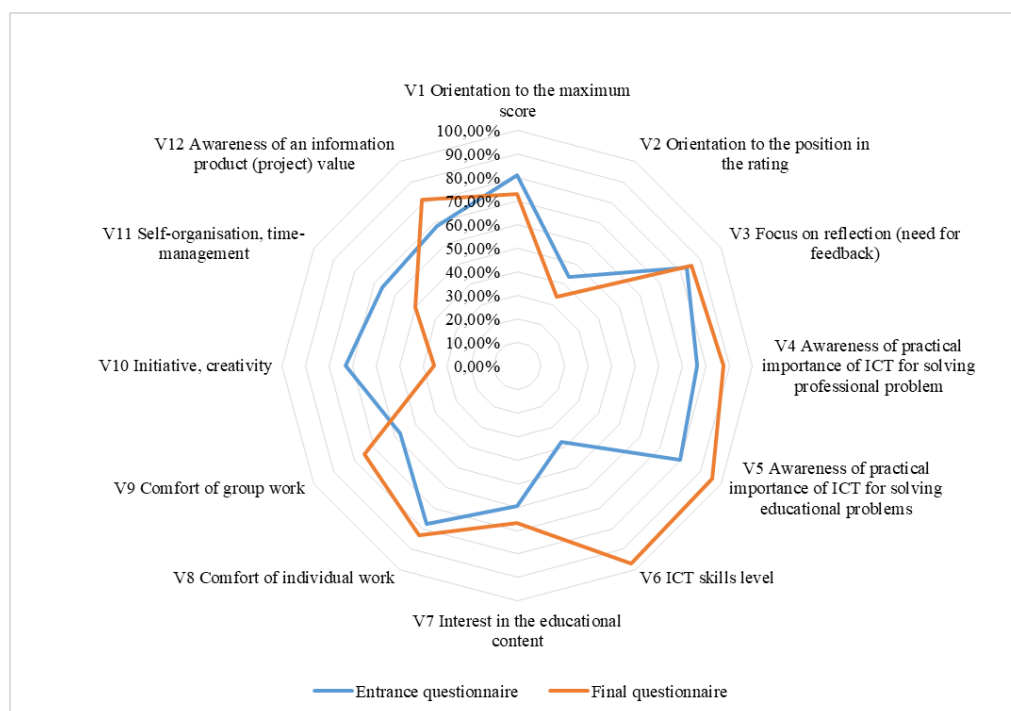


Figure 2: Comparative analysis of the entrance and final questionnaires.

Source: own work.

Most variables of the “attention” component decreased in values - V1 “orientation to the maximum score” and V2 “orientation to the position in the rating”. V3 “focus on reflection” increased. There are several reasons for this. At the beginning of training, students could overestimate their capabilities (for example, in terms of self-organisation and creativity in solving problems). In addition, priorities could change during training. The values of all the “relevance” component variables increased. The largest change is characteristic of V6 “ICT skills level” which is natural since students took part in focused training. In the “confidence” component, we witness the decrease of V10 “initiative, creativity”. Moreover, the “satisfaction” component shows the raise of V12 “developing own project” but the decrease of V11 “self-organisation”.

The correlation analysis showed that in the process of mastering the course, students’ awareness of the importance of the new skills for the future profession increased.

Particularly, at the beginning of the course we saw significant correlations between V4 and V5 (awareness of practical importance of educational content for solving educational and professional problems). Moreover, at the end of the course, V4 merged in a cluster with V6 (ICT skills level, $r=0,42$), V8 (Comfort of individual work, $r=0,42$), V12 (Developing own project, $r=0,43$) and V7 (Interest to the ICT - educational content, $r=0,36$). This is an important outcome of the course since along with the development of competencies that ensure human actions in the modern information environment, the priority task was associated with the development of a promising professional position for a future teacher.

However, the results confirmed that the greatest risks of an e-course from the students' educational behaviour point of view are associated with the "attention" component, a little less risky are the "confidence" and "satisfaction" components, even in the situation of active learning and a sufficiently high motivation to acquire new skills, and the least problematic is the "relevance" component.

How did students evaluate the importance and the outcomes of the e-course? 90% of learners marked the course as "very good". This was caused by the modular structure of the course, a sufficient number of training materials, clearly stated objectives of the course, as well as a detailed methodological support. Students facilitated by the teachers could master educational material and develop their projects at a convenient pace. The e-environment allowed students to work on the material, receiving feedback from all the stakeholders. Since the e-course was for the blended learning model, all course materials were intended for autonomous study. Most of students (93%) were satisfied with the created conditions for such work. In particular, students were satisfied with the proposed format of mini video lectures. This time format allows keeping students' attention, clearly and fully presenting the material. Since almost all students fully achieved the planned goals of the course (elaborated own projects), we can conclude that the course was successful.

The main indicator of a student's project effectiveness is the fact that the author not only invented and described the project, but also implemented it in real practice. The most interesting and productive students' projects can be given as examples. A first-year master student Elena Zaboeva presented a project "Social Media Advertising". The project addresses were the first-year bachelor students. The main idea of the project was to present media advertising products developed by students individually or in groups (graphics, video, or animation) on the topics of the modern society problems (ecology and environmental protection, digital world risks, information gap, tolerance, etc.). The steps of the projects included a presentation of works in a social network to organise public discussion, commenting, and voting for the best works. A Ph.D. student Egor Shcherbakov presented a project "Social Media and Gamification". The goal of the project was to organise a master class for bachelor students before their first teaching practice at school on the use of mobile applications in the classroom.

CONCLUSION

The experience of the described detailed analysis of the e-course effectiveness allows offering recommendations on an e-course design and key assessment criteria.

E-course objectives should meet today's university education learning requirements in developing cognitive, social, behavioural, and digital skills through project-based joint work for finding new ways to solve practice-oriented problems in the future professional field.

An e-course design should be based on three main groups of digital resources – information, communication, and management resources. This approach makes it possible to project and plan both the teaching and learning processes within a course. To systematise all directions of an e-course design can be used, for example, D. Keller's ARCS model.

It is important to keep in mind students' previous learning the experience of e-learning (b-learning), experience of an autonomous learning, digital skills level, communication preferences, etc. For revealing prior knowledge, skills, experience, and preferences, an entrance diagnostics is advisable. It may occur that after detecting learning profiles of newly enrolled students, some notable changes should be introduced to the e-course.

In terms of students' digital content preferences, the most preferable features are a modular structure of a course, a sufficient number of various training materials (especially, in a short video format), clearly stated objectives, and a detailed methodological support (assignment recommendations, assessment criteria). Additional attention should be paid to students' collaboration and peer assessment. Students might have not sufficient experience of such activities; however, this is an important basis for developing competencies for future professional activities demanded by the digital society.

Special attention should be paid to the outcomes of a course. It is valuable when students can create a real product during the study, demonstrate their results to others, compare them, and assess themselves, their development, and advancement. An important indicator of learning outcomes that has long been a classic in pedagogy is knowledge and skills retention and transfer (Gagne, 1992). If some percentage of students complete their projects in real practice, it demonstrates the course undoubted effectiveness.

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Computer Measuring Systems and Their Impact on the Popularity of Individual Parts of the Physics Subject in Primary Schools in the Czech Republic

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Abstract

The popularity of science subjects in the long term is very low. Physics is one of the least popular subjects ever. This article describes the popularity of individual parts of physics lessons at elementary schools in the Hradec Kralove Region of the Czech Republic. It determines the popularity of the practical part of the lesson, the part of theory-interpretation and practice. The research itself focused on the popularity of individual parts of the lesson, especially on practical applications of individual parts of the lesson of physics. With the aid of computer-aided measurement systems, the popularity of individual parts of the physics lesson was investigated.

Keywords

Popularity of Subject Physics. Computer Measuring Systems. System SMPSL. Computer Aided Learning. School Physical Experiment.

INTRODUCTION

This article focuses on the popularity of individual parts of physics lessons at elementary schools in the Hradec Králové Region of the Czech Republic and the influence of computer-based measurement systems on increasing the popularity of parts of physics lessons. Especially impact of popularity on practical components of physics lessons. This influence was examined using questionnaires for pupils. The questionnaire was given to pupils in the form of pre-test and post-test in parallel groups. The result of the research then gives the result of the influence of computer-based measurement systems on the popularity of practical applications of individual parts of the lesson of physics.

POPULARITY OF THE PHYSICS SUBJECT

There are many researches into the popularity of the subject physics. A summary of these studies has been described in the article Influence of Systems for Measurement Using Computers to Popularity of Subject Physics at Elementary School - Some Results (Němec and Hubálovský, 2015). The most important was the research of Gerhard Höfer et al. - Teaching physics in a broader context - pupils' opinions (Höfer et al., 2005). As in (Němec and Hubálovský, 2015), where the purely popularity of the subject of physics was investigated, this article is the basis for research (Höfer et al., 2005). The research (Höfer et al., 2005) was based on the Research project: A thorough analysis of the state of physics education in elementary and secondary schools on new approaches in the education of physics teachers (Höfer et al., 2003). Further results are in the Opinions and Attitudes of Pupils towards the Teaching of Physics (Svoboda and Höfer, 2007a), Opinions and Attitudes of Pupils towards the Teaching of Physics: Completion (Svoboda and Höfer, 2007a) and Some Results of National Research: teaching physics (Svoboda and Höfer, 2007b). This research was carried out in 2003/2004 on a sample of 6408 pupils.

The results of the research (Höfer et al., 2005) and (Němec and Hubálovský, 2015) confirmed that physics according to the popularity of pupils belongs to the last places in the list of subjects taught in primary schools.

COMPUTER MEASURING SYSTEMS

Computer measuring systems consist of the hardware part to which the sensors and software that are installed on the computer are connected (Němec et al., 2013; Němec et al., 2014; Balogh, 2016, Balogh and Turčáni, 2016). The software then evaluates the sensor data recorded. A great advantage is the display of data in graphs (Voborník, 2016b). The course of the graph is immediately displayed when measuring some physical (or chemical) phenomenon. This helps pupils immediately see the development of the measured phenomenon (Voborník, 2015; Strnadová and Voborník, 2015). It does not have to take long time to record individual values over time, but everything is taken care of by this computer-based measurement system. (Němec and Hubálovský, 2014; Němec and Tříška, 2013) There are professional systems sold in the range of several thousand to ten thousand Czech crowns. These include Vernier (Vernier Software & Technology Global Gateway, 2019) and Pasco (Pasco, 2019). Other examples include the Czech EdLab (EdLaB, 2019), the IP Coach and Coach system (v. 5 and 6) from the Dutch Foundation CMA (CMA, 2019) and the iSES system (iSES - Internet School Experimental System, 2019) developed in the Czech Republic at MFF UK. The high price of computer-aided measurement systems can be compensated by the author's developed SMPSL system (Computer-aided Measurement System in the School Laboratory), the documentation of which is available at <http://smpsl.radeknemec.cz> (SMPSL, 2020).

COMPUTER MEASURING SYSTEMS AND THEIR IMPACT ON THE POPULARITY OF INDIVIDUAL PARTS OF THE PHYSICS SUBJECT

The aim of this research is to find out the popularity of individual activities of the lesson of physics in the Hradec Králové Region in the Czech Republic. Especially finding impact of popularity practical applications of popularity of individual parts of the lesson. And whether pupils who have participated in teaching physics using computer-based measurement systems rank teachers with practical applications ranking higher in the popularity ranking of each part of the lesson than pupils who have attended teaching without these systems. The research is based on the aforementioned research project of Gerhard Höfer et al. (Höfer et al., 2005; Höfer et al., 2003; Svoboda and Höfer, 2007a; Svoboda and Höfer, 2007b). Continues with article (Němec and Hubálovský, 2015).

Description of research and research methods

The research was carried out using a questionnaire (Voborník, 2016a; Voborník, 2014; Berková, 2014). The questionnaire covered more areas. (Milková and Ambrozová, 2018; Hubálovský et al., 2019; Hubálovská and Hubálovský, 2016; Hubálovský, 2013) In this article only the results of popularity of individual parts of the subject Physics are presented. (Hubálovský and Šedivý, 2013; Borkovec et al., 2013; Hubálovská et al., 2015; Hubálovská, 2015)

Questionnaires were distributed into 4 primary schools about the same size, the number of pupils and mainly into two parallel classes of eight grade taught by the same teacher.

The methodology was based on findings the results of questionnaire survey before and after the implementation of system for measurement using the computer to learning of physic (independent variable). In control and experimental group of pupils. After the pretest there was conducted statistical comparisons of the same division of pupils. Hereinafter, the learning of physics in experimental group was deployed by system for measurement using a computer (dependent variable that affects the popularity of physics, looking forward, experimentation, necessity, utility and personal professional focus). In the control group of pupil's lessons proceeded were experiments carried out by manual measurements, manual readings of values, manual calculation and manual charting. After making several measurements the pupils filled out the same questionnaire - the posttest was conducted.

Name of the questionnaire was as follows:

"Questionnaire for elementary schools in the Hradec Kralove region of the Czech Republic for determination of popularity of physics."

Introductory text familiarizes students with reason for filling out questionnaires. The full text is as follows:

"This questionnaire determines popularity of physics. The questions in the questionnaire are designed for getting the information on your perspective on learning in primary schools in the Czech Republic focused on individual subjects and especially on the learning of physics."

Follow the instructions and acknowledgments:

"Instructions for filling out the questionnaire

1. Questionnaire is anonymous and your answers will be used only for research purposes.
2. Questionnaire contains twelve questions with different variants of choices. For each number of the question you can choose answer (answers) according to the instructions in the questionnaire.
3. You can start processing of questionnaire until prompted of submitter.

Thank you for completing the questionnaire."

The questions of the questionnaire follow. The questions were divided into general input questions and questions regarding the learning of physics - popularity, looking forward, experimentation, necessity, utility and personal professional focus.

Input questions are:

1. You are a boy / girl?
2. What is your age?
3. In what year do you go?

Questions related to learning of physics, its popularity, looking forward, experimentation, necessity, utility and personal professional focus.

This was followed by a question about sorting items by popularity. These results are available in (Němec and Hubálovský, 2015).

Problem Solution

There were 310 pupils in the research. There were 164 boys (53 %) and 146 girls (47 %). The average age of pupils was 13.9. All pupils attended the 8th grade of primary school (Němec and Hubálovský, 2015).

The results will be displayed according to the following key. Table 1.

Table 1: Indication of variables

Description	Indication of variables
school 1–4, all schools	S1..S4, S
control class	C
experimental class	E
pretest	Pre
posttest	Post

Example of variable indication is in Table 2.

Table 2: Example of indication

Description	Indication of variables
school 1 pretest of control class	S1_Pre_C
school 1 posttest of control class	S1_Post_C
school 1 pretest of experimental class	S1_Pre_E
school 1 posttest of experimental class	S1_Post_E

Popularity of individual teaching activities

The questionnaire dealt with the popularity of individual parts of physics lessons. On a scale of 0–6 pupils chose favourite activities, where 0 was most unpopular, 3 middle (un)popular and 6 most popular.

The following parts were examined: revision and examination, teacher's explanation, problem solving, papers, narration and reading about the history of physics, internet monitoring, video, film, teacher's experiments, pupil's experiments.

Several of these have been selected and included in the practical part of the lesson. These were the practical parts: internet monitoring, video, film, teacher's experiments and pupil's experiments.

Table 3 shows how this part looked in the questionnaire.

Table 3: Popularity of individual teaching activities

In the table for each activity by scale, write down the number of your favorite.

Scale:

most unpopular – middle (un)popular – most popular						
0	1	2	3	4	5	6

Activity:

Revision and examination		Internet monitoring	
Teacher's explanation		Video	
Solving problems		Film	
Papers		Teacher's experiments	
Narration and reading about the history of physics		Pupil's experiments	

Results

The following table (Table 4) shows the range of 0-6 popularity of each lesson activity of all schools.

Table 4: Relative frequency of popularity of individual parts of the lesson

	Pre_C	Post_C	Pre_E	Post_E
Revision and examination	2,21	2,25	1,56	1,66
Teacher's explanation	3,39	3,31	3,01	3,09
Solving problems	2,99	3,01	2,80	2,82
Papers	3,95	3,90	3,62	3,90

Narration and reading about the history of physics	2,70	2,67	2,69	2,76
Internet monitoring	4,42	4,37	4,64	4,61
Video	4,96	4,90	4,90	5,04
Film	5,21	5,15	5,23	5,15
Teacher's experiments	4,83	4,58	4,80	4,83
Pupil's experiments	4,80	4,76	4,74	4,66

In graphical form this can be seen in Figure 1 below.

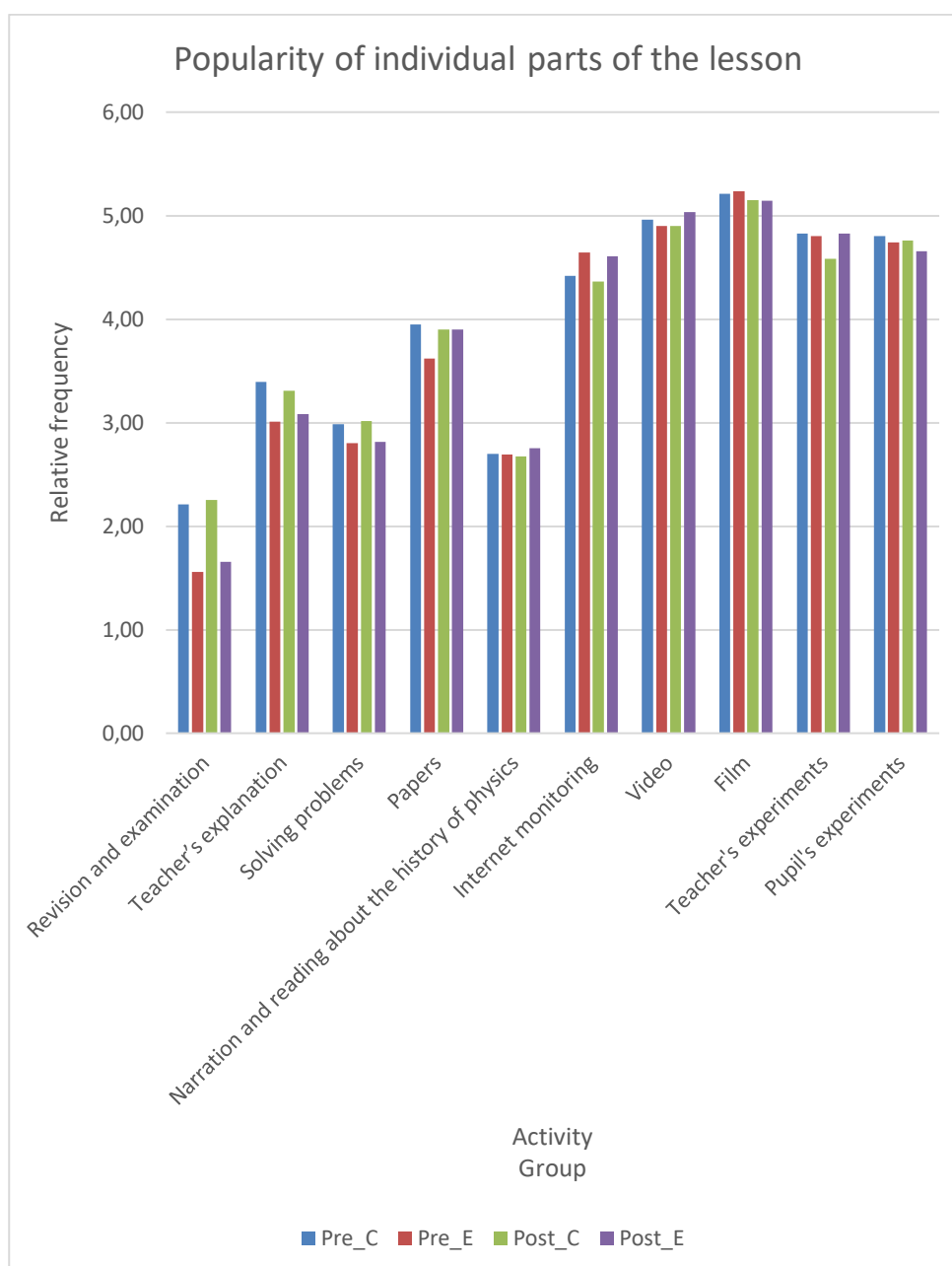


Figure 1: Popularity of individual parts of the lesson

Individual parts of the lesson can be divided into three parts.

- Practical application
 - Teacher's experiments
 - Video
 - Film
 - Pupil's experiments
 - Internet monitoring
- Theory - Explanation
 - Teacher's explanation
 - Papers
 - Narration and reading about the history of physics
- Practicing
 - Solving problems
 - Revision and examination

The order according to this structure can be seen in Table 5. The table also shows the diameters of the individual parts. These averages are then shown in Figure 2.

Table 5: Relative frequency of popularity of individual parts of the lesson according to categorization

	Pre_C	Post_C	Pre_E	Post_E
Practical application				
Teacher's experiments	4,83	4,58	4,80	4,83
Video	4,96	4,90	4,90	5,04
Film	5,21	5,15	5,23	5,15
Pupil's experiments	4,80	4,76	4,74	4,66
Internet monitoring	4,42	4,37	4,64	4,61
average	4,84	4,75	4,86	4,86
Theory - Explanation				
Teacher's explanation	3,39	3,31	3,01	3,09
Papers	3,95	3,90	3,62	3,90
Narration and reading about the history of physics	2,70	2,67	2,69	2,76
average	3,35	3,29	3,11	3,25
Practicing				
Solving problems	2,99	3,01	2,80	2,82
Revision and examination	2,21	2,25	1,56	1,66
average	2,60	2,63	2,18	2,24

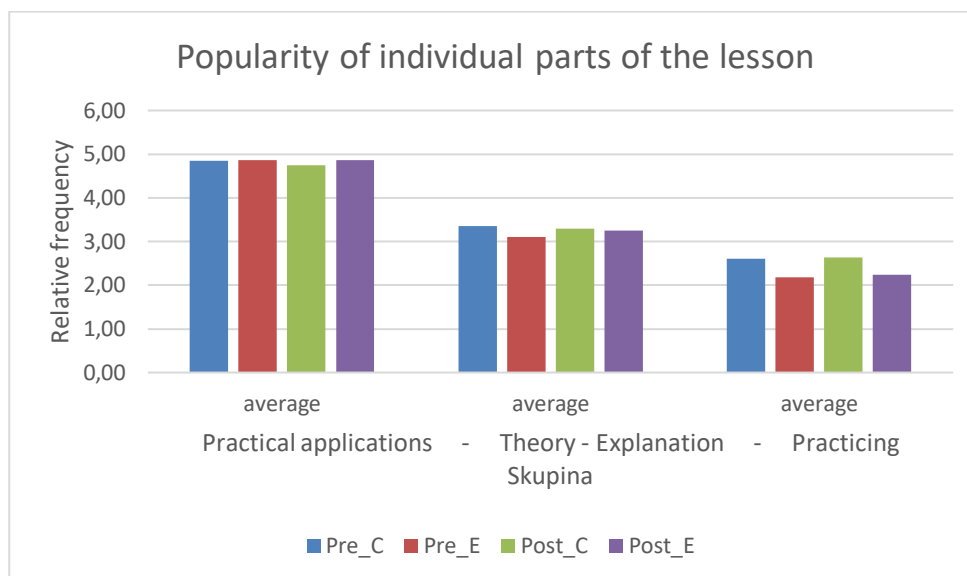


Figure 2: Popularity of individual parts of the lesson according to categorization

Figure 3 shows the popularity of individual parts of practical applications.

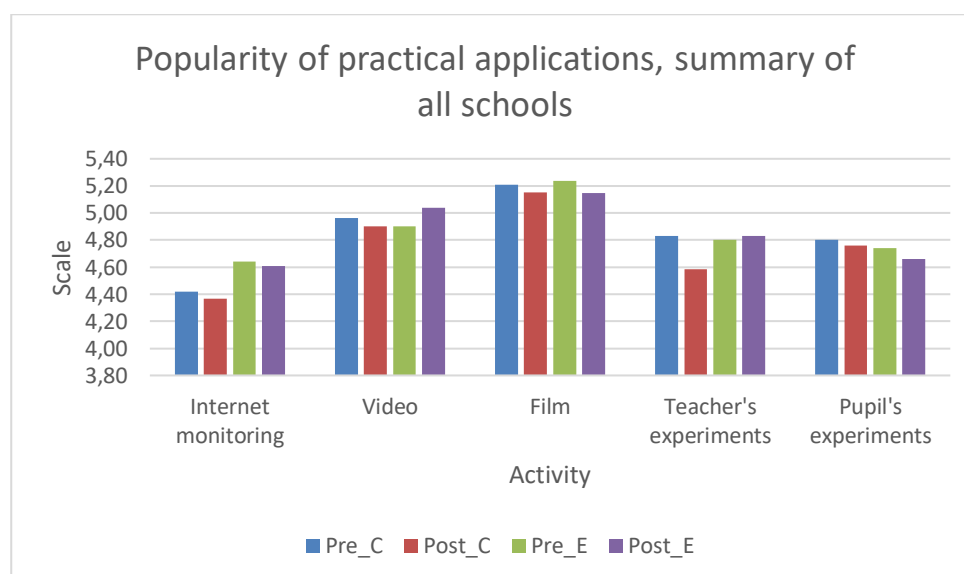


Figure 3: Popularity of individual parts of practical applications

Hypotheses of the research

Elementary school pupils who have participated in physics education using computer-based measurement systems rank practical applications higher than those who have attended classes without these systems.

RESULT AND DISCUSSION

The program was carried NCSS Mann-Whitney U test with the following results was carried out in NCSS application. The results are shown on Table 6 and Table 7.

Table 6: Statistically calculated result

School	Alternative hypothesis	Decision (-5%)
1	Pre_E \neq Pre_C	Accept Ho
	Post_E > Post_C	Reject Ho
2	Pre_E \neq Pre_C	Accept Ho
	Post_E > Post_C	Accept Ho
3	Pre_E \neq Pre_C	Accept Ho
	Post_E > Post_C	Accept Ho
4	Pre_E \neq Pre_C	Accept Ho
	Post_E > Post_C	Accept Ho
1–4	Pre_E \neq Pre_C	Accept Ho
	Post_E > Post_C	Accept Ho

Table 7: Statistically calculated result - experimental classes

School	Alternative hypothesis	Decision (-5%)
1	Pre_E \neq Pre_C	Accept Ho
	Post_E > Pre_E	Accept Ho
2	Pre_E \neq Pre_C	Accept Ho
	Post_E > Pre_E	Accept Ho
3	Pre_E \neq Pre_C	Accept Ho
	Post_E > Pre_E	Reject Ho
4	Pre_E \neq Pre_C	Accept Ho
	Post_E > Pre_E	Accept Ho

1–4	$\text{Pre_E} \neq \text{Pre_C}$	Accept H_0
	$\text{Post_E} > \text{Pre_E}$	Accept H_0

The pre-test tested the null hypothesis of the identical results of the experimental group (Pre_E) and the control group (Pre_C) against the alternative that the results differ. In schools 1, 2, 3, 4 and in the summary of all four schools, at the significance level $\alpha = 0.05$, the null hypothesis was not rejected (NCSS gives the $\text{Pre_E} \neq \text{Pre_C}$ Accept H_0 for the bilateral alternative hypothesis). It is therefore assumed that practical applications in the subject of physics were equally popular among pupils of the control and experimental groups.

For the post-test of the experimental group (Post_E) and the post-test of the control group (Post_C), only the school 1 rejected the null hypothesis of the same distribution of results in favor of the unilateral alternative hypothesis $\text{Post_E} > \text{Post_C}$. Thus, better results were obtained in the experimental group than in the control group. After teaching using computer-based measurement systems, the popularity of the practical parts of physics was higher than in the traditional form at school 1 only. On the other hand, schools 2, 3, 4 and all 4 schools (1-4) did not test posttest results. experimental (Post_E) and control (Post_C) groups rejected the null hypothesis of consistent results (Accept H_0).

A (Wilcoxon) paired test was used to test the change in results only in the experimental classes. Here again, only one school (3) rejected the null hypothesis ($\text{Post_E} = \text{Pre_E}$) in favor of the alternative hypothesis $\text{Post_E} > \text{Pre_E}$ (according to NCSS the decision Reject H_0 was given for the unilateral alternative hypothesis $\text{Post_E} > \text{Pre_E}$). Thus, after teaching using computer-based measurement systems, only the school 3 has become more popular with the students of the experimental group in the physics practice. posttest of experimental groups (null hypothesis was not rejected).

CONCLUSION

The results show the following. For posttest only at school 1, the practical application of part of the physics lesson increased. Therefore, systems for measuring by means of computer have almost no influence on the popularity of practical parts of physics education. This is probably due to the fact that the practical applications included in addition to trials and watching the Internet, video and movies. Watching the Internet, video, and movies could be more applied to the lesson than doing experiments. For test changes in exp. classroom again only at school 3 increased the popularity of practical applications of part of the physics class. Even in the case of a change in the experimental group, there was no change in the popularity of the practical parts of the physics lesson, respectively. this only happened at one school. Probably this was due to the inclusion in the practical part of watching internet, video and movies instead of just making experiments by the teacher or pupils.

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Augmented Reality in Teaching Children in Primary Education

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Abstract

Nowadays, children are constantly surrounded by mobile technologies. Some teachers perceive them negatively, but they can assist in teaching if we use them appropriately. This work presents findings of some possibilities for using mobile technologies, especially the augmented reality applications in teaching in primary education. The method used for this research was observation. The results of the pre-research form the base for the direction of the further study concerning the augmented reality in teaching practice. The chapter focuses on the educational potential of augmented reality for support in primary education. The chapter presents the opportunities that augmented reality brings to primary education. The authors give a brief overview of selected applications suitable for primary school children. They then focus on Quiver and HP Reveal, which were used in a research project in Primary school. We used semi-structured interviews with children and focus group. The research showed that children are more motivated with application with augmented reality.

Keywords

Augmented Reality. Primary Education. Digital Technology in Education.

INTRODUCTION

Currently, digital and mobile technologies are part of the everyday life of children in both pre-primary and primary education. Joanne G. Sujansky and Jan Ferri-Reed (2009) wrote in their book „Keeping the Millennials“ that young people have an ability of multitasking. It means that they are able to work on a computer, watch TV, listen to music and write messages at the same time. It is essential that pupils in pre-primary and primary education know about possibilities of using smartphones and other technologies. It increases their digital literacy.

Most educational experts agree and believe that digital technologies can support pupils' competence development. Majority of digital researches have confirmed these discussions and have found that new technologies impact children's lives significantly. On the other hand, there are studies warning about various risks that need to be considered. Most of these doubts are based predominantly on the misconception that modern technology in education makes pupils passive receivers or lonely computer game players. For using digital technologies in pre-primary and primary education, it is necessary to determine the digital product suitability and adequacy with respect for children's age, select

carefully appropriate applications and place them into constructive digital environment/context.

Sylva and Siraj-Blatchford (2006) identified four key areas of learning in Early Childhood Environments (ECE). It is the educational theory section about learning (formal and informal) young children under the age of 8 and it reflects how and in which areas ICT can support them.

They are:

- communication and cooperation – they appear naturally in collaborative problem solving - applications based on experiments with programmable toys
- creativity - children have to acquire schemes and need playful dispositions to try these schemes in a new context to be creative
- sociodramatic play - there is a lot of space to integrate ICT into the playing young children environment
- learn to learn - there is evidence that computers help young children think of thinking. (Korenova, Lavicza, Veress – Bágyi, 2020)

Constructivist teaching approaches and pedagogical research concerned with the application of this theoretical direction to teaching have often been an interest of researchers (e.g., Bodner, 1986, pp. 875–876; Held, Pupala, & Osuská, 1994; Renström, Andersson, & Marton, 1990; Žoldošová & Prokop, 2007). They deal with basic questions of science principles of using Augmented Reality in primary education. This trend in research has found continued motivation, both abroad, because children often use only rote memorization as their learning technique without gaining any in-depth understanding of subject's essence (Tóthová, 2014). (Csandová, Koreňová, Tothova, 2019)

Arnheim (2004) argued for the unity of perception and abstract thinking, according to which mental processes do Augmented Reality Applications in Early Childhood Education not only consist of operations with words and numbers, but also imaginary thinking. (Korenova, Lavicza, Veress – Bágyi, 2020)

AUGMENTED REALITY APPLICATIONS AND THEIR USING IN PRIMARY EDUCATION

Several projects in the Czech Republic enable schools to acquire digital technologies. These are various calls from the Ministry of Education (Templates I and Templates II, Call 51) that encourage schools to include activities developing ICT. Another possibility is a founder who can contribute to these aids. Our Elementary School in Ludgeřovice has 150 iPads for pupils and teachers too. In 2014, pupils from the 4th class participated in the O2 project (O2 is a mobile operator) and won 20 iPads for the school. As the number of iPads was increasing, educators were trained and iPads have been used widely.

There are no calls or projects to support augmented reality in schools at present. There are several methodological guides.

RESEARCH OF AUGMENTED REALITY APPLICATIONS USABLE AT THE LOWER SCHOOL LEVEL

Subsequent applications with augmented reality were tested in teaching in 2019. We chose some which can be applied suitably at primary school.

- **Quiver - Platonic Solids** - Platonic Solids is a part of the Quiver educational application. We can visualise Platonic bodies by it. Pupils at the first level can get to know formations in three-dimensional space and, for example, look for the geometric shapes which they already know - square, triangle. This application is suitable for mathematics, but by using other printable worksheets, it is also applicable to natural sciences. Therefore we use the STEAM concept.
- **AR Flashcards Shapes and Addition** - AR Flashcards itself is free, both Shapes and Addition are paid for, but worth mentioning. They can help children to develop basic mathematical skills. Addition app illustrates counting by using animal images from $0 + 1$ to $9 + 9$. Shapes allow pupils to colour a geometric shape and after then they can hear its name, color and shape in English. At the same time, it shows where it is possible to find the shape in the real world. It is suitable for teaching mathematics.
- **Augmented polyhedrons - Mirage** - motivating applications where pupils observe three-dimensional shapes side-by-side to see differences. The application can be used in mathematics teaching.
- **ARuler** - pupils can use it to measure real things in mm, cm, m.
- **Natural science** - At the first stage of the primary school Natural science contains a lot of different curriculum. Augmented reality applications allow pupils to see and learn about human anatomy, the Universe.
- **Night Sky** - during Universe teaching, especially the constellation, students observe the real constellation where it is (5th class)
- **Spacecraft 3D** - the application was created by NASA cooperation and all objects (satellites, missiles, spaceships, etc.) are real. Students can identify and track the various technologies on Mars, Earth and in the Universe.

Others - other applications include applications that are applicable in pre-primary education and also in the primary education to develop imagination and other subjects.

- **AR Flashcards** - the application is useful after printing web material and can be used to practice English animal names or practice the English alphabet.
- **Aurasma (HP Reveal)** - by using this application pupils can create a picture or video. The teacher hides tasks in class (by loading specific things) or places the camera to the title - assign a picture. This app is applicable to all subjects.
- **AR Dragon** - by using this application children (even in pre-primary education) learn to look after a pet. They learn responsibility and develop social skills.
- **Sketch AR** - this application shows a virtual image on white paper so pupils can sketch the image and then complete it themselves. It develops drawing skills and imagination.

- **Quiver Education** - is a coloring application that links to education. There are pictures for pre-primary education and teaching material for the first grade of primary schools. We can find here a volcano erupting description, the capitals of states and cell description.
- **Animal 4D +** - animals in 3D can be shown by this app right on the desk. For pupils it is astonishing to see and hear animals they have never seen and heard.
- **Catchy** - in the classroom area we can see a secret puzzle with letters that we catch throughout the class and place them correctly to guess the puzzle. This application can be used in Czech and English lessons.
- **AR Makr** - using this application a teacher can create a story or a fairy tale in space. After that pupils can tell the story or show it to their classmates.

Action research

The action research took place at the Elementary school and Kindergarten in Ludgeřovice, where I have been teaching the first level pupils for four years. We use technology mainly for repeating curriculum, and also for pupil motivation. The school has 120 iPads, Dash and Dot robots, Ozobots, Lego Mindstorm, Beebots and Micro:bits that are used by teachers in their classrooms as needed. There is also a class of iPads in education, where we do more advanced work with iPads and robots. From kindergarten and at the first level (1st - 2nd class), we begin to program Bee-bot called "robotic bees", which are very intuitive and simple. Then we follow to program Ozobots (3rd - 4th class), which are programmed by colour combinations or by programming language on a PC or iPad. We use Dash and Dot robots in the 3rd class by using simpler applications and we build codes in the programming language with older pupils in the 4th and 5th classes. With robots we start using iPads from the first class, which pupils have in the classroom 1: 1. In 2018 - 2019 we did action research in the 3rd and 4th class at the first level at Elementary School in Ludgeřovice. There were 24 pupils in the class. Pupils had experience with iPads and were able to control them. By using the qualitative research method – observation - was found following information for several used applications and websites.

Apps used on iPads:

In the research we observed pupils in the digital environment of certain applications. We observed their behaviour during using applications and whether they were motivated by their work.

HP Reveal - we can use augmented reality to display whatever we want anywhere in the static room. Pupils should read the book once a month. Questions and tasks directly relevant to the book are hidden by HP Reveal on the book cover. After reading the book, the pupils have to answer these questions in their reader's diary or iPad application. They work with a book and look up information on the Internet. Parents do not help them, so they are more independent. From the pedagogical point of view, working with iPad after reading books, is motivating.

Pupils worked with **Quiver** in groups once a week. They had not known before which information was supposed to be brought by application. They worked with this application for about 20 minutes, each group had a different worksheet that they read and communicated about it (Plato bodies). After group work, each group had to prepare the output of what they had seen. After all outputs, the pupils discussed whether they had seen

the same thing or whether the worksheets had been different. They began to understand the number of sides and shapes that make up body formations. This application helps pupils visualize mathematical objects and many other things that are difficult to imagine.

Focus group – elaboration

The focus group for data acquisition was used as a research method. A focus group is a discussion group that represents a group of people. This group of people communicate with each other in the form of group interview. The main method of qualitative research was an unstructured observation. It means the observer minimizes interaction with pupils. By observing we can see the cooperation, creativity, motivation, digital literacy and independence through augmented reality. We used a direct observation - observation of communication among pupils and also an indirect observation - observation of real situations during education.



Figure 1: Children uses application Quiver

Research implementation - data collection was realized by the implementation of the focus group during an action research with pupils in the 1st class at the Primary school in Ludgeřovice in Czech republic in 2018, in which 23 pupils participated. By using the focus group, pupil were expected to be more open and to share their views more easily. The teacher was here as a guide, asking questions and encouraging children to answer them. At the beginning of the focus group, the teacher challenged pupils to answer the questions and to share their opinions and remarks. The questions were: „What did you like most when we were using augmented reality apps on iPads?“ „Do you think you learned something interesting?“ „What surprised you?“ „What did you not like?“ „Would you like to do it during other classes?“

We used a digital dictaphone for recording. The pupils answered and reflected on their work with the augmented reality application during the last 15 minutes of the lesson. This audio recording was then transcribed to a written form. The transcript was written as open coding and individual categories were created. (Tab.1)

We performed observation of the action research at the Elementary school in Ludgeřovice between 2018 - 2019 (November - April). The observed pupils involved in the focus group at the end of the observation were from 3rd and 4rd class. There were 24 children in the research and 6 children in each focus group. The aim of the unstructured observation were proceedings of the teaching process via his/her teaching, the teacher began to consciously support the pupil's digital literacy development through augmented reality.

The pupils worked individually in the groups, but they also had to cooperate. They participated in achieving of the same goal through their activities, but also in fulfilling their own individual goals. Pupils respected each other in the group and shared their experience with others. They communicated over the images without realizing that this way they were learning. Direct and indirect observations were registered to a written protocol (see Protocol 1).

By indirect observation we searched for the presence of a phenomenon - its occurrence, in which situations it occurs and how often it occurs.

During the analysis of pupils' statements in the focus group, all statements were included to search for an insight in how to use best the possibilities of the augmented reality in the teaching process. Through using open coding the process of data exploring, comparing, categorizing, coding and conceptualizing was implemented.

Table 1: Protocol 1. Statement snippets of pupils from the focus group

<ul style="list-style-type: none"> ▪ I liked when a volcano appeared above the table. / VD / I liked when things on a paper became "living" things. / PH / I liked that I could work and show things on the iPad with my classmate. / MFV / I liked the fact that we worked with the tablet and did not sit at desks. (MFV) I liked the volcano erupting above the table. / VD / I liked the fact that I could compare a cube to a classmate if he had the same cube. / MFV ▪ I learned to work with a tablet more. / VD / I learned what is happening with the volcano. / VD / I learned that a body can be made by other shapes. I learned that each cube can have a different number of walls. / VD / I did not learn, we rather played on iPads. [VD] I had already known everything, but it was great. / VD / ▪ I was surprised how can be these things shown. (PH) I was surprised when I painted the picture, the same colored cube was flying in the classroom. [VD] I was surprised the lesson finished so fast. (MFV) I was surprised the classroom was so quiet. (PH) I was surprised by the volcano that finally exploded. / VD / ▪ I liked everything. / RU / I didn't like it was so short. / PH / I did not like some sheets could not be loaded. ▪ I would like a tablet during every lesson. (MFV) I would like a tablet one hour a day at least. [MFV] I would like to have more tablets than we have it. / MFV / I would like to watch everything like this. / MFV /
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We obtained the main ideas expressed by a specific sentence (concepts), which were categorized in the statement protocol.

Table 2: Protocol 2. List of identified categories, concepts and codes in the protocol.

Interpretative category	Concepts	Codes
The teacher's role	Teacher as an advisor, a listener, an observer.	RU
Teaching methods and forms	Group work. Individual work. Working with tablet. Working without a tablet.	MFV
Child's performance	The child is improving his / her potential and abilities. The child decides independently. The child gets information in different ways. The child can find out how to perform a certain activity.	VD
Added value	The child carries out the activity independently. The teacher realizes teaching by his / her individuality.	PH

CONCLUSION

At this time, digital technologies are a desirable tool in education. They are not only an excellent motivational element, but they can also influence several senses of pupils at the same time, and, in that way, instil the curriculum more permanently.

The research aim was to create a model for didactic support to develop digital literacy of children in primary education through augmented reality. The main aim was to find out the impact and benefits of augmented reality on development of children's digital literacy. The augmented reality contribution in the area of the children's digital literacy development was significant among the pupils. While children were playing with tablet and augmented reality, a high level of engagement, motivation and mutual communication were observed. The pupils were able to distinguish between reality and the virtual world.

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Modern Approaches of Cognitive Processes Development Using Mobile Technologies and Microlearning

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Abstract

The authors of this paper describe ways of possible positive effects on student's cognitive processes and thinking by using modern technologies and educational methods, especially in nowadays classrooms. This article reflects the current trend of minimalism not only of technical equipment, but also the educational process itself. While informational - technological aspects of minimization is mainly reflected in the implementation of mobile phones, tablets and their applications (apps) in schools instead of using personal computers, in the education itself this trend is resulted in the emergence of so-called microlearning. Students have a wide range of options and possibilities of education, but the time they are willing to spend is still shorter, as further research confirms. Part of the paper is an analysis of existing technological, theoretical and software resources and results of current research on these topics. The authors mention concrete examples of interaction between technology and students, and also present research questions on how to use this cooperation to support cognitive thinking, which are answered at the end of the paper. These researches can then help current teachers and contribute to improving the relationships between information technology, teachers and students.

Keywords

Cognitive Processes. Modern Learning. Mobile Technologies. Microlearning. 3D Graphics.

INTRODUCTION

The generation of students is currently at the edge of technological possibilities. This era and lifestyle is fast and everyone is surrounded by information and news. We are forced to react in quick impulses and new information strike almost every moment, and human thinking adapts accordingly. While adults, including teachers, of course, are trying to adapt to this phenomenon as quickly as possible, the young generation (pupils and students) have already adapted and all these stimuli are consumed. However, the problem is whether this approach is effective and positively affects the education process.

The current trend is minimization. Not only of the technologies, which is most evident in mobile technologies, but also of the learning process itself. That has resulted in the genesis of so-called microlearning or other modern trends. Educational institutions thus try

to respond to the situation, to simplify and speed up the whole educational process, but to preserve its quality and efficiency. As a result, new modern approaches to education such as: E-learning, computer-based learning, gamification, algorithmic learning are already widely used

Amongst popular devices for applying these approaches not only for students but also teachers are mobile devices with a wide selection of educational applications (apps). With its large touch display, camera, personalization and performance capabilities, the iPad appears to be a convenient hardware tool for working in both classic and special education (Dickens, 2013). In addition, these features support working with 3D graphics, virtual or augmented reality, which was previously reserved for use on computers.

Based on the current state, we determine the following research questions:

- What are the modern technical and software options for developing cognitive thinking?
- What current educational methods best suit to cognitive development?
- How to properly combine these options and use them to develop cognitive processes?

METHODS

For research of cognitive processes development using modern approaches, it is necessary to analyze the current situation from two essential points of view. The first aspect is pedagogical-psychological, in which the issue of cognitive processes and the resulting concepts are analyzed. The second aspect: information technology (IT), analyzes the current state of hardware and software.

Analysis of cognitive processes

In the following part are listed the most important terms that we worked with during the research. Cognitive processes are mental activities through which reality is recognized. Enable us to capture, register, process and evaluate information about the outside world and ourselves. Cognitive processes include: sensory processes (or sensation), perception, learning, memory, imagination, thinking and speech. These cognitive processes are dealt with by cognitive psychology, which understands the human psyche as an information-processing system. (Plhakova, 2007). Cognitive psychologists use a number of methods in their research. In many cases, these are controlled experiments that combine with other methods, such as computer simulation (Plháková, 2007). It is these aspects of cognitive thinking that we try to develop using modern approaches.

We try to develop or refine all (or combination) of the cognitive processes mentioned below.

Perception

Perception is an active and selective process of receiving and processing information. The more accurate and clear the student's perception, the greater the prerequisite for their mastery. Acquisition of knowledge should not take place passively as the acquisition of finished knowledge, but as a process of active processing of information, in which memory,

imagination, thinking, problem solving, etc. are involved. not tied to reality, they allow abstraction and generalization, they are an important step towards intellectual cognition.

Types of perception: visual (visual perception), auditory (acoustic perception), olfactory (chemical stimuli, smells, odors), taste (chemical stimuli from substances dissolved in saliva), tactile (tactile, tactile stimuli), body senses (perception of heat and cold, posture and body movement).

Fantasy

Creating brand new, unique and original mental representations. Creating fantasy imaginations is based on past experiences, but these are not mere reproductions. What we know, we have perceived, modified, combined and refined, creating something completely new. We do not work with any clues, but we create a brand new object that we have never seen in any form before.

Imaginative processes

The ability to create audio - visual and movement ideas to create mental representations of objects and phenomena that we do not perceive or have not perceived in a given form before. We can divide them into:

Commemorative notions: They are created on the basis of impulses from external reality. Often there are objects that are in consciousness. They are sometimes considered a weakened copy of the perception. Memory images are less vivid and clear compared to perceptions.

Fantasy Imagination: Imagination imaginations include events that we have not experienced yet or objects and people we have not known. The impulses of imagination come from internal sources.

Agglutination = a new notion created by combining several other notions.

Imagination: Based on the rules of imaginative processes. The basis is working with memories, with past experiences and experiences. The result is commemorative notions, which according to the accuracy and specificity of the equipped picture we divide into general (general characteristics of the presented phenomenon, not solved details) and unique ideas (almost accurate object).

Spatial imagination has been identified as a key area for child education that has had a great positive or negative impact on the child's further education, education and future and future careers (Gustafsson, 2004).

Creativity

Creativity is defined as a complex ability to a successful synthesis of cognitive abilities, personality traits and some motives. (Plhakova, 2007). Creativity can lead to a solution or facilitate the solution of a problem. It is manifested by the production of new, original and suitable ideas. An excellent level of creativity can arise when they occur in an ideal constellation. But creativity is not easy to measure and diagnose.

Creativity tests must be studied for future task design and creativity development.

The Torrance test has three separate parts, which the student has to elaborate using paper and stationery. Creating a picture and creative use of cut out shape. The originality of

the picture and the title and collaboration are evaluated here (other categories are not worth evaluating here). Ten incomplete figures to be completed in the most creative and interesting way. All four categories are evaluated separately for each of the figures. Use circles to create new shapes. Again, all categories are evaluated (except for the originality of the title, for which a rating is not recommended).

Urban's figural test of creative thinking: In principle, it is similar to the Torrance test. It has only one part that can be reused by rotating the entire template 180 degrees.

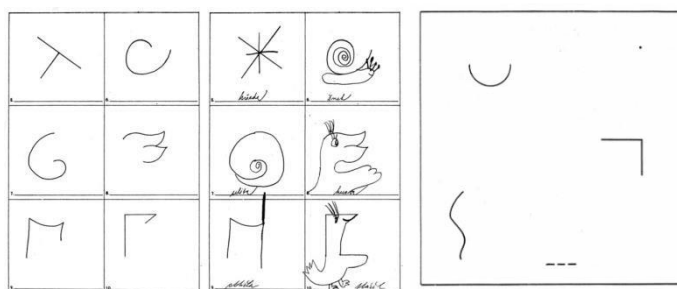


Figure 1: Torrance and Urban's figural test of creative thinking

Microlearning

Microlearning as a concept can be seen most often in the context of mobile learning or e-learning and its interpretation can be interpreted in several definitions. The aim of microlearning is to make the learning process as efficient as possible. Unlike the classical learning of long parts and subsequent testing after some time, this new way of learning is to concentrate into smaller parts. Material or study problem given to the student in smaller pieces but more systematically distributed parts is better understood by the student (Hug.2007). This trend has been applied in popular educational applications such as: codecademy, udemy, duolingo

Microlearning follows these rules (Kapp, 2019):

- Dividing learning content into small but effective parts
- Transform content into interactive form
- Ask simple questions at the end of each section
- Create tasks in each section
- Add additional materials, links, useful resources

All tasks created for the development of cognitive processes were created using the principles of microlearning

Analysis of information technology tools

For successful research it's necessary to analyze the existing technological possibilities and find out tools we can currently use for the development of cognitive processes.

Since the launch of the iPad in 2010 by Apple, affordable and easy-to-use touch tablets with downloadable applications have been available. Many researches has been focused on attitudes towards these technologies. One of the main aspects of iPads or tablets in general is, of course, the fact that the large touch screen is much more convenient to work with 3D objects than, for example, the smaller display of smartphones. The big and high-quality

display is the key for iPads. Another benefit is the iOS itself, which is more suitable for application developers and therefore can be found in Apple AppStore more serious and compliant applications.

One of the aims of education is to develop students' cognitive processes, and this is where new ways of using previously difficult to apply technological tools such as computers, mobile devices and their peripherals are opening up. In the past, before the advent of the development and popularization of smartphones or the advent of the Internet, there were several obstacles to the use of modern tools, such as:

- Price range of suitable devices for use in teaching. Expensive or unavailable equipment for schools or parents. The same applies to the software tools or peripherals needed to work (monitors, tablets, stylus, etc.)
- Insufficient hardware performance for quality and fast work with the necessary software or tools
- Lack of teaching materials, teachers...

Most of these problems have been solved very effectively in recent years, opening the door to working with more advanced and technologically demanding computer technology entities. These are, for example: 3D graphics, 3D printing, virtual reality or augmented reality.

Augmented reality: Most represented through mobile games and apps. The principle is based on the overlay of the computer generated through the real world through the camera. Researches have shown that AR is motivating and interesting for students. The thesis provides inspirational materials and ways how to develop language skills and communicative competences using augmented reality applications (Taskiran, 2018). Augmented reality is also suitable tool for people with hearing disabilities (Berger, 2019).

3D Computer graphics: Alongside with 2D graphics (vector and raster) in computer science belong under the category of computer graphics. Sometimes we come across the acronym CGI - computer generated imagery (Luebke, 2003). Objects created using 3D computer graphics tools are widely used not only in the entertainment industry, but also in medicine, architecture, automotive or psychology (nowadays popular use of virtual reality). These 3D objects can also be applied to the real world using 3D printing or projection technologies. Geometric objects have three-dimensional parameters (height, width, depth) created by a computer to simulate real or abstract entities.

3D printing: Realization (printing) of a virtual model into physical equipment. The model is divided into individual layers of material that are placed on top of each other until the model is finished (Anon, 2017). Josef Průša, a pioneer in 3D printing in the Czech Republic, has developed one of the most widely used 3D printers in the world. Use of 3D printers in the area: Healthcare, engineering or even art. The first 3D pen invented in 2012 - 3D Doodler - works on a similar principle to 3D printers. Josef Průša 3D printers - he became famous as a developer of so-called personal 3D printers and his products in the field of 3D printing are highly appreciated not only in the Czech Republic but mainly abroad .

Application analysis

Is the current offer of mobile applications suitable for the development of cognitive processes sufficient? The research included 64 applications available for both iOS and

Android devices. From all the applications analyzed, the ones that were most suitable for the development of cognitive processes and the above mentioned technologies were selected.

RESULTS

Based on the analyzed content, concrete steps were taken in order to achieve possible positive effects of cognitive processes in students. Specific results:

- Specific technologies have been recommended
- Specific applications have been recommended
- Specific tasks have been created

Recommended Technology

Considering the current possibilities and situation in education, 3D graphics was chosen as a suitable branch for the development of cognitive processes. The main aspect was modesty and accessibility for any area of education. One of the basic techniques for modeling 3D objects is that almost any complex object can be modeled using six basic primitive objects (cube, platform, cylinder, sphere, cone, pyramid). Thought processes are similar to those children know for example in ceramics. At the beginning they have a lump of clay and gradually modeling to get a pot. In this kind of modeling, however, they do not get dirty hands and are not limited by the amount of clay. It helps to develop creativity.

These principles and processes can help students with spatial orientation or imagination problems, they can also develop motivation among students. Students can learn that even complex things can be created from a simple foundation if they have the appropriate patience and knowledge of basic algorithms. These techniques then help to develop creativity and motivation. Many young pupils (mainly in primary schools) have problems with spatial orientation and imagination. In various mathematical competitions, problems can be found on this topic. The problem is that pupils meet them only in certain situations and the solution is usually presented to them orally or only in the form of an assessment: good or bad. However, if we present the assignment in 2D and then let them verify the correctness, for example, in the application on the tablet, which will find the assignment in 3D, which will also be able to manipulate with gestures, so it better tests its skills. Capabilities can thus be further developed by entering more and more complex geometric bodies. Students can also use the tools to create for themselves various assignments in the form of games. In this way, we can develop students' orientation in space and motivate them to create their own 3D models.

However, such tasks require no demanding programs or computers nowadays. This particular example can be demonstrated in mobile applications that support the handling of imported models, including their texture, on smart devices.

Recommended applications

The biggest advantage of working with mobile devices is the full use of the touch screen. Thus, the student can use the gestures to rotate or zoom in on the three-dimensional model and view and explore all sides without any restriction. In this particular case, the use of tablets is more convenient. Based on active work, experience and testing, these applications

(the best of three) have been selected, which are also suitable for microlearning and free of charge.

OnShape: High quality application with all the features of professional CAD software for PC. Another benefit is its use in the web browser interface. Possibility to work on PC, tablet but also mobile phone. Useful application for novice and advanced designers.

Display.land: Currently almost revolutionary application that allows to create a 3D model from almost anything in the real world. Scan and create a virtual representation of the room, including all the things in it. The created model can then be viewed by the user and further worked with it. This application can develop spatial orientation and imagination.

Shapr3d: Probably the most advanced and according to the evaluation of many users and reviewers the best application fully replacing CAD software for PC. The application is continually being improved and a large number of educational materials and tutorials are created for the application through an extensive community. One of the most suitable applications for working with 3D graphics on a mobile device.

Examples Creating tasks for the development of cognitive processes

During the research and consultations with colleagues psychologists, we found out that it is not easy to diagnose and investigate creativity. For the research it was necessary to design and assemble original tasks for working with 3D graphics and three-dimensional objects so that they have positive effects on the solvers (students) and develop.

In order to develop certain aspects of human capabilities the proposed tasks must best suit to several criteria. These criteria are designed in such a way that tasks are feasible in almost all circumstances and eliminate obstacles that could prevent, prolong or hinder their processing.

Key criteria and features of tasks:

- solvable in any 3D graphics software or application
- suit to microlearning rules
- simple to understand, not contain many complex instructions
- easy on IT capabilities. Also feasible by a user with basic IT skills
- Correct solution tasks must not exceed a maximum of 5 minutes
- basics of logic and algorithmization
- suitable for solvers from 7 to 60 years

The proposed tasks are inspired and based on already conducted researches, which combine geometric puzzles combined with spatial imagination and three-dimensional space. Because it has been clearly shown that spatial skills are also critical for mathematical performance. Based on these suggestions several tasks (3D sudoku, 3D puzzle) were created and tested.

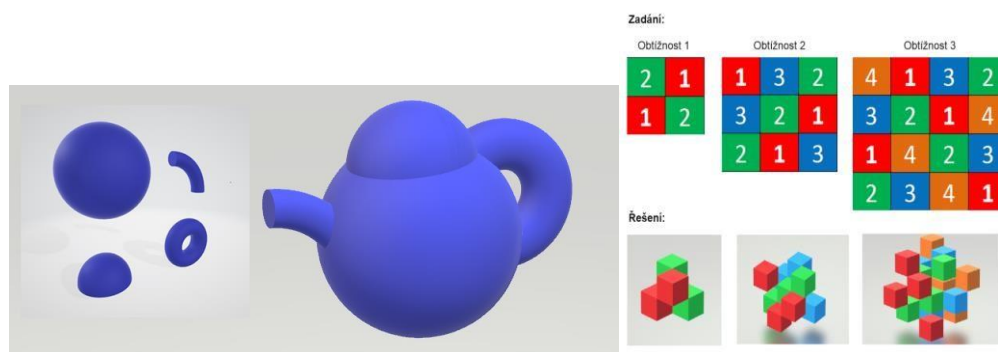


Figure 2: Designed 3D tasks (3D puzzle and 3D sudoku)

DISCUSSION

The analyses and results published in this article will continue to be refined in the future as the market is not fully explored by these technologies and applications, and there may be other ways to direct research. Research will also focus more on quantitative data. It will also continue to create tasks for working with 3D graphics and their fulfilment using mobile technologies with the application of microlearning, on the basis of which a study material could be created.

CONCLUSION

At the beginning of the article questions were asked, based on the analyses and research we are able to answer:

Analysis proved that the current situation in the field of hardware and software equipment has wide possibilities for the development of cognitive processes. iPads in combination with 3D graphics or augmented reality applications such as: Shapr3d, Display.land, OnShape are the most suitable.

It has been found that the most convenient methods for developing cognitive processes M-learning, Microlearning and 3D computer graphics.



Figure 3: Students and their work with 3D tasks

Tasks (3D puzzles, 3D sudoku, etc.) have been suggested that can positively influence cognitive processes:

- Creativity Development: Art and drawing can increase student creativity, working with 3D tools and objects can have a similar effect. Modeling with these tools can be compared to ceramic art or LEGO kit.
- Development of spatial imagination and orientation: Thanks to 3D technologies, the user can explore complex objects very easily from all sides. Students can solve complex geometric puzzles and improve their spatial imagination and orientation.
- Developing interest in IT technology: 3D graphics is one of many parts of computer technology that is also connected to many other industries. This allows students to develop their interest in IT technologies and can get into programming or multimedia.
- Developing Algorithmic Thinking: The principles and algorithms of use in 3D modeling or 3D model construction can develop students' algorithmic thinking.
- PC motivation: Creative use of 3D tools can increase PC motivation. The principles are similar to PC games
- Mobile motivation: Creative use of 3D tools can increase mobile motivation. The principles are similar to mobile games.

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Analysis of Tools Evaluating Pedagogical Digital Competences in Relation to the Current Paradigm of Education

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Abstract

This study deals with the issue of codification of teachers' digital competences into the teacher's professional standards, with deeper development of teachers' digital competences into specific frameworks and with ways of self-assessment and assessment of the level of digital competence of teachers. The authors draw on analytical studies, international and national documents as well as professional reports that highlight the need for system linking of standards, frameworks, curricula and courses and self-assessment and assessment tools that can provide effective use of the ever-expanding range of ICT resources in digital teaching and learning in all components of lifelong learning.

Keywords

Assessment of Digital Competences. Framework for Digital Competences. Pedagogical Digital Competence. Teachers Professional Qualification.

INTRODUCTION

There is a consistent approach to defining digital competence as a key competence across Europe. The development of digital competence is included in the vast majority of countries at all three education levels. However, unlike other traditional school subjects, it is not only addressed as a topic in its own right, but also as a transversal key competence (European Commission, 2019).

It is a generally accepted fact that in times of ICT boom, didactic tools based on digital technologies are coming into the focus of teachers. These educational materials and digital technology in general call for the need for new skills and competences. Thus, new requirements for teachers are emerging. Teachers have to be ready to work and manipulate with modern digital technologies as well as to be able to design and create suitable educational materials. Brox (2017) notes, „in the last decade, much effort has been put into

defining the specific demands on new teachers' digital skills and to how they should be strengthened in their training" (p. 130). After initial teacher education, the professionalisation process continues throughout a whole teacher's career. In today's society career-long professional development is a reality for all or almost all professions.

In order to support the development of teacher-specific digital competences through continuing professional development activities, it is necessary to know the level of existing skills or competences. Assessment is a key element.

AN ANALYSIS OF EDUCATION PARADIGMS

Pedagogical Digital Competences (PDC) are a significant subject matter as they are a prerequisite for efficient digital technology applications in the teaching and the learning process. In many countries of the world, the PDC are integrated into the educational framework of the educator.

If we want to talk further about pedagogical digital competences, it is first necessary to describe the paradigms of education in relation to the implementation of ICT into education. It helps us to explain the position and role of ICT utilization in different learning styles and thus understand appropriate ways of using modern ICT tools in education.

The traditional education paradigm is based on the theory of systems and planning lessons and it reflects the ideas of behaviorism and neobehaviorism (Zounek, 2009). As far as technologies are concerned, the traditional education paradigm highlights the concept of programmed learning. Teacher acts as the central person of education, the pupil has a passive role as a recipient of information. Role of an ICT tool is to carry learning content, to provide practice, to revise and to give feedback.

In contrast, **the contemporary education paradigm**, whose ideas are based on constructivism (social and cognitive), comprehend the importance of internal assumptions for pupil's learning, as well as the importance of the pupil's interactions with the environment (Zounek, 2009). The teacher acts as facilitator and guide, the pupil is active and cooperative creator of knowledge. The aim is not to provide complete knowledge, but its construction. ICT tools role is informative, constructive and communicative (see Table 1).

Table 1: Comparison of education paradigms (adapted from J. Zounek, 2009)

Elements	Traditional education paradigm	Contemporary education paradigm
Role of the teacher	The teacher is the central person who manages educational process	Facilitator, guide, helper
Teaching	Based on knowledge transfer, lessons are instructive, checking pupils' work and feedback	Approach to teaching is interactive and based on dialogue. Adapting teaching to existing concepts and skills of pupils.
The role of a pupil	Passive role. The pupil is controlled. Activity is necessary only at some stages.	Active and cooperative "creator" of knowledge, who takes responsibility for own learning.

Curriculum	Based on strictly defined standards and syllabi.	Based on projects and problem-based learning.
Learning	Learning is mainly receptive and reproductive, it does not take place in a context. The subject matter is divided into small steps. Feedback provides necessary firming.	Based on productive style of learning. The importance of dialogue.
Learning aims	Acquisition and remembering specific knowledge and skills.	Restoring, understanding and utilization of knowledge, cognitive flexibility, critical thinking, experience sharing, the ability of reflection.
Teaching styles	Mainly frontal teaching, but also individual instruction (when working with the program). Low variability in educational activities.	Group work, project teaching, presentation, experimentation, synthesis of information. Greater variability in educational activities.
Teaching methods	Based on interpretations and explanations, studying of textbooks, audio-visual teaching.	Based on discussing problems, active participation in solving problems.
Evaluation and assessment	Summative evaluation, testing, marking.	Performance tests, portfolios, generally formative evaluation, self-assessment, and peer assessment.
Sources	The main source is the teacher and defined range of educational materials.	Anything can be a source - classmates, teacher, school or external experts. Textbooks, audio or video recordings, internet...

It is obvious that in both education paradigms, ICT tools take an important but differentiate role as well as teachers. Therefore, the contemporary education paradigm requires different demands from teachers.

Role of the teacher in contemporary education paradigm

Teacher responsibility is to set up environment and opportunities for deep educational experiences that can expose and boost pupils' capacities. Teachers become activators of meaningful education, not just facilitators. Teachers are also mentors who create relationships of trust; orchestrators of individual and group learning; alchemists who submit strategies, techniques and resources to ignite pupils' creativity; welders who connect pieces of knowledge and activities into a meaningful whole; team players, understanding and evolving their own and others potential to the full— teachers need to cope all these roles (Caena, 2017).

Selected trends in the area of ICT tools implementation into education in relation to contemporary education paradigm

Considering a massive explosion of ICT, gradual process of inclusion of ICT tools into the educational theory and practice is a logical conclusion. Klement et al. (2017) generalized the problematics in a form of contemporary trends which are possible to be observed in the area of development of ICT tools implementation into education. These trends are specific in a purposeful application of some elements of constructivist theories, not only in the cognitive area, but also in psychomotor and affective areas.

- *Trend of employment of a broader spectrum of learning styles while using ICT tools;*
- *Trend of a more effective achievement of educational aims via ICT tools;*
- *Trend of employment of virtual reality as a learning environment mediated by ICT tools;*
- *Trend of a further development of the understanding of multimediality and interactivity from the perspective of ICT tools.*

ASSESSING THE LEVEL OF TEACHER PDC DEVELOPMENT USING SELF-ASSESSMENT TOOLS

The starting point for addressing the question of evaluation or self-evaluation is the approach to assessing the competences of teachers as a whole. Measures for assessing the development of teacher competences are very important because: they can raise teachers' awareness of the need to develop their competences; they can facilitate early intervention to improve teaching (Supporting teacher competence development for better learning outcomes, 2013). Designated assessment tools and techniques are designed to support teacher development (formative assessment), monitor their progress (summary assessment), or determine their level of competence development (qualification assessment).

The tools for (self) evaluation of teacher digital competences have recently become a center of interest for teaching professionals as well as for all other stakeholders. Their main benefit should be to provide feedback and documentation to update relevant training needs.

The DigCompEdu Framework

This document is a recommendation of the European Commission to Member States on how to define the required digital competences of teachers. It builds on the previous frameworks - The Digital Competence Framework for Citizens and The Digital Competence Framework for Consumers and the definition of digitally functioning educational organizations (Framework for Digitally Competent Educational Organizations). DigCompEdu aims at educators at all levels of education, from early childhood to higher and adult education, including general and vocational education and training, special needs education, and non-formal learning contexts (DigCompEdu, 2017).

DigCompEdu considers six different competences areas with a total of 22 competences (see Figure 1). Also, the authors of this framework have used proficiency levels to describe their digital competences in individual areas considered as motivational. They also used the

Common European Framework of Reference for Languages (CEFR) as the previous framework and named and characterized each level. Newcomers (A1) have reported very little contact with digital tools and need guidance to expand their repertoire of pedagogical digital competences. Explorers (A2) have been using digital tools without, consistent approach, they need insight and inspiration to expand their pedagogical digital competences. Enthusiasts (B1) are used to experiment with digital tools and they are trying to understand which digital strategies work best in which contexts. Professionals (B2) use range of digital tools confidently, creatively and critically to enhance their professional activities. Experts (C1) rely on a broad repertoire of digital strategies. Pioneers (C2) innovate and are a role model for younger teachers (DigCompEdu, 2017).

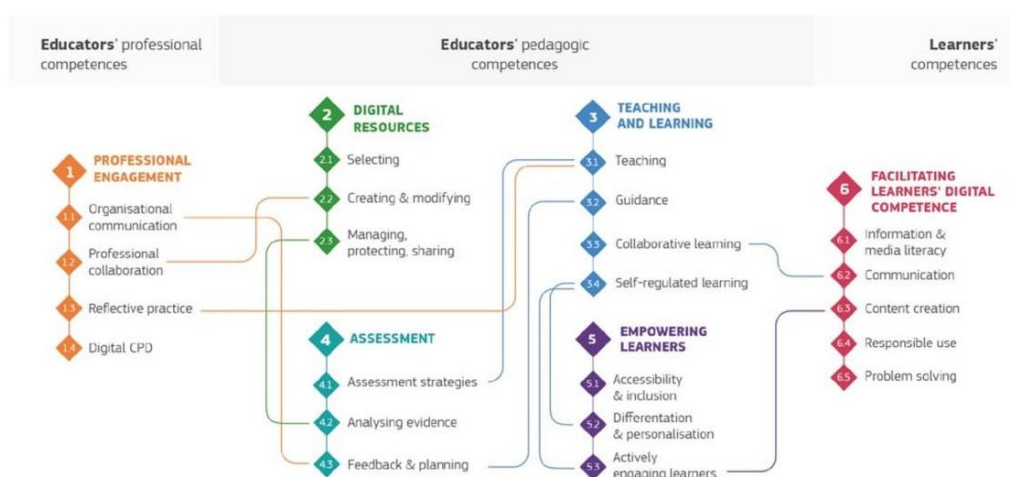


Figure 1: The content of the DigCompEdu Framework (DigCompEdu, 2017, p. 8)

However, DigCompEdu is a scientifically sound background framework which helps to guide policy and can be directly adapted to implement regional and national tools and training programmes, but these are not the main avenues in which the framework aims to foster innovation and change in education. More and more evidence recently points out that digital education policies are only successful if and where it has been possible to obtain the teachers' buy-in, participation, engagement and, eventually, ownership of the process (Conrads et al., 2017).

The DigCompEdu self-assessment tool

- The DigCompEdu Framework has been used as the basis for developing a self-reflection tool for educators, provisionally called **"DigCompEdu CheckIn"**. This is online self-assessment tool, which is freely accessible in a number of languages (<https://ec.europa.eu/jrc/en/digcompedu/self-assessment>). Answering the 22 questions of this self-assessment tool teachers receive detailed feedback with useful tips and the key milestones on their personal roadmap to innovating teaching. Tool consists of 22 items, one per competence (corresponding to DigCompEdu). Each consists of a statement describing the core of the competence in concrete, practical terms, and five possible answers which are cumulatively structured and mapped onto the proficiency levels. Teachers are asked to select the answer that best reflects their practice (Caena et al., 2019). The analysis of a preliminary set of data collected by the German version of the tool (Ghomi et al., 2019), showed high levels of validity and reliability.

MENTEP project

An important evaluation tool is the TET-SAT (Technology Enhanced Teaching Self-Assessment Tool) developed by MENTEP (MENToring Technology-Enhanced Teaching). MENTEP was a cross-country policy experimentation designed to test the impact of using a self-assessment tool on teachers' digital pedagogical competences development. The project was therefore designed to support and broaden teachers' reflection on their pedagogical practices using ICT in their teaching, their teaching skills and their own learning by using to an online self-assessment tool. The experimentation was running between March 2015 and May 2018. Project is considered as one of the largest randomised controlled trial (RCT) to date, by numbers of participating countries, on teacher training (7.391 teachers from 496 schools in 11 countries took part in the experimentation - Cyprus, Czech Republic, Estonia, Finland, France, Greece, Italy, Lithuania, Portugal, Slovenia and Spain) (Abbiatti et al., 2018).

MENTEP self-assessment tool: TET-SAT

- **TET-SAT** focuses on four areas: digital pedagogy, digital resource use and creation, digital communication and collaboration, and digital citizenship. The tool consist of 30 questions, the teacher always chooses one of the five prepared statements that best fits his teaching practice (see Figure 2). This tool exists as an online application and is freely available to anyone in 18 languages: Czech, Croatian, German, English, Greek, Estonian, Finnish, Hungarian, Italian, French, Lithuanian, Norwegian, Polish, Portuguese, Swedish, Spanish, Slovenian, Turkish. TET-SAT aims to trigger teachers' self-reflection, identify learning needs and initiate actions developing competences. This tool is fully and free of charge, and its further development and updating should be ensured. Research has shown that the use of the self-assessment tool (TET-SAT) leads teachers to critically assess their own competences. Teachers (especially older teachers and women) who have tried the self-assessment tool tend to reduce their subjectively perceived ability to integrate digital technologies into teaching. Experts working on this self-assessment tool assume that teachers who have 'seen' through the self-assessment tool and are aware of some gaps in digital technology will make use of the recommended resource system (national and European ecosystem) offered to further their professional development and subsequently apply the acquired knowledge to their teaching (Abbiatti et al., 2018).

The screenshot displays the TET-SAT interface. At the top, there are four tabs: 'Digital pedagogy' (selected), 'Digital content use and production', 'Digital Communication and Collaboration', and 'Digital citizenship'. Below the tabs is a navigation bar with buttons for 'Question 13', 'Question 14', 'Question 15', 'Question 16', and 'Question 17'. The main area shows the question 'Finding and evaluating digital information' with five response options in boxes. The third option, 'I select and use information I find online, critically evaluating the value of the information.', is highlighted in green. At the bottom, there are buttons for 'Previous question' and 'Next question', along with a status bar showing 'Last save 25/November/2017@13:30' and 'You have completed 19/30 Questions'.

Figure 2: An example of how the Digital Pedagogy competence is measured (Abbiatti, 2018, p. 8)

ASSESSING THE LEVEL OF TEACHER PDC DEVELOPMENT USING ASSESSMENT TOOLS

An analysis of available domestic and foreign sources shows that in most cases the tools for teacher self-assessment are used to assess the level of development of teachers' PDC skills. Their importance should not be overestimated, however, the results of research surveys focused on the evaluation of teachers' PDCs (MENTEP project, ECDL Foundation, etc.) show that teachers tend to overestimate their digital skills. Self-assessment tools should therefore only work at the level of supportive tools that can help teachers to discover new horizons of the digital world, and hence limits to their own digital skills they had never known before. Self-assessment tools are built on the basis of subjective assessment of teachers' own skills, they basically rule out an objective comparison of the level of pedagogical digital competences among teachers. The results obtained from the use of self-assessment tools are therefore only indicative.

Despite this fact, it is still difficult to find assessment tools that will not assess the notional competences that the teacher thinks they achieve, but will focus on the teachers' real and verifiable competences.

Digital Competence Assessment Tool in Finland

In 2014 - 2016, the Digital Competence Assessment Tool was verified in Finland (Karraakainen, 2018). High school students (n = 3159) and their teachers (n = 626) participated in the study. The evaluation tool was a digital skills test consisting of 42 tasks. Respondents chose from 4 possible answers, where just one was correct. The tasks were focused on 17 areas (see Figure 3). Three factors of ICT skills were created using factor analysis: basic digital skills, advanced skills and professional skills.

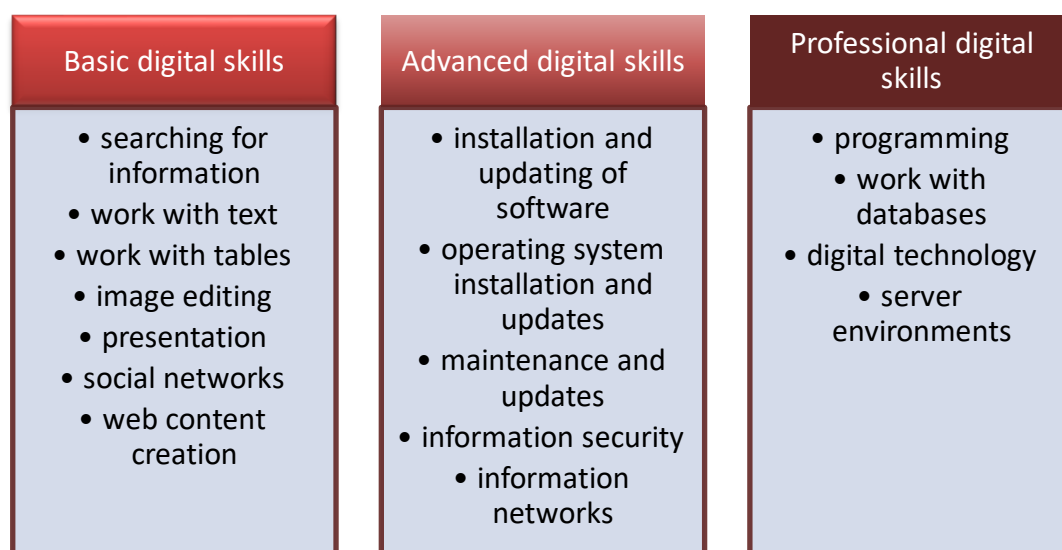


Figure 3: Factors of digital skills based on factor analysis (own resource)

The results showed:

- there were no statistically significant differences in gender outcomes in students' basic digital skills;

- in the field of advanced and professional skills of students, male students showed better results than female students;
- male teachers showed a better level of skills than female teachers;
- students of vocational secondary schools had better results than students of secondary schools or grammar schools.

Performance in the ICT skills test was also disaggregated by gender, as male and male teachers outperformed female students and female teachers. Above-average performance also occurred at the level of education, as students and teachers at upper secondary level were considered to have higher knowledge in the field of ICT than students and teachers at a comprehensive level. Karraakainen (2018) argued that in order to compare ICT skills with the validity of the assessment, they needed to ensure consistent assessment for both students and teachers. In addition, in order to reduce the gap in ICT skills between students, interventions using formal education are urgently needed and, in particular, more attention should be paid to both teacher training and in-service training.

Digital Competence Assessment Tool in Chile and Uruguay

In 2018, the Digital Competence Assessment Tool was verified in Chile and Uruguay (Silva et al., 2019). The instrument was designed for evaluation of pedagogical digital competences for teacher training institutions in Chile and Uruguay. A representative sample of 568 students (N=273 from Chile and N=295 from Uruguay) was examined. The instrument was administered to the sample of students in the last year of pedagogy in Chile and Uruguay. The final instrument was composed of 40 questions, distributed in four dimensions (see Figure 4): D1. Curriculum, Didactics and Methodology: 16 questions; D2. Planning, Organizing and Managing Digital Technology Spaces and Resources: eight questions; D3. Ethical, legal and security aspects: eight questions and D4. Personal and Professional Development: eight questions. Each correct answer was assigned one point and the instrument awarded 40 points maximum.

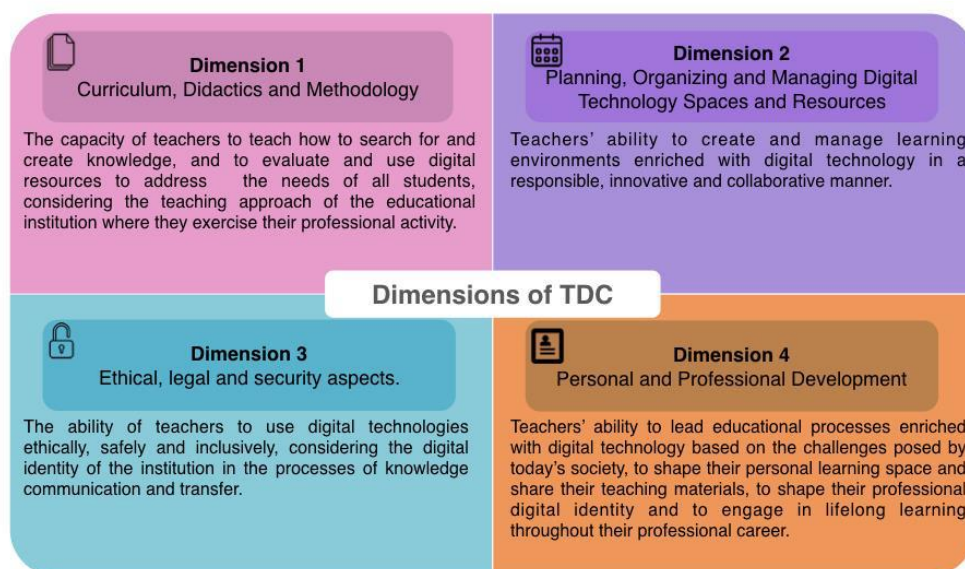


Figure 4: Dimensions of Pedagogical digital competence (Silva et al., 2019)

The results showed:

- no significant differences were observed with regard to gender in the four studied dimensions;
- the proportion of students of Secondary Education with advanced development of TDC is significantly higher than that of students at the Primary Level.

These tools could become an inspirational impetus in creating our own evaluation tool. The aim is to design and validate an external evaluation tool that reflects the level of pedagogical digital competence of primary school teachers (see Figure 5).

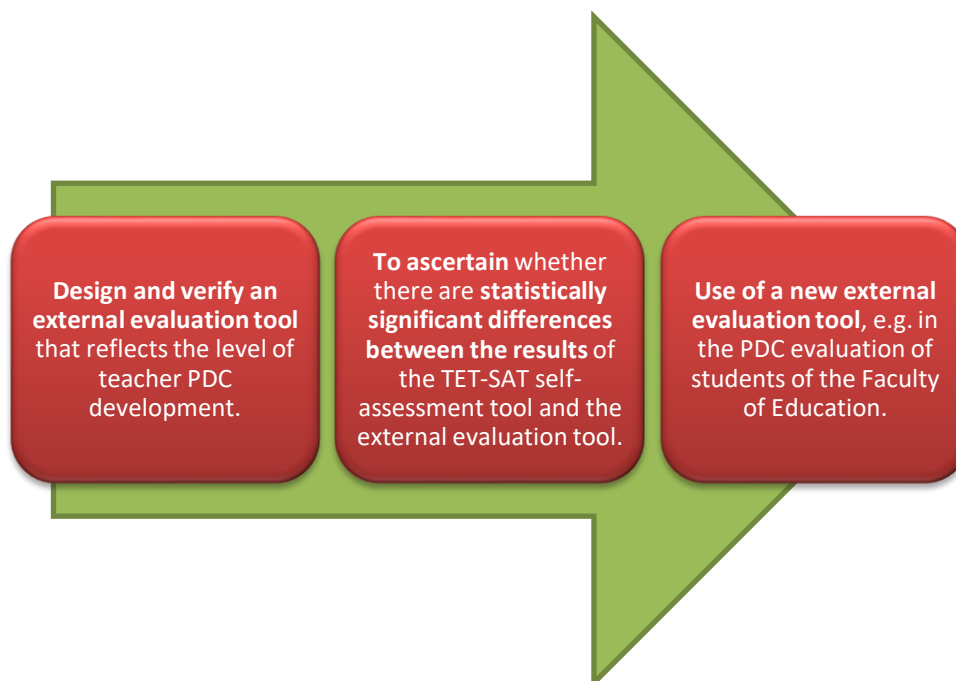


Figure 5: Creating an evaluation tool (own resource)

CONCLUSION

Pedagogical digital competences relate to skills, knowledge, approaches and attitudes in relation to digital technology, learning theory, subject, context, and the relationships between these. PDC is thus something that can be expected to develop the more experienced teachers become.

To achieve PDC, it is not enough just to understand educational concepts, to be acquainted with the current development of science and research in the field and to know what digital technologies are available. There is also a need for practical skills, such as the ability to use technology adequately, and to provide pupils and students with exactly the support they need to progress. The person who owns the PDC must be able to support students on their way to achieving the expected learning outcomes, to understand how this process works and how it relates to regulatory principles.

In the professional circles, in the area of assessment of pedagogical digital competences, individual levels of PDC development are gradually identified. Evaluation

tools move from self-evaluation tools to tools that identify real pedagogical digital skills for teachers based on multiple-choice test tools. In the near term, evaluation tools should be devised to validate pedagogical digital competences by independently solving specific tasks based on the teacher's real experience, knowledge and skills without using instructional answers.

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Section:
Intelligent Computing

Time Spent on Web Page as an Indicator of Interest

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Abstract

The paper aims to present an analysis of time spent on the web pages of a web portal by the web users. The time spent on the web page can indicate that the web page contains important information or has too much content. This article works with the preprocessed data from a log file of a web portal of a banking institution. The web portal pages were joined into logical web parts that were joined into more specific categories. The results of the experiment have shown that there are statistically significant differences in the average time spent on the web categories, web part. The information of a long time spent on the pages can indicate that there is important content for web users or that there is too much content on the pages. These results can be important information for web administrators to revisit the web pages and also for banking institutions for their web design in relation to disclosures.

Keywords

Web Usage Mining. Data Preprocessing. Intelligent Computing. Knowledge Discovery. Data Analysis.

INTRODUCTION

Web portals are full of information. The web administrators are regularly revisiting the portal to improve the experience of the web user. The data of the web user's accesses are stored in log files. These files store anonymous information about user actions that occurred on a web portal. The log files contain in the case of web portals too much information that is not necessary for the analysis. Data preprocessing methods are used to prepare the log file. Various methods can be used but many are portal specific. This article will be focused on the analysis of time spent on the web pages of a web portal. However, the more robust a web portal is, the more ragged the results for each page would be. Based on that were the web pages categorized based on the content of the pages. Importantly, web portals of banking institutions are specific in their design due to disclosures, which means requirements to disclose reports based on specification in regulation. These reports, Pillar 3 reports, are the subject of the analysis, what can be helpful in the process of designing web page in relation to disclosures for banking institutions and in process of designing new regulation for authorities.

The rest of the paper is structured as follows. The next section describes the related work in the field of Web Usage Mining. The third section summarizes the used methodology to obtain the results. The fourth section is focused on the results of the experiment. Subsequently, the last section provides the conclusion and future work.

RELATED WORK

Srivastava et al. (Srivastava et al., 2015), introduced an algorithm used to clean a log file of the unnecessary data. The authors use time interval and can order the records based on the timestamp. Despite that has the algorithm an issue with big data where a significant slowness of the data cleaning. The authors have not dealt with the cleaning of robots of search engines. Authors in the paper (Carmona et al., 2012) focus on a study of the design of an e-commerce website using web usage mining techniques. Their used dataset was extracted from Google Analytics and then processed using data mining techniques such as clustering, association rule learning and subgroup discovery. Based on the results authors recommend important problem areas of interest for the webmaster team. Authors in the paper (Abdullah et al., 2014) propose a sequential preprocessing model and sequential preprocessing tool in an attempt to generate the sequential dataset. In their study, they work with a log file extracted from an e-Learning System, which offers a very specific environment. They worked with a MySQL database and extracted a sequential dataset which can be used by other data mining tools. The modifications needed for sequential pattern analysis by other data mining tools are minimal. Pattern or association rules mining is one of the most important topics in data mining. On the other hand, sequential pattern mining is a bit different because it involves discrete or continuous order of events. Jozani and Ahmadi (Jozani and Ahmadi, 2014) explored in their article the ranked set sampling that has many applications in various fields. They have considered the information content of perfect and imperfect ranked set sampling data using the Shannon entropy, Rényi and Kullback-Leibler information measures. The results of their experiments showed desirable properties of ranked set sampling in comparison to the commonly used simple random sampling in the context of the information theory.

Data preprocessing techniques can be applied also across various research fields (Škropil and Šťastný, 2009; Stencil and Stastny, 2010). Liu et al. (Liu et al., 2020) proposed to use data mining to discover grouting knowledge from data. Safhi et al. (Safhi et al., 2019) introduced a framework that automatically assesses the reliability of the knowledge discovery process. The authors focused on extracting knowledge from Big Data and applied the framework to unstructured data. The research was focused on the data cleaning phase. Authors (Balogh and Kuchárik, 2019; Francisti and Balogh, 2019; Magdin et al., 2019, 2016; Magdin and Prikler, 2019) focused on extracting and classifying knowledge from emotions. The data presented to the users had to be preprocessed and the authors used data mining methods. Kapusta and Obonya (Kapusta and Obonya, 2020) dealt with the analysis of fake news extracted from web portals. The data had to be preprocessed using text mining methods that are similar to web mining preprocessing methods. Authors (Halvoník and Kapusta, 2019; Skalka et al., 2019) dealt with the identification of problematic parts of educational materials on an e-learning course. The authors applied web mining techniques to the log file extracted from a web portal of the virtual learning environment. Reichel and Kuna (Reichel and Kuna, 2014) also had analysed the behaviour of students in the virtual learning environment. The authors had to preprocess a log file obtained from a specific system. The data cleaning phase was in this case not so time consuming.

METHODOLOGY

The dataset consists of preprocessed standard web server log files. It contains only useful information for the analysis of user interest with the web portal. The dataset contains data and variables that deal with the Pillar 3 regulations. The Pillar 3 are specific regulatory disclosures requirements implemented into EU law and subsequent laws of the member states. Those regulations order the bank to publish various information and stakeholders can better understand the risk. The research methodology was inspired by (M. Munk et al., 2010; Michal Munk et al., 2010; Munk et al., 2015). The web usage analysis was done based on a sample of 2 071 235 logged accesses that were obtained after data preparation.

The first step is data cleaning. All client requests on multimedia files, cascade styles sheet, javascript and other non-content file types had to be removed. All those requests form the web page design and are not valuable for the content analysis. The access to search engines robots was removed, too. Search engines robots are identified based on the *userAgent* or special access to robots.txt file on the webserver. After data cleaning phase the raw data file only with accesses to HTML or PDF files of the portal is available.

To analyse the user interest in the web portal parts *unixTime* variable is needed. The *unixTime* represents the standard Unix time in seconds starting on January 1, 1970. The *Length* variable represents the time spent by the web user on the specific web page.

The next step is variables determination for the user behaviour analysis. A bank expert was asked to categorize every webpage according to the terminology used in the bank environment. The result of this process is the 19 different parts of the web represented by the *webPart* field each attached to 6 different categories – the variable *category* (Pricing list, Reputation, Business Conditions, Pillar3 related, Pillar3 disclosure requirements, We support..). Pillar 3 related information are those which are contained in the bank annual reports, minutes from general assembly meetings, the prospect of eminent, information

about group and information for banks. The Pillar 3 Disclosure Requirements consists of information on the Bank (organizational chart, information about employees or bank activities), financial information (financial statement information, information on asset quality, information on liquidity); information on risk management (risk strategies, policies, credit risk management). For the need of this experiments, there will be analysed the Pillar 3 categories (Pillar3 related, Pillar3 disclosure requirements) and all other categories will be joined into one category- Other. Also in the case of web parts were chosen only those that are connected to the Pillar 3 (9 web parts).

RESULTS

The experiment was focused on the analysis of the time spent by the web user on each web part of the bank portal. The time spent on the web parts can show us the interest of the web users in the examined information. The decision was made to use the average time spent on the web parts to better intercept the demand for information from the web parts. First is the focus on all of the categories dealing with Pillar 3 related web parts.

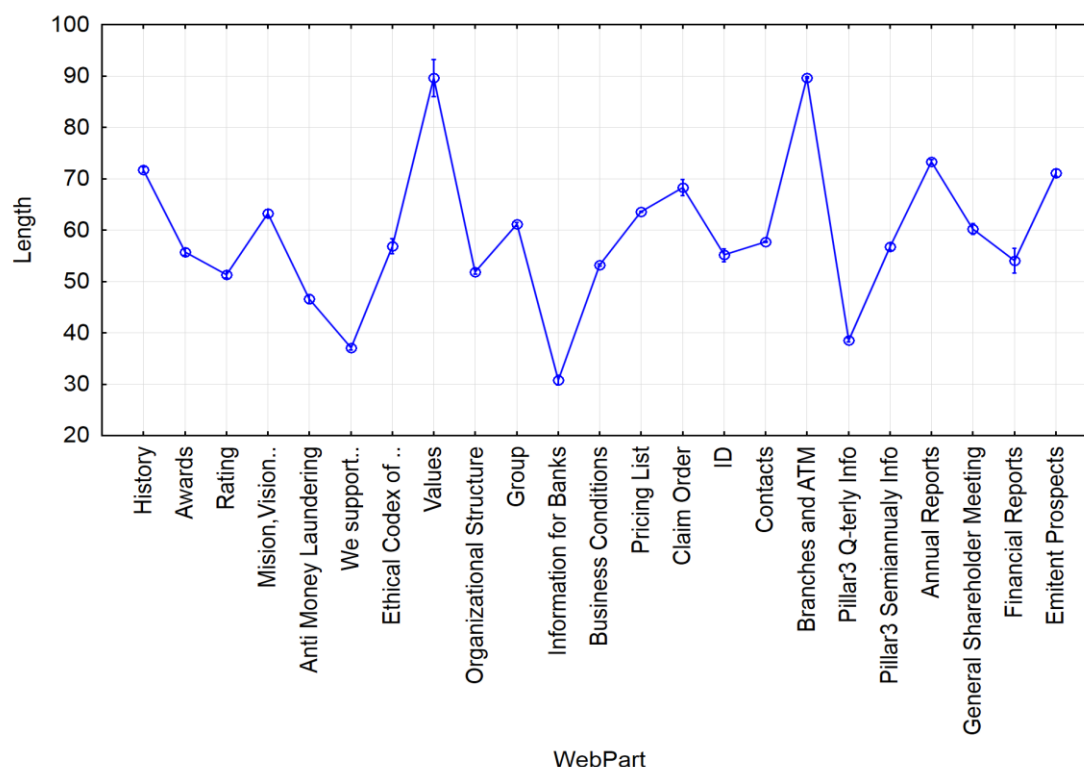


Figure 12 Visualisation of the average time spent on the web parts

The variable representing the time that the web user spent on the web part was analysed and examined (*Length*). Differences in the time spent on the web parts can be seen from the point and interval intervals of the average (Figure 1). The users spent most of their time on web parts *Values* and *Branches and ATM*. On the other hand, the least time was spent by the users on the web part *Information of Banks*. Based on these results, a null statistical hypothesis will be tested that claims that there is no statistically significant difference in the time spent on the web parts.

Table 2: Univariate results for the WebPart variable of all Pillar3 web parts

	Deg. of Freedom	Length SS	Length MS	Length F	Length p
Intercept	1	599028100.0	599028112.0	225675.2	0.0000
WebPart	22	653563700.0	29707439.0	11191.8	0.0000
Error	3502259	9296332000.0	2654.0		
Total	3502281	9949896000.0			

Table 1 describes the ANOVA univariate results ($F = 11191.8, p < 0.001$), the zero hypotheses is rejected at the 0.1% significance level, i.e. a statistically significant difference in the times spent on the examined web parts was identified.

WebPart	Length Mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Information for Banks	30,79	****													
We support..	37,07		****												
Pillar3 Q-terly Info	38,58			****											
Anti Money Laundering	46,58				****										
Rating	51,35					****									
Organizational Structure	51,89					****									
Business Conditions	53,25					****	****								
Financial Reports	54,05					****	****	****							
ID	55,15						****	****							
Awards	55,77							****							
Pillar3 Semiannually Info	56,79							****	****						
Ethical Codex of ..	56,86							****	****						
Contacts	57,69								****						
General Shareholder Meeting	60,25									****					
Group	61,15									****					
Mision,Vision..	63,28										****				
Pricing List	63,59										****				
Claim Order	68,28											****			
Emitent Prospects	71,14											****	****		
History	71,73												****		
Annual Reports	73,28													****	
Values	89,65														****
Branches and ATM	89,71														****

Figure 13 Unequal N HSD for the Pillar3 web parts

After rejecting the global zero hypotheses, the interest is in which pairs have a statistically significant difference.

Nine homogeneous groups have been identified (Figure 2) (Rating, Organizational Structure, Business Conditions, Financial Reports), (Business Conditions, Financial Reports, ID), (Financial Reports, ID, Awards, Pillar3 Semiannually Info, Ethical Codex of ..), (Pillar3 Semiannually Info, Ethical Codex of .., Contacts), (General Shareholder Meeting, Group), (Mision, Vision.., Pricing List), (Claim Order, Emitent Prospects), (Emitent Prospects, History) and (Values, Branches and ATM).

A more detailed look at the Pillar3 web parts was identified only three homogenous groups (Rating, Financial Reports), (Financial Reports, Pillar3 Semiannually Info) and (General Shareholder Meeting, RZB Group), statistically significant differences were identified between the remaining pairs at the 5% significance level.

The users spent the least time on the *We support..* web part. This web part offers general information of the bank category, as well as does the *Information for Banks* web part related to Pillar3, and the Pillar3 Q-terly Info, which belongs to the mandatory disclosure category (< 40).

On the other hand, the web users spent most of their time on the *Mision, Vision...*, *Pricing List, Claim Order, History, Values, Branches and ATM* web parts, offering general information on the bank and the *General Shareholder Meeting, Group, Issuer Prospects, Annual Reports* associated with Pillar3 (> 60).

Based on the results of the previous research (Munk et al., 2017) it was decided to analyse the Pillar3 Q-terly Info web part. The web part was divided into another seven categories (Figure 3).

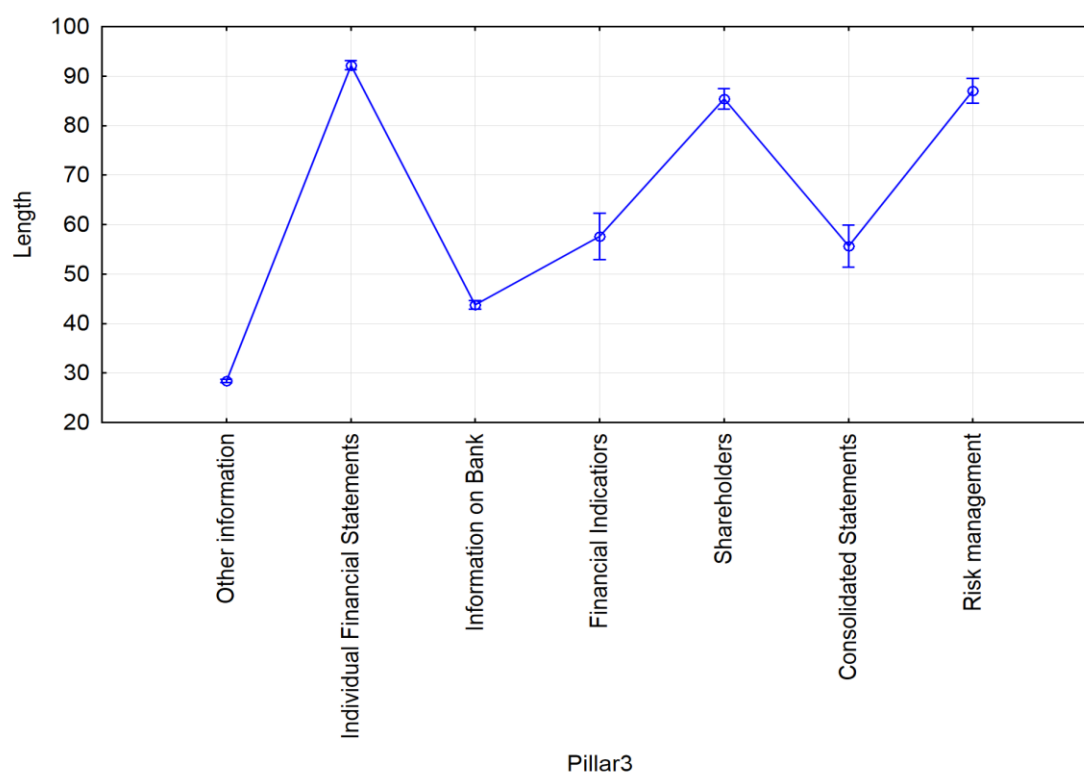


Figure 14: Visualisation of the average time spent on the Pillar3 Q-terly categories

The plot (Figure 3) shows there are differences between the visit times of the examined Pillar3 Q-terly categories. The web users on the web parts Individual Financial Statements, Shareholders and Risk Management spent most of the time on these parts. Least time was spent on the web parts Other information and Information on Bank. Based on these results, a null statistical hypothesis will be tested that claims that there is no statistically significant difference in the time spent on the examined Pillar3 Q-terly categories. Based on the ANOVA univariate results ($F = 3458.1, p < 0.001$), the zero hypotheses rejected at the 0.1% significance level, i.e. a statistically significant difference in the time spent on the examined Pillar3 Q-terly website categories was identified.

Table 3: Unequal N HSD for the Pillar3 Q-terly categories

Pillar3	Length Mean	1	2	3	4	5
Other information	28.38				****	
Information on Bank	43.76					****
Consolidated Statements	55.67	****				
Financial Indicators	57.63	****				
Shareholders	85.44		****			
Risk management	87.05		****	****		
Individual Financial Statements	92.22			****		

After rejecting the global zero hypotheses, the interest is in which pairs have a statistically significant difference. Three homogeneous groups (Table 2) have been identified (Consolidated Statements, Financial Indicators), (Shareholders, Risk Management) and (Risk Management, Individual Financial Statements), statistically significant differences were identified between the remaining pairs at the 5% significance level.

CONCLUSION AND FUTURE WORK

In this paper was analysed the time spent on a web portal of a banking institution. Nowadays, banking institutions face broad regulatory requirements for design of their web pages in relation to disclosures, which should be disclosed on their web pages. Therefore, these results can be important for banking institutions in their web design and also for regulators in the process of designing new regulation. The results of the experiment have shown that there are statistically significant differences in the average time spent on the web parts dealing with Pillar3 and categories of web part Pillar3 Q-terly. The most average time was spent on web parts dealt with Pillar3 *Values* and *Branches and ATM*. On the other hand, the least time was spent by the users on the web part *Information of Banks*. When the Pillar3 Q-terly web part is analysed in more detail, it can be seen that there are web pages that are more interesting for web users. The categories *Individual Financial Statements*, *Shareholders* and *Risk Management* have been identified as the web pages with the most time spent by the web users. The information of a long time spent on the pages can indicate that there is important content for web users. However, there can be another look at the results. The long time spent on the web pages can indicate that there is too much content on the pages. This can be important information for web administrators to revisit the web pages and also for banking institutions for their web design in relation to improvement of their regulatory required disclosures.

The future work will be focused on further analysis of the interest in the web pages. The time would be combined with other variables to discover a more detailed interest of the web users. The analysis could take into account the time of day, day of the week, the season of the year, etc. There could be discovered more dependencies between the web user interest in the web portal and the time he/she spent on the web portal. Another option is to include text mining techniques to analyse the content of the specific web pages and look for dependencies with the time the users spent on these web pages.

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Neural Machine Translation as a Novel Approach to Machine Translation

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Abstract

The aim of the paper is to present the most used machine translation- Statistical Machine Translation system and introduce a novel system- Neural Machine Translation. Neural Machine Translation structure is built on an encoder-decoder framework. The encoder transforms a source language sentence into continuous space representation through a recurrent neural network. Origin of neural networks was inspired by the understanding of the functioning of the human brain, or all connections between neurons. However, in contrast with the human brain, where neurons can freely interconnect, artificial neural networks consist of discrete layers, connections, and data dissemination. This paper deals with neural machine translation as a novel approach that is examined by many researchers that try to implement it into already used frameworks. The results show that neural machine translation offers an improvement of the translation output but still has to be evaluated in the future.

Keywords

Natural Language Processing. Machine Translation System. Neural Machine Translation. Statistic Machine Translation.

INTRODUCTION

In the beginning, machine translation was based mainly on Rule-based Machine Translation (RBMT), the idea being to create grammatical rules for the source and target language. Machine translation acted as a kind of translation between languages based on this set of rules. However, the problem was mainly the addition of new content, new language pairs, because maintaining and extending such a set of rules was too time-consuming and costly. Statistical Machine Translation (SMT) was created to overcome this problem (Koehn, 2010). SMT systems create statistical models by analyzing an aligned set of source and target language sentences (training set). It is then used to create a translation. The advantage of SMT is its automatic learning process and relatively easy adaptation. The disadvantage of SMT is the training itself, so it is necessary to create a usable tool and a large database of source and target language segments. The disadvantage is also difficult to work with grammatically more complicated languages. Neural Machine Translation (NMT) has recently started to be promoted for this reason. NMT looks at the sentence as a whole and can form associations between phrases even at greater distances in the sentence. The result should be improved by grammatical accuracy compared to SMT.

SMT and NMT operate on a statistical basis and use pairs of source and target language segments as a basis. In principle, SMT is Phrase-Based Statistical Machine Translation (PBSMT), which means that SMT divides source segments into phrases (Koehn, 2010). SMT creates a translation and language model during training. The translation model stores various phrase translations, and the language model stores the likelihood of a sequence of phrases on the target page. During the translation, the decoder selects a translation that works best based on these two models. In principle, SMT can produce very good results at the level of phrases, but the fluency and grammar of the translation are lagging behind several times. The paper describes the novel approach of neural machine translation and its usage by other researchers.

The rest of the paper is structured as follows. The next section describes the research background and introduces the main topics of Statistical Machine Translation and Neural Machine Translation. The third section summarizes the usage of the novel approach to Machine Translation. The last section provides the conclusion.

RESEARCH BACKGROUND

Statistical machine learning (SMT) is an approach to Machine Translation that is characterized by the usage of machine learning methods. SMT treats translation as a machine learning problem (Lopez, 2008). The basis of SMT is to create a system that can automatically discover translation rules of the large bilingual corpus, merge starting sentences of text (input data) with target sentences (output data) and “be taught” by the results of the statistical analysis of relevant data (Koehn, 2010). Statistical machine translation deals with the translation of text from one natural language to another. Its approach to machine translation is characterized by the usage of machine learning methods. This means that the learning algorithm is applied to a large group of the previously translated text, referred to as parallel corpus, parallel text, bitext or multi-text. This approach uses the power of computers to create sophisticated data models capable of translating text from one language to another. Basically, statistical machine translation systems use computer algorithms to create a translation that selects the best and most likely statistically output of the millions of possible permutations.

The advantage of statistical machine translation systems is the removal of manual translator work for each language pair. On the other hand, the disadvantage is the restriction to a single region of texts (domain), i.e. if the system is trained on one type of corpus (e.g. administrative), then it should be used to translate administrative texts, not e.g. technical texts. The quality of the translation would be unpublished in this case, and therefore it is important to train the system with the corpus, which is thematically similar to the starting text (Munková and Munk, 2016). As statistical machine translation has evolved over the years, its systems have evolved and improved too. In the very beginning, separate word translation was used, but progress in machine translation and in science itself was mainly in rapid development. New systems, larger collections of parallel corpora, and more powerful computers have continually improved the quality of statistical machine translation.

The first systems for statistical machine translation were based on the translation of individual words. Although this system is no longer widely used, many of its principles and methods are still up to date.

The smallest units in this system are words that can be translated, inserted, omitted, or their order in the sentence changed. These systems are based solely on lexical translation - the translation of isolated words. It requires dictionaries that map the translation of words from one language to another (Koehn, 2010). Looking at a common vocabulary, we find that a word can have more meanings in a foreign language. Some of them are used more, some less. As an example, a translation of the German word *Haus* into English can be used. In this case, the English word *house* will in most cases be considered the correct translation. Options such as *building* or *home* are also common, while others are used only in certain specific circumstances, e.g. the word *shell* that can refer to the slug home.

The correct translation or the most probable possibility of translation is then selected using parallel corpora. Let's say that in the hypothetical text the word *Haus* would appear 10 000 times. Of which 8 000 would be translated as *house*, 1 600 times as *building*, 200 times as *home*, etc. Based on these calculations, it can be estimated the likelihood of a lexical translation. Formally speaking, the aim is to find a function

$$p_f : e \rightarrow p_f(e),$$

which will help in translating another German text to determine what translation of *Haus* is most likely. This function returns the foreign word *f* (in this case the word *Haus*) and the probability for each of the possible translations *e*. This will tell how likely it is to have the correct translation.

A machine translation system based on the translation of individual words was already mentioned. Words like the smallest translation units, may not be the best choice. Sometimes one word in a foreign language is translated into two English words or vice versa. Word-based models often diverge and differ in these cases. In more advanced statistical machine translation, the basic unit of translation is expanded from words to phrases of potentially unlimited length and may not be defined as phrases from a syntactic point of view (Chiang, 2007).

At present, one of the best systems for statistical machine translation is considered on phrase-based models - systems that translate a small sequence of words at once. In phrase models, any sequence of contiguous words can be considered a phrase. Each input phrase is non-empty and is translated exactly to one non-empty output phrase. However, phrases are not required to have the same length, so this model can produce translations of varying length (Lopez, 2008).

Phrase translation systems work by dividing the input sentence into segments - phrases (polyword units). Each of these segments is translated into the target language and the phrases are finally sorted. However, the number of phrases at the input and language targets may not match.

One of the basic elements in any statistical machine translation is a language model that measures the likelihood of a given word sequence that will be actually used by English-speaking person. It goes without saying that it is required of the machine translation system not only to produce output words that are correct with respect to the original text but also to put them in the right string (Koehn, 2010). The language model, however, usually does

much more than just allows smooth output. It supports difficult decisions on word order and word translation. For example, the probabilistic language model p_{LM} should prefer the correct word order instead of the wrong word order:

$$p_{LM}(\textit{the house is small}) > p_{LM}(\textit{small the is house}).$$

Formally speaking, a language model is a function that takes an English sentence and returns the probability that the sentence was created by an English-speaking person. Based on the example above, it is more likely that an English-speaking person would rather say a sentence *the house is small* than *small the is house*. Therefore, a good language model of p_{LM} assigns a higher probability of the first sentence.

This advantage of the language model helps statistical machine translation systems to find the right word order. Another area where the language model helps translation is the choice of words. If a foreign word (for example, German *Haus*) has several translations (*house, home, ...*), the more common translation (in this case *house*) will be favoured based on the likelihood of a lexical translation. However, other translations may be appropriate in certain specific contexts. Here the language model that gives a higher likelihood of a more natural choice of words in the context, is applied again. For example:

$$p_{LM}(\textit{I am going home}) > p_{LM}(\textit{I am going house}).$$

One of the main methods in the language model is the N-gram language model. N-gram is a term commonly used with language models for speech recognition. It can give the probability of the next word, based on the previous sequence of words from the training corpus (Yamamoto et al., 2003). The principle of modelling language using n-grams is that the model divides the sentence into several fragments (words/phrases) that often occur in the corpus and carry language information and determine the probability of individual fragments. If the fragments of the sentence are in the correct order, then the sentence should have a high probability (Munková and Munk, 2016). Returning to the example, after analyzing a great deal of text, it was identified that *going* is followed by *home* more often than *house*.

Formally speaking, in language models, it is anticipated to calculate the probability of a string:

$$W = w_1, w_2 \dots w_n.$$

Simplistically, $p(W)$ is the probability of randomly selecting a sequence of English words (whether in a book or a magazine) and getting W . To calculate $p(W)$, it is needed to collect a large amount of text, where is calculated how often W is present. Most of the long word sequences, however, will not be found in the text at all. Therefore, it is required to analyze the calculation of $p(W)$ into smaller steps for which can be collected sufficient statistics and further divide the probability estimate.

Dealing with the limited amount of data that limits us in gathering enough statistics to reliably estimate the probability of distribution is a major problem in language models.

On the other hand, the Neural Machine Translation (NMT) structure is built on an encoder-decoder framework. The encoder transforms a source language sentence into continuous space representation through a recurrent neural network (RNN) from which the decoder generates a target language sentence using another RNN (Cheng, 2019). NMT uses deep learning, which in principle is represented by the neural network (Bessenyei, 2017;

Stencl and Stastny, 2010). Machine learning could simply be understood by algorithms that process data from which they can learn, and on that basis, they can make decisions or predict solutions to certain problems. Origin of neural networks was inspired by the understanding of the functioning of the human brain, or all connections between neurons. However, in contrast with the human brain, where neurons can freely interconnect, artificial neural networks consist of discrete layers, connections, and data dissemination. Neural networks use distributed, parallel information processing to perform calculations. Knowledge is stored primarily through the strength of links between individual neurons. The basic feature of neural networks is learning. The neuron receives signals from the environment from other neurons, processes them and sends them as input signals for the neurons in its surroundings. Multilayer neural networks consist of three layers (Fig. 1):

1. Input layer - the input is from the external world and the output is another neuron,
2. Hidden layer - input is from the external world or from other neurons, the output is another neuron,
3. Output layer - the input is similar to the hidden layer and the output is directed to the external world.

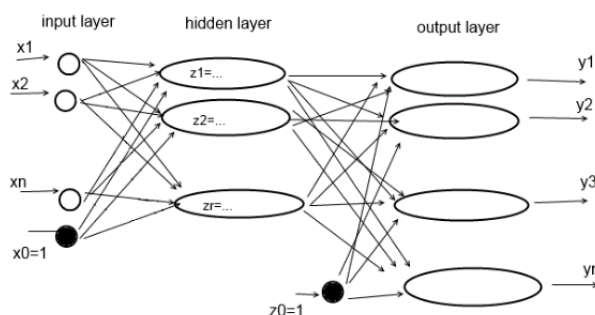


Figure1 Multilayer neural networks (Cheng, 2019)

Each neuron assigns some weight to its input. The weight represents the degree of fulfilment of the task being performed, the higher weight means the better solution. The final output of the neural network is thus affected by the total sum of the weights. The essence of machine translation is the different length of input $X = (x_1, x_2, \dots, x_T)$ and output $Y = (y_1, y_2, \dots, y_{T'})$. In other words, T and T' may not be the same. For this reason, it is necessary to use a special type of neural networks - recurrent neural network. The RNN retains its internal state as long as it reads the sequence of inputs, in this case, a sequence of words, and can process the input of different lengths. The goal of RNN is to compact the sequence of input symbols into a fixed vector by recursion. Recursion in simplicity means defining a function or method by itself. The overall architecture is based on the encoder-decoder principle (Kalchbrenner a Blunsom, 2013; Sutskever et al., 2014; Bahdanau et al., 2016; Cho et al., 2014).

The encoder is a straightforward RNN application based on sequential summaries, i.e. an activation function is recursively applied to an input sequence or sentence until the last input state of RNN is a summary of the entire input sentence. First, each word of the source sentence is represented as a so-called 1-of-K encoded vector. Words are equidistant from each other, which means that there is no relationship between words. A hierarchical approach is used to extract a sentence representation (a vector that summarizes an input sentence). In principle, the network will learn from data. The encoder then linearly projects

the 1-of-K encoded vector using an E matrix that has as many columns as there are words in the source dictionary and as many lines as the programmer chooses (typically 100-500). The projection results in a continuous vector for each source word. Each vector is later updated to improve compiler performance.

When a fixed sentence representation of a source sentence is created using the encoder and RNN, we use the decoder with RNN to create a translation. Starting from RNN, the internal state of RNN is calculated based on the source sentence summation vector, the preceding word, and the previous internal state. Using the internal hidden state it is possible to score each target word based on how likely it will follow all previously translated words based on the source sentence. This is possible by assigning probabilities to each word. The difference between score and probability is that the sum of the probabilities of all possible words equals 1, but the score does not need to be 1. Based on the score, the next step is to calculate the probability that serves to select a word by choosing from a multinomial distribution. After selecting the i -th word, it returns to the first step, calculating the hidden state of the decoder, evaluating and normalizing the target word, and selecting the next $(i + 1)$ word. The procedure is repeated until the end of the sentence (called <eos>) is reached. By using a neural network, translation performance can be maximized (Bahdanau et al., 2016).

Corpus is needed to train a neural network and the maximum log-likelihood estimation method is used (Cheng, 2019). Each corpus element is a pair of source and target sentences. Each sentence is a sequence of numerical indexes corresponding to words, which is equivalent to binary vectors (one element vector is set to 1). During the training process, the NMT system attempts to set the neural network weights parameter based on the reference values (translation from target to source language). Taking any pair from the corpus, the NMT system can calculate the conditional log-probability of the target sentence from the source sentence. The result is a neural network that can process source segments and transform them into target segments, with NMT passing through whole sentences, not just phrases. The advantage of this approach is precisely the appropriate context of the translation, which also improves the fluency of the translation. But the accuracy of the terminology can sometimes be insufficient.

MACHINE TRANSLATION APPLICATIONS

SMT is used for many years to produce the output for various language pairs. Authors in (Munková et al., 2014, 2013) focused on the preparation of text where it depends on the data sources used. The aim of this work was to determine to what extent it is necessary to carry out the time-consuming data pre-processing in the process of discovering sequential patterns in e-documents. Munkova et al. (Munková et al., 2020) focused on the evaluation of translation quality of sentences of the MT output and post-edited MT output. The authors' used metrics of automatic MT evaluation for a language pair Slovak-German. The MT translation was done using an SMT system. Munk and Munkova (Munk and Munkova, 2018; Munkova and Munk, 2015) introduced an exploratory data technique representing an instrument to evaluate and improve MT systems. The authors used residual analysis to identify the differences between an SMT system output and post-edited MT regarding human translation. Using residual analysis, the authors identified sentences that contained significant differences for the scores of automatic metrics between MT output and post-

edited MT output from Slovak into English. A system for post-editing the SMT system output was presented by (Munková et al., 2016). The aim of the study (Munkova et al., 2019) is to compare translation quality and effectiveness (translator productivity) using measures of the automatic evaluation of machine translation output. The examined translation(s) was a legal text, translated from Slovak (mother tongue) into German. We distinguish human translation (HT), machine translation (MT) and post-edited MT (PEMT). For the evaluation we used our own tool, wherein were implemented the metrics of automatic MT evaluation.

Many authors analyze neural machine translation as a novel approach and try to implement it into already used frameworks. Banik et al. (Banik et al., 2019) analyzed the a statistical approach to combine the outputs of various machine translation systems. The authors have selected only the best phrases among the multiple systems' outputs and merged them into the final translation. The used NMT systems were Google Translate (Wu et al., 2016) and Bing Microsoft Translate (Dolan et al., 2002) and the authors used a Hierarchical system. The experiment was done using 8 different language pairs and the results were evaluated based on a fuzzy-based MT evaluation metric LeBleu (Virpioja and Grönroos, 2015). The results of the experiment showed that the outputs obtained by Google and Bing are very similar most of the times. The output from the SMT system may have different word orders or synonyms. The system combination model produces translations matching with those of Google and Bing Microsoft Translate. Bentivogli et al. (Bentivogli et al., 2018) compared the NMT with the phrase-based MT system on an English-German and English-French dataset. The analysis was done thoughtfully. Not only did the authors evaluate the translation quality using TER and HTER metrics but also based on morphological analysis. The morphological analysis consisted of identifying lexical errors, morphology errors and word order errors. The lexical analysis has shown various results. The NMT results for proper nouns were worse than for the phrase-based MT in the case of English-French language pair. On the other hand, the NMT showed better handling of complex sentences in the case of English-German language pair. The morphological error identification showed that NMT makes considerably less morphology errors in both language pairs. The word ordering errors analysis showed that this issue is language specific. The NMT has done well for the English-German language pair where it was successful at generating well-formed sentences. Also in the case of language pair with less complex reordering phenomena the NMT performed better than phrase-based MT. Bentivogli et al. (Bentivogli et al., 2018) showed that NMT is superior to phrase-based MT but identified also some shortcomings of NMT. NMT has issues with the translation of proper nouns and with the reordering of particular linguistic constituents. Xia (Xia, 2019) introduced a statistical machine translation system based on deep neural network. The focus of the article is oriented to the word alignment and pre-ordering in SMT. The word alignment model was created by a combination of multi-layer neural network and undirected probability graph model. The linearly ordered pre-ordering model was created using the multi-layer neural network to vocabulary the representation. Both of these models were combined in the same deep neural network framework named DNNAPM. The framework was tested on a sample of 100 000 sentence pairs. Accuracy was used as the evaluation metric for the field of word segmentation. Marzouk and Hansen-Schirra (Marzouk and Hansen-Schirra, 2019) analyzed the application of controlled language to improve the machine translation output. The authors compared the impact of nine controlled language rules to the quality of NMT output and compared the results for other MT systems: rule-based, statistical and hybrid MT. The experiment was done with the English-German language pair using texts of the technical

domain. The results of the experiment showed that NMT behaves differently when controlled language is applied. The quality of the NMT output is higher without the application of controlled language. This is in contradiction with other MT (rule-based, statistical, and hybrid) where the application of controlled language improves the output of the translation. The NMT system obtained the best results between all of the MT systems regardless of the application of the controlled language. The limitation of the experiment was in the use of only one language pair and the experiment should be done for other language pairs. The application of the controlled language did not bring any expected results. Based on the results of the experiment it seems that the application of controlled language could become obsolete for the novel MT system. Pinnis et al. (Pinnis et al., 2018b) presented an integration of NMT systems into document workflow translation of a cloud-based translation system and introduced examples of formatting-rich document translation. Pinnis et al. (Pinnis et al., 2018a) validated the NMT application to more difficult language pairs with less resources available for the NMT training. The authors compared the SMT and NMT systems for highly inflected languages (Estonian, Latvian and Russian). The authors also compared the results of the SMT and NMT systems output for a broad data domain and narrow data domain. The MT output was evaluated using automated (BLEU, NIST, and ChrF2) and manual methods (system comparative evaluation and error analysis of translations). The results of the evaluation showed that NMT system achieved better results for 83 % language pairs of broad domain. On the other hand, the narrow domain results showed that the SMT system produced significantly better translations than NMT system.

CONCLUSION

In this paper was described the novel approach of machine translation- neural machine translation system and the most used statistical machine translation system. Both of the machine translation systems were introduced and described in detail. The SMT as the most used system is getting replaced by the NMT as a novel approach. This paper presented the use of NMT by other researchers. Other authors start to use it and analyze its potential for the specific language pairs. The results of the described experiments show a potential improvement of the translation output of NMT in comparison with the SMT output. Despite that, there are some shortcomings of the novel NMT system where the SMT still offers better results. The future work would be focused on a detailed analysis of the Neural Machine Translation system output for a fleective language such as the Slovak language. The research would compare the difference of output of SMT and NMT systems. Also, it would be interesting to compare Google Translate before it changed to NMT and observe whether the change improved the translation quality also for fleective languages.

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Comparison and Evaluation Functionality of Smart Bracelets for Obtaining Physiological States

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Abstract

During the teaching process, changes in students' emotional states may take different directions. From the teacher's point of view, it is important to direct the learning process so that the students are interested in the curriculum and get the most out of the learning process. It is important for the teacher to be able to record the student's feelings change (emotional state), so it is necessary to create an appropriate tool to provide relevant information about these states. Smart wristbands are a suitable tool to record changes in emotional states in students by measuring physiological functions. Before researching the identification of changes in emotional states, it is important to test and find out how the acquired data can be transferred from the mobile application to the central device, which is also the aim of the article. The research part of article will be the bracelets test from multiple manufacturers. Also, the solution has to transfer obtained data to a central facility.

Keywords

Sensory Networks. Smart Bracelets. Data Analysis.

INTRODUCTION

Sensory networks are nowadays growing into one of the most important technologies in this century, which will in many areas greatly affect our lives. According to the author (Rom, 2016) wireless sensory networks (WSN) are the key to achieving the full potential of the Internet of Things (IoT).

IoT-based solutions allow automation of daily tasks and remote control of devices, enabling efficient monitoring and control of connected devices. This leads to improved efficiency and convenience in performing tasks that significantly increase the level of flexibility for citizens by providing them new areas of services and applications (de Matos *et al.*, 2020; Štencľ and Štastný, 2010; Skorpil and Stastny, 2008).

When we want to describe sensor network in more detail, it represents a complex system of interconnected devices that can communicate with each other through the Internet and are capable of automatically performing assigned tasks by capturing real-world phenomena and transforming them into the appropriate form so that they can be further processed (Sánchez López *et al.*, 2012).

Authors (Bilal and Kang, 2017) disclose that wireless sensor networks consist of a large number of distributed sensor nodes, and that each sensor node is an autonomous system that monitor and collect environmental data and, based on a local decision process, transmit this data to the user. The nodes are deployed directly in an object such as a school, home, factory or a particular area of interest (Rusek *et al.*, 2017; Zahorec, Haskova and Bilek, 2014; Hubalovsky and Sedivy, 2011) (Lamanauskas, 2009).

In the IoT system, sensors send information directly to the Internet, and there is no direct Internet connection in WSN. This means that in the case of IoT, when monitoring the surroundings, the data will be sent immediately or periodically directly to the Internet, where the server can process and interpret it on the front-end interface (Kocakulak and Butun, 2017).

The most common areas of use for sensor networks are health, agriculture, industry, logistics, energy, security, and smart city solutions (El-Sayed, El-Bakry and El-Sayed, 2019; Cencelj *et al.*, 2019; Eger, 2018).

Based on previous researches and current state analysis of the problem, it is possible to identify changes in the emotional state by acquiring physiological function (heart rate). In previous performed studies in the past has been found that a device comprising a sensor capable of measuring heart rate is a suitable tool to obtain physiological functions. Our research will use wireless smart wristbands containing the heart rate sensor. In order to be able to use them in the research of measuring the physiological function of the heart rate, an important task is to test their accuracy (Magdin, Benko and Koprda, 2019; Magdin and Prikler, 2019).

The aim of our article is to compare smart wristbands from multiple manufacturers and the correctness of the heart rate measurement function. The smart wristbands will include a sensor in the form of a photodiode capable of measuring the physiological function of the heartbeat.

RELATED WORK

When we considering about IoT, we consider about the idea that any device can be connected to other devices. As we know, IoT is good example for new and creative ideas that can add to the everyday tasks. As an example, we can imagine an alarm clock that wakes us up in the morning while signalling our coffee machine to turn on and start brewing coffee. Suppose our printer knows when the paper runs out and automatically orders them. Another example is a wristwatch that tells us when we are most productive during business hours. The Internet of Things provides almost endless opportunities to connect our equipment and facilities (Foote, 2016; Minařík and Št'astný, 2008).

IoT devices collect a significant amount of data about their users. In the home, this can include wake-up and sleep times, movies, purchases, and times when someone is or is not in the house. Voice assistants continuously monitor conversations and can potentially record every word we speak at home. For this reason, it is emphasized that government regulations and standards are needed to protect citizens (IEC, 2020; HaddadPajouh *et al.*, 2019).

An extensive group of applications for IoT devices is often divided into consumer, business, industrial and infrastructure premises. The growing part of the IoT devices is designed for consumer use, including connected vehicles, home automation, wearable technology, connected health and remote monitoring devices etc. (Alli and Alam, 2020; Námesztovszki *et al.*, 2020) (Draghici, Mocan and Draghici, 2011).

Wireless Sensory Networks (WSN) are key to achieving the full potential of the IoT future. By providing new areas of services and applications, technology will significantly increase the level of flexibility for citizens, including professional users, in their daily lives and environments. However, important challenges still need to be overcome (Elappila, Chinara and Parhi, 2018).

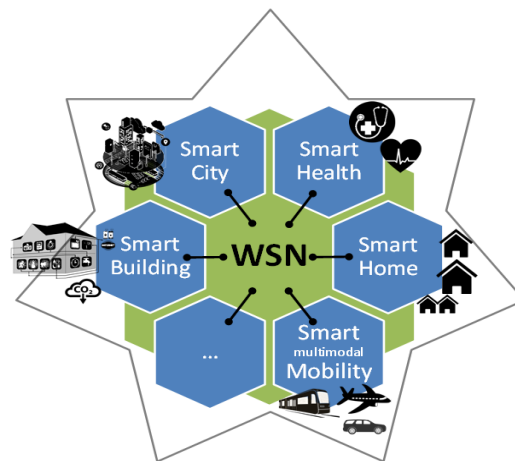


Figure 2 Diagram of the relationship between wireless networks and the Internet of Things

From the above figure (Figure 1) we can see that WSN is a technology often used in the IoT system. Basically, any device that is connected to the Internet can be considered an IoT device. This type of network we can expand with new industries, services and applications. The wireless sensory network must be reliable, secure and above all trustworthy. It is important to note that WSN consists only of a network of wireless sensors, which means that if it contained at least one cable sensor, it could no longer be referred to as a wireless sensor network. Such solutions offer countless advantages over conventional wired systems such as:

- the size and weight of the devices,
- no wiring restrictions,
- facilitate system configuration and auto-configuration,
- increased flexibility,
- easy maintenance,
- easy network topology switching,
- adding additional devices,
- reduced assembly costs (Rose, Scott and Chapin, 2015).

IoT as a "system of the systems" can be realized only if WSNs are interconnected with the cloud using new communication technologies, such as 5G, to handle increased data and real-time requirements (for example automated driving, etc.)(Rom, 2016).

IoT wearables, for example smart wristbands and fitness trackers (Figure 2), are one of the most prominent examples of IoT technology. The way people use wearable devices reflects the wider trend as stand-alone technologies, not only in the ecosystem of connected devices. As a result, IoT technology has not penetrated consumers' daily lives. Research shows that people use wearable devices primarily to perform simple tasks or tasks that can be performed without a connected device or any complex technology. Using a portable device for complex tasks, such as managing financials or handling household appliances, requires users to intend and often other integrations that they cannot or do not want to complete (Li *et al.*, 2019).



Figure 3 Different types of smart wristbands

Wearables are often impractical for certain tasks compared to desktop or mobile devices. One of the main reasons of using wristbands is the small screen size. Scrolling pages and clicking through screens is easier to do in an interface with a more open and transparent user experience. Wearable IoT devices generally rely on Bluetooth, Wi-Fi or mobile connectivity to work beyond simple tasks. If there is a connection problem, the functions are very limited.

Wearable devices often offer redundant functionality that cannot compete with smartphones for simplicity and reliability. As a result, wearable devices are used in a unique way, and people hesitate to connect them to other IoT devices, because they don't want to deal with the problems of integrating their devices with other IoT technologies. Different devices are often made of incompatible technology. This is because software is often developed by various companies that have little incentive to offer integration with competing software products. As a result, users are required to perform further integrations themselves, which many people cannot, do not want, or do not know how to do (Nelson, Verhagen and Noordzij, 2016).

The positive side of wearable devices can be their "passive" functions, specifically in health monitoring. Passive use of a wearable device can monitor vital signs and even save lives. There are several examples, e.g. people who have experienced irregular heartbeat or other serious health problems. Wearable elements are a new frontier in healthcare, for example by:

- ensure emergency care,
- monitor baby beds,
- collect continuous electronic health records.

Continuous monitoring of the user's vital signs using wearable devices, allows people and healthcare professionals to notice inconsistencies that are otherwise is not noticeable (Niknejad *et al.*, 2020).

Recognition of sensor-based gestures has been widespread in health care in recent years. It can be used for remote control of medical devices, non-contact X-ray navigation and magnetic resonance imaging (MRI), which can largely improve patients' daily life skills (Zhao *et al.*, 2019).

In addition, to recognize gestures, authors (Costa *et al.*, 2019) in research has sought to detect the emotional states of a group of entities using a wristband for physiological functions measuring and send the value of social emotion to iGend in order to change the home environment and to inform the caregivers. This project is beneficial for older people's communities, such as retirement homes, where a harmonious environment is necessary and where the population is constantly growing. The aim is to provide an affective system that directly interacts with people by discreetly improving their lifestyles. The authors further describe the usability of the wristband and the data models and provide their evaluation by real individuals and confirmation of the evaluation.

MATERIALS AND METHODS

In order to identify the emotional state, it is necessary to determine certain physiological functions, which include pulse frequency, body temperature, skin resistance and others. In terms of comfort and non-invasiveness, we have started to use already existing smart (IoT) devices from which it is possible to extract this type of data. An important parameter is the synchronization of all acquired data and subsequent data analysis. Subsequently, the classification of data according to Ekman and the attribution of emotional state according to established physiological functions should be performed.

The aim of the research will be to find out how to export the data obtained from smart wristbands to a computer for further analysis. There are a large number of wristband manufacturers incorporating a heart rate sensor, and it is important to what extent we are able to analyse the obtained data.

The research methodology was divided into several steps (shown in Figure 3):

1. wristbands categorization,
2. heart rate measuring using smart wristbands,
3. connection between wristband and smartphone application,
4. transfer obtained data from wristband to mobile device,
5. transfer data to computer,
6. processing and evaluation of obtained data.

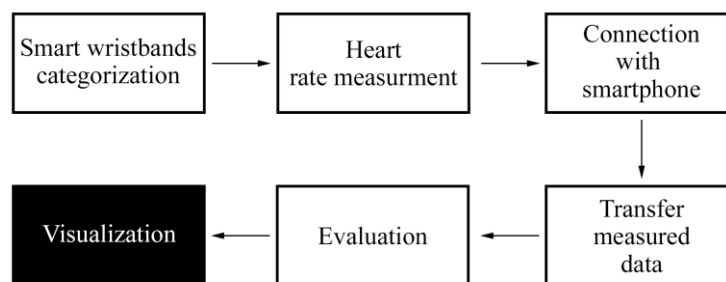


Figure 4 Conceptual model of research

Selection and categorization of smart wristbands

In the first step of the research, smart wristbands from multiple manufacturers were categorized. In the research we used wristbands from the two producers: Fitbit (Charge 3) and Xiaomi (Mi Band 2, 3, 4).

Physiological function (heart rate) measurement

Before measuring the selected physiological functions, certain rules were defined. Tests on the accuracy and stability of the measured data were performed to confirm the results at the measurement time intervals for each wristband were set to 120 minutes. The respondent, while measuring physiological functions, did the same activity for each type of wristband so that the differences between the measured data were statistically significant. Also, all types of wristbands during the research were tested on the same respondent.

Connection between smart wristband and mobile application

Since the smart wristbands do not contain large internal memory, a mobile device was used to store obtained data. Wristbands use Bluetooth technology for connection with a mobile phone, through which then synchronizes the measured data after a certain time interval. Each wristband manufacturer provides its own application, where all applications provide similar information.

The disadvantage of these applications is that they do not provide the possibility of obtained data export, in our case heart rate data. For this reason, it was necessary to use external applications that offered this feature in the research. In the following section, will be described in more detail the applications that offer exported data for wristbands from Fitbit and Xiaomi.

With the Fitbit wristband, there is a web interface that provides results and visualization of all collected data. In addition to visualizing the data, it also provides the ability to export in bulk. Exporting itself can be done in several steps (Figure 4). In the first step is required to choose Data Export from the menu. It is also necessary to choose the time horizon of the obtained data. The manufacturer has added the possibility to choose the format in which the data will be displayed and what type of data we want to export.

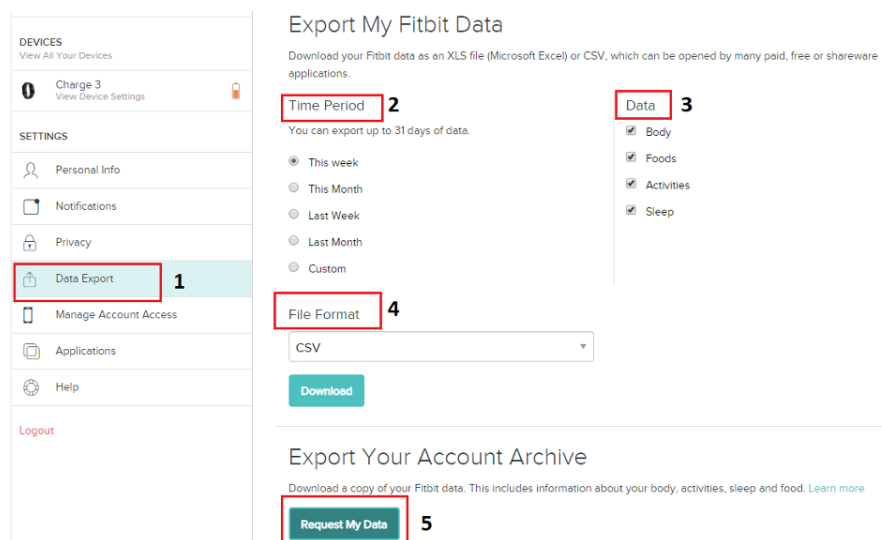


Figure 5 Exporting data for Fitbit

After selecting 'Request my data', an email has been received with information about the possibility of downloading the collected data. The packaged file contains all the data that was marked during export.

While exporting the obtained data from the original Xiaomi application, tables containing no data. Mi Band Tools mobile application had to be used to export the data. In addition to exporting the obtained values, the tool also enables the measurement and evaluation of acquired data in real time. To export the obtained data from Mi Band Tools, the Export to CSV option must be marked in the settings, and then a file containing the obtained data was created.

Data processing and visualization

The data obtained from Fitbit was in .json format and had to be converted to .xls in the first step. The converted file contained items such as date and time, heart rate, and other items that were removed during data cleaning (Figure 5). We found that the Fitbit wristband allows and provides continuous heart rate measurements and all measured values are recorded.

	A	B
1	dateTime	value/bpm
2	01/29/20 11:38:52	70
3	01/29/20 11:39:07	70
4	01/29/20 11:41:17	71
5	01/29/20 11:41:27	71
6	01/29/20 11:41:42	71
7	01/29/20 11:41:52	72
8	01/29/20 11:42:02	71
9	01/29/20 11:42:07	72
10	01/29/20 11:42:17	73

Table 1 Obtained data from Fitbit wristband¹

Wristbands from the manufacturer Xiaomi allow heart rate measurement every 15 seconds. After export, the file contained only measurement time and heart rate and no further purification of the data was necessary.

After the data were cleaned and processed, a graphical visualization was created (Chart 1), which can be used in the future, for wristbands comparison with a professional measuring instrument - a medical holster (Obonya and Kapusta, 2018). Also as an aid in the course of changes in the physiological function of the heart rate.

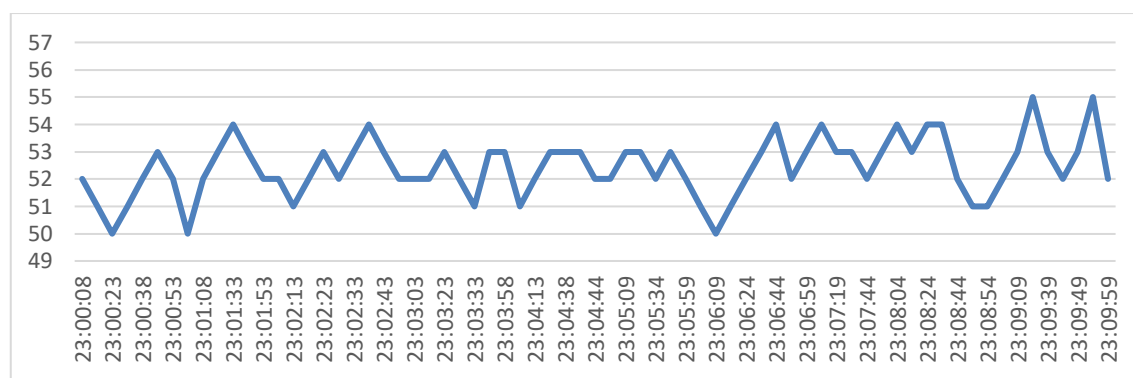


Chart 1 Visualization of the obtained data from Xiaomi wristband

CONCLUSION AND FUTURE WORK

The aim of the research was to test the ability to measure the physiological functions using smart wristbands containing a heart rate sensor, as well as the possibility of transfer the data to a computer. We've found that there is a way to transfer the data to a computer for further analysis on both manufacturers' wristbands. We also found that the Xiaomi wristband is a suitable tool for further testing, as the data export process was simpler than the FitBit wristband. Also, a wristband from Xiaomi is more affordable.

The research has chosen a device that is able to measure the heart rate of students and which can then be used in further research to identify changes in students' emotional states during the teaching process. As the research continues, the wristbands will be further tested and compared to a reference holster and ECG. After evaluation, the most accurate smart wristbands are selected so that we can use these smart wristbands in an experiment to

¹ Table 1 source: Author of the article

obtain basic physiological states from students and thus be able to classify the emotional states of each student.

Through a comprehensive system in which tested smart wristbands play an important role, teachers will be able to detect emotional changes in students and direct the teaching process in such a way that they show a positive emotional change in students and also to students get the most out of the teaching process.

ACKNOWLEDGEMENT

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A Comparison of different approaches used in the learning process by means of the Moodle Data Analysis

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Abstract

The contribution deals with the application of data mining methods in the log data of the Moodle learning management system. In the first step the attention is paid to the pre-processing of data cleaning, transformation, and aggregation. This pre-processing of data preparation focuses on logs that describe the students' assignments and quiz activities in detail. The selected activities do not belong to the evaluation quizzes, but these quizzes and assignments are constructed as training activities. The developed automatic generator of parameterized tasks allows to assemble such quizzes with unique assignments for each student in the course. The used data mining methods analyse the relationship between students' activities during the preparation for the final exam quiz and the final exam grade. The data of the courses with optional exercises are compared with the data of the courses with obligatory exercises. Based on these data the activities and success rate are analysed. The activities of both types of courses are compared and then the dependency between the activities and success rate is studied. Students with optional and obligatory exercises do not have any statistically significant different results. The data in the group with optional exercises show a significant difference in success between the volunteering students and the students without any activity. The tests confirm the dependency between the activity indicators and the results of the final exercise. On the other hand, these activities had no such effect on the outcome of the final exam.

Keywords

Knowledge Discovery. Educational Data Mining. Moodle. Data Pre-processing. Data Preparation.

INTRODUCTION

Data mining is known for its powerful role in uncovering hidden information from large volumes of data. Its advantages have landed its application in numerous fields including e-

commerce, bioinformatics and, lately, also within the educational research which is commonly known as Educational Data Mining (EDM) (Baker, 2010).

EDM is defined as an emerging discipline, and it deals with developing methods for exploring the unique types of data that come from the educational setting, and those methods are then used to understand students better (Baker and Yacef, 2009).

A large amount of data comes from the Virtual Learning Environment (VLE) log files. Some researchers use the log file of the VLE web servers to analyse the behaviour of VLE users (Munk et al., 2011). A variety of data mining methods are used to analyse the data thus obtained. The main purpose of these methods is to identify students' learning styles by classification or clustering, and then to predict the students' assessment based on their behaviour in the e-learning course (Baker and Inventado, 2014).

Many papers in this area apply data mining methods on a variety of attributes from different course activities including quizzes and assignment activities. This contribution focuses on an analysis of the relationship between the quizzes together with the assignment activities and the final exam grade. Contrary to other contributions these activities are represented by different training students' activities in the e-learning course.

The reminder is structured in the following way. The section called Related work provides an overview of the literature on the problem of EDM. The section Methodology describes the methods for the Moodle data preparation and the methods of data analysis including the hypotheses formulation. The section Results presents the results of the proposed hypotheses tests. The results are summarized, discussed and, finally, the conclusion is stated.

RELATED WORK

Many contributions in EDM area search for the learner's behaviour in the Virtual Learning Environment. The authors in (Preidys and Sakalauskas, 2010) use k-means clustering to identify 3 learner's style using VLE BlackBoard Vista. Similarly, in (Lavigne et al., 2015) the authors analyse the characteristics of the students' navigation in VLE and they inferred different learning strategies of students that follow the individualized navigation paths. The authors (Krpan and Stankov, 2012) show practical experience with LMS Moodle and apply the data mining technique for the analysis which serves as a tool for grouping students with similar characteristics.

In another contribution (Macfadyen and Dawson, 2010) the authors monitor students' online activities to predict their academic achievements. Based on the data of the Blackboard Vista system, they proved a significant simple correlation with the student final grade and they constructed a predictive model on the basis of the regression modelling. This way they have developed an 'early warning system' for teachers. By means of the Moodle system the authors of (Luna et al., 2017) developed the Moodle Data Mining tool (MDM) which eases the knowledge discovery process, including selection, data pre-processing, and data mining from Moodle courses.

The data of pre-processing is a very important part of the educational data analysis. The contribution (Romero et al., 2014) focuses on the data pre-processing as the first step in any data mining process. The authors consider this pre-processing as one of the most important

but less studied tasks in the educational data mining research. However, many authors rarely describe this important step, or they consider this step to be self-evident and do not deal with it in detail.

In this paper, selected methods are applied on Moodle raw data. These raw data require an extensive pre-process preparation. We follow the publication (Romero et al., 2008) in which the authors describe the full and step by step process for mining e-learning data by means of the Moodle system. They introduce the application of the main data mining techniques, such as statistics, visualization, classification and clustering in relation to the Moodle data mining.

In our contribution the assignment activities are analysed only. In the above-mentioned publications, the quiz activities are mostly part of the evaluation and therefore they closely relate to the final grade. The relations between the training activities and the final exercise test or exam grade are analysed. Different type of 'training' quiz is unlimited according to quiz time and assignment time. There is used the number of quizzes attempts and the number of assignments attempts in quiz. In comparison with the attributes in (Romero et al., 2008) other new attributes can be used, such as the number of assignment attempts, the number of quiz attempts, the average number of attempts per one assignment, the number of successfully solved assignments, etc. In comparison with (Macfadyen and Dawson, 2010) the number of attributes is reduced, and only the attributes closely related to the solving of the assignments in the training quizzes are used. This raises an important question. Does the exercise intensity affect the success rate of the final exercise tests or exams? The contribution focuses on the two tasks in detail. In the first one the final exercise test (exam) results from the students' group with obligatory exercises (OE) and the exercise test (exam) results from the group with non-obligatory exercises (NE) are compared. In the second task the relationship between the intensity of the exercises, represented by the length of the task processing, the number of erroneous results, etc., and the results of the final tests are analysed.

METHODOLOGY

A special type of unlimited training quizzes in the adaptive mode allows students an unlimited number of attempts with respect to the solved tasks and with respect to the unlimited number of the newly generated quizzes. This approach requires a system of automatic generation of parameterized tasks. We have developed such a system and this system was used to create many variants for each solved task (see Gangur, 2011)). The system allows not only to generate unique inputs with different parameter values but also to generate dynamic images (Plevný and Gladavská, 2014), (Plevný and Gangur, 2016) and training data (Gangur, 2018). This automatic generator of parameterized tasks allows to create many variants of each task and this way it generates unique assignments and quizzes for every student. Each student solves a unique problem assignment. This is a very important assumption as the tracked relevant attributes are not influenced by any unwanted cooperation among students over the same assignment.

In an analysis of the relevant educational data, we focus on such course activities that contain only training quizzes and they serve as support courses for the main lecture course. The tracked activities only relate to solving the assignments and inserting the results in the

system. The duration of the solved tasks, the number of the quiz attempts, the number of the attempts to solve the individual tasks that are represented by the number of the inserting results (attempts) for one assignment are analysed.

The data mining process that is applied to the LMS Moodle data consists of the same four steps as in the general data mining process and it goes as follows: Collect data, pre-process the data, apply the data mining, interpret, evaluate and deploy the results (Romero et al., 2008). The results or models obtained are interpreted and used by the instructor for further actions. The instructor can use the information discovered to make decisions about the students and the Moodle course activities to improve the students' learning.

Data

Four courses for both tasks are chosen. The parameters of the course are listed in table 1. The course parameters are: course abbreviation, task number, obligation of quizzes, number of students, number of quizzes per course, number of assignments per course and number of records of the raw data that describe students' behaviour during the assignment solution.

Preparation of Moodle data

Moodle is an open-source learning management system (LMS) for organizing and managing e-learning courses (Moodle, 2010). Moodle keeps detailed log of all students' activities and has a modest log viewing system built in. The log files can be filtered by parameters, such as the course, participant, day and activity.

Table 1: The parameters of the courses (Source: own)

Course (Sample)	Task	Obligation	Students	Quizzes	Assignments	Records
STA_Ch_1	1,2	No	37	7	28	9532
STA_Ch_2	1	Yes	27	7	28	20679
STA_PI_1	1,2	No	220	7	28	31003
STA_PI_2	1	Yes	127	7	28	70944

Table 2: The attributes of raw data (Source: own)

Name	Description
student_id	ID of student
Quiz	Number of quizzes
quiz_attempts	Number of quizzes try
assignment	Number of assignments
attempts	Number of assignments attempts
start_time	start time of quiz try
finish_time	close time of quiz try
answer_time	time of assignment try answer
State	state of assignment solution
Name	assignment operation

The applied LMS Moodle stores the logs in a relational database MySQL. The Moodle version 3.5.5+ database has about 435 interrelated tables. Several of them are used and the

data are converted from these tables into the required format by means of analysing tools. For this reason, the pre-processing of Moodle data must be applied. The pre-processing data allows the original data to be transformed into a suitable format for the data mining algorithm. This task can be processed by administrators with access to the relevant data in tables and the administrator must apply several general data of pre-processing tasks (data cleaning, user identification, session identification, path completion, transaction identification, data transformation and enrichment, data integration, data reduction) (Romero et al., 2008). The pre-process consists of the following tasks:

- Select data: It is necessary to choose which course mining can be useful for analysing.
- Create summary tables: It is necessary to create, in several steps, a summary table from the information stored in the Moodle tables. The first summary temporary table contains relevant information for each user and each of his/her quizzes. The duration of each quiz assignment is counted as the difference between the time of the first response and the time of the last response that are linked to the assignment. The total time is then the sum of all assignments in the given quiz.

Table 3: The attributes of the final summary table (Source: own)

Name	Description
student_id	student id
no_quiz_attempts	number of quiz attempts
avg_duration_per_quiz	average duration per number of quizzes
total_duration_of_assignments	total duration of all assignment attempts in all student's quizzes
total_no_of_assignments	total number of assignments in all student's quizzes
avg_duration_per_assignments	average duration per number of assignments in all student's quizzes
total_no_assignment_attempts	total number of all assignment attempts
avg_no_assignment_attempts	average number of assignments attempts per number of assignments
total_no_attempts_solved	total number of attempts of successfully solved assignment
total_no_assignments_solved	total number of successfully solved assignments
avg_no_attempts_solved	average number of successfully solved assignment attempts per number of successfully solved assignment
points	number of points of final exercise test
success_index	success rate index of final exam (SRI)

The final table 3 summarizes the core data about students' activities in the assignment solution. These are especially the total duration of all assignment attempts; the average number of assignments attempts and the average number of attempts of the solved assignments. These attributes are related to the grade data that represent the final evaluation of a student - the number of points of the final exercise test and the success rate index of the final exam (SRI). This index is calculated as the exam grade + $(MAX(try,1)-1) * 4$,

where the exam grade is the grade of the final exam (1-4), try is the trial number of the exam (1-3). The scale of index is 1-12, where the value 1 is the best and value 12 is the worst (3 unsuccessful attempts). The index of students without exam attempts is set to maximum value 12. A lower value of the number of points and a higher value of SRI represent a worse result.

Explanatory variables (or independent variables) *avg_duration_per_quiz*, *avg_duration_assignments* and *avg_no_assignment_attempts*, *avg_no_attempts_solved* and responses (or dependent variables) *points*, *success_index* were used for further processing.

Analysis of data

The analysis of data consists of several statistical hypotheses' tests. The following hypotheses HP1-HP4 for task 1. and HP5 for task 2 were formulated.

Success rates comparison

- HP1
 - H_0 : The means of points of samples STA_Ch_1 and STA_Ch_2 are equal. (The means of SRI of samples STA_PI_1 and STA_PI_2 are equal)
 - H_1 : The mean of points of sample STA_Ch_1 is less than the mean of points of sample STA_Ch_2. The mean of SRI of sample STA_PI_1 is greater than the SRI of sample STA_PI_2.
- HP2
 - H_0 : The means of points of students with zero activity (total duration of assignments is zero) in samples STA_Ch_1 and students with non-zero activity in sample STA_Ch_1 are equal. (The means of SRI of students with zero activity in samples STA_PI_1 and the means of points of students with non-zero activity in sample STA_PI_1 are equal.)
 - H_1 : The mean of points of students with zero activity (total duration of assignments is zero) in samples STA_Ch_1 is less than the mean of points of students with non-zero activity in sample STA_Ch_1. (The means of SRI of students with zero activity in samples STA_PI_1 are greater than the means of SRI students with non-zero activity in sample STA_PI_1.)

Activities comparison

- HP3
 - H_0 : The proportions of the successfully solved assignment number and the solved assignment number of sample STA_Ch_1 (STA_PI_1) and sample STA_Ch_2 (STA_PI_1) are equal.
 - H_1 : The proportion of the successfully solved assignment number and the solved assignment number of sample STA_Ch_1 (STA_PI_1) is less than the proportion of the successfully solved assignment number and the solved assignment number of sample STA_Ch_2 (STA_PI_1) are equal.
- HP4

- H_0 : The means of the average number of the successfully solved assignment attempts of samples STA_Ch_1 (STA_PI_1) and STA_Ch_2 (STA_PI_2) are equal.
- H_1 : The mean of the average number of the successfully solved assignment attempts of samples STA_Ch_1 (STA_PI_1) is less than mean of average number of the successfully solved assignment attempts of sample STA_Ch_2 (STA_PI_2). Then hypotheses for task 2 (for samples STA_PI_1, STA_Ch_1) were formulated.

Dependency of the activities and success rate

- HP5

- H_0 : The number of points (success rate index) does not depend on the average indicators of the activity.
- H_1 : The number of points (success rate index) depends on the average indicators of the activity.

All relevant samples were analysed according to normality. Shapiro-Wilk test was applied for the normality test. The result of the normality test determined the test of the two population means equality. Wilcoxon test or the t-test was applied for the hypotheses test with respect to homoskedasticity of samples. Bartlett test of homogeneity of variance was applied for homoskedasticity test and the result of this test selected Aspin-Welch test or t-test (HP1, HP2, HP4). The proportion equality test was used for the proportions comparison (HP3).

The χ^2 test of independence was used for the hypotheses test of task 2 on discretized data (HP5). The data discretization was processed using the k-means cluster method with different numbers of clusters. The three samples of data were created for 5, 7 and 9 clusters. The analysis was performed only on NE courses, i.e. on STA_Ch_1 and STA_PI_1 sample for all variables of activity and variables of success.

In case of p -value < level of significance (0.05) the coefficients of dependency were calculated. The results with the value of Pearson contingency coefficient > 0.7 are accepted only.

RESULTS

Success rates comparison

First, success rates, represented by the number of points or success (STA_Ch_*) rate index (STA_PI_*) (hypotheses HP1), were compared. In table 4, the basic statistics are listed. The number of points in course concerns the non-obligatory exercises (NE) is less than number of points in courses with obligatory exercises (OE). By the same way the SRI in NE courses is greater than SRI in OE course.

Table 4: Basic statistics of success rate indicators

Sample/No of points	Min.	1 st Qu.	Median	Mean	3 rd Qu.	Max.
STA_Ch_1	0.00	6.00	14.00	14.97	22.00	32.00
STA_Ch_2	7.50	13.50	17.25	17.11	21.75	24.75
Sample/SRI	Min.	1 st Qu.	Median	Mean	3 rd Qu.	Max.

STA_PI_1	1.000	3.000	7.000	6.607	12.000	12.000
STA_PI_2	1.000	3.000	6.000	6.268	10.500	12.000

It seems that the success rate is higher in OE course and this result confirms our hypotheses. The statistical tests were applied for the comparison of samples. The normality test resulted in normality for STA_Ch_1 and STA_Ch_1 sample, non-normality for STA_PI_1 and STA_PI_2 sample. That's why the Bartlett test of homogeneity of variance and, based on its result, Aspin-Welch two sample test were used for STA_Ch_* samples. On the other hand, Wilcoxon rank sum two sample test was applied for STA_PI_* samples. In Aspin-Welch test p -value = 0.1135 did not confirm any significant difference in the number of points, and, likewise, in Wilcoxon test p -value = 0.2267 did not confirm any significant difference of SRI. Our alternative hypotheses in HP1 were rejected.

In the following step we focused on the comparison of the success rate only in NE courses and the success rate of students with non-zero activities (volunteers) and zero activities non-zero - hypotheses HP2 were compared. The basic statistics (table 5) confirmed our assumption that the students with activities have better results.

The Wilcoxon rank sum two sample test was applied for STA_PI_1 sample according to normality test result. The Bartlett test of homogeneity of variance determines two sample t-test

Table 5: Basic statistics of success rate indicators in NE courses

STA_Ch_1/No. of points	Min.	1 st Qu	Median	Mean	3 rd Qu	Max.
Zero activities	0.00	3.50	11.00	10.89	14.00	28.00
Non-zero activities	6.00	14.00	19.00	19.28	24.00	32.00
STA_PI_1/SRI	Min.	1 st Qu	Median	Mean	3 rd Qu	Max.
Zero activities	1.000	3.000	7.000	7.291	12.000	12.000
Non-zero activities	1.000	3.000	3.000	4.911	7.000	12.000

used for STA_Ch_1 sample. In t-test p -value = 0.001353 confirmed a significant difference of number of points and in the Wilcoxon test p -value = 0 confirmed a significant difference of SRI. The alternative hypotheses in HP2 were confirmed. The students with non-zero activities have better results in comparison with the students with zero activities.

Conclusion: In comparison with the previous tests, which did not show the expected statistically significant difference between the success rate of NE and OE courses, this result shows the effect of volunteering on success. The students who solve the exercises voluntarily have proven better results than those who do not solve the exercises. On the other hand, the students in the course with the obligation to solve the exercises do not have significantly better results than the students in the course with the optional solution of the exercises.

Activities comparison

The activities of students in OE and NE courses were compared. First, the proportion of the successfully solved assignment number and the solved assignment number in both relevant samples (hypotheses HP3) were compared. The figure 1 depicts the proportions for

samples STA_Ch_1, STA_Ch_2 and samples STA_PI_1, STA_PI_2. The proportions are lower in NE courses. Two-sample tests for equality of proportions were applied. Both tests for STA_Ch_* and STA_PI_* with p-value = 0 confirmed a significant difference of proportions in favour of the OE courses. The alternative hypotheses in HP3 was confirmed. The proportions of the successfully solved assignments in NE courses is lower than in OE courses.

Next the number of attempts of the successfully solved assignment per one successfully solved assignment was compared between OE and NE courses - hypotheses HP4. In this case the results can be affected by the students with zero activity and with no successfully solved assignments. That's why these students were deleted from the data for the tests.

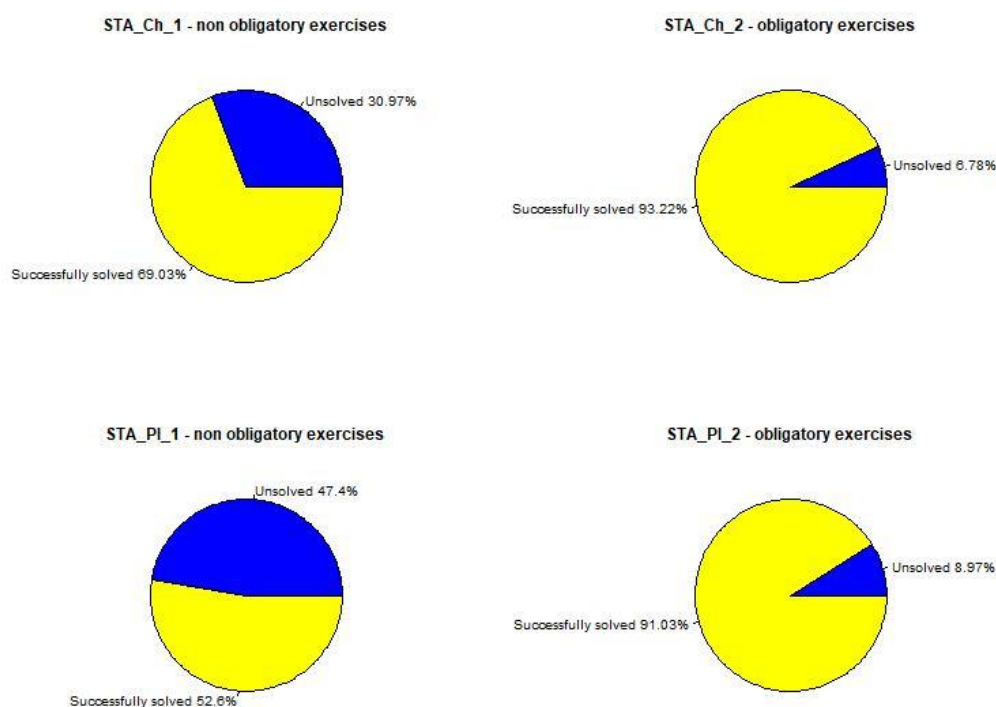


Figure 1: The proportion of the successfully solved and the solved assignment number

Figure 2 depicts these averages for relevant samples. The graphs show a lower average of attempts of students in NE courses in comparison with students in OE courses. The Wilcoxon rank sum test was applied for this comparison.

In both cases, the Wilcoxon rank sum left tail test showed a zero p-value, i.e. a statistically significant difference in the average attempts for NE courses and OE course. The alternative hypotheses in HP4 were confirmed. In case of OE course, the students logically showed greater effort for the correct result even in case of more complex tasks. In NE courses with optional exercises, the students had a smaller average number of solving examples, indicating less effort to solve more difficult tasks.

Conclusion: The assumption of greater activity of the students in the OE courses in comparison with the activity of the students in NE courses is confirmed.

Analysis of the dependency between the activity and the success rate

The algorithms described in subsection Analysis of data were applied. The significant results of the dependency were obtained only for the sample STA_Ch_1, i.e. for the dependency of the activity variables and the success rate represented by the number of points. The tests indicate the dependency of points on the selected activity indicators, i.e. *total_duration_of_assignments*, *avg_duration_per_assignment*, *total_no_of_assignment*, *total_no_of_assignment_attempts*, *avg_no_attempts_solved*, *total_no_of_assignment_solved*. Pearson contingency coefficient is from $CC_{cor} = 0.73-0.79$ for 5 clusters discretization to $CC_{cor} = 0.88-0.89$ for 9 clusters discretization.

The test results indicate only the dependency of points of the final exercises test on the activities in the exercises. A stronger dependency of the success rate index on the exercise activities were not proved. In the analysis of points only some of the activity indicators show a strong dependency ($CC_{cor} > 0.7$). The possible cause of this difference is a different approach of students to the preparation for the final exercise credit test and for the final exam.

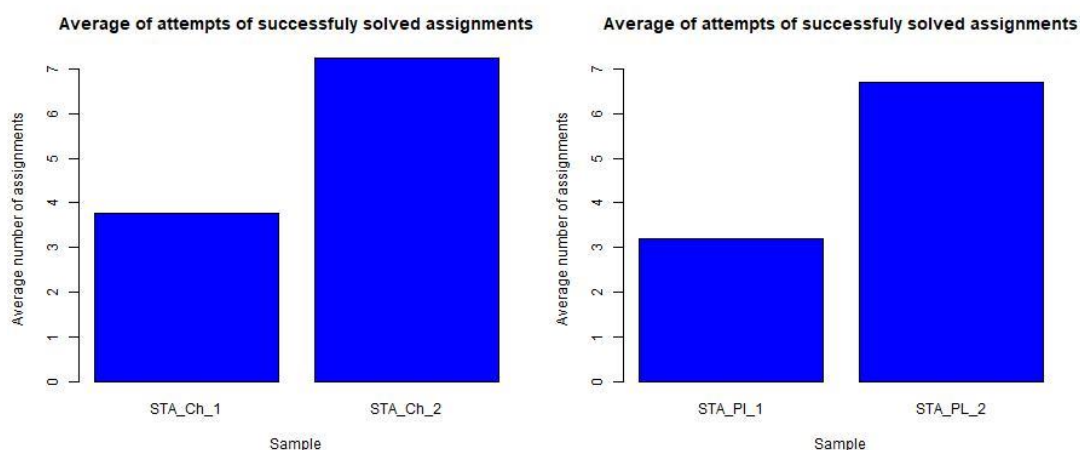


Figure 2: Average of attempts of successfully solved assignment

The results of the hypotheses tests are summarized in the following list:

- HP1: Alternative hypothesis has been rejected. Significant difference has not been proven.
- HP2: Alternative hypothesis has been confirmed. Significant difference has been proven.
- HP3: Alternative hypothesis has been confirmed. Significant difference between proportions has been proven.
- HP4: Alternative hypothesis has been confirmed. Significant difference between activities has been proven.
- HP5: Alternative hypothesis has been confirmed only for sample STA_Ch_1, Alternative hypotheses has been rejected for other samples. Dependency has been proven just for sample STA_Ch_1.

CONCLUSION

In the contribution, the relationship between students' activity in practice and the success represented by the exercise test or the final exam has been dealt with. Statistical tests on data, obtained from the group with optional exercise solution and from the group with obligatory exercise solution did not show the expected significant difference in success between these two groups. On the other hand, further tests only on the data from the group of the optional exercise solution showed a significant difference in success between volunteering students and students without any activity. Overall, these tests show a greater impact of voluntariness than obligation.

Other tests compare the average number of attempts of the successfully solved assignments. The share of the attempts number of the successfully solved assignments and the attempts number of all assignments showed a significant difference in which the students of the groups with obligatory exercises have a larger share of the number of the successfully solved assignment attempts. These students logically show more effort in solving exercises while students with optional exercises mostly do not finish more complex assignments.

When examining the relationship between the exercise activity indicators and success, only some activity indicators and only the result of the final exercise test showed a significant dependency. These activities had no such effect on the outcome of the final exam.

The presented analyses also have their limitations, which suggests a topic for possible future research. The study results of the individual groups were not compared with the results of different approaches to the learning process in other courses. Therefore, it cannot be said with certainty that the results of the analyses depend only on the applied approaches and not on the difficult content of the analyzed course.

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Problematic Internet of Things Usage as a Risk Factor for Information Security in Adolescents

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Abstract

The study analyzes the psychological characteristics of the interaction of adolescents with various digital technologies to solve their specific problems. The research question was: does the number of devices used with the Internet of things technologies influence the change in psychological boundaries and problematic Internet use in adolescents? It has been established that the use of a variety of mobile devices is typical for giving adolescents the possibility of almost constant access to the network. They use the Internet of things primarily for obtaining information, recreation, shopping, monitoring their health and entertainment, and much less often - for controlling household appliances. In the process of interaction with smart devices, adolescents experience changes in psychological boundaries, which are manifested in the impossibility of abandoning devices, in experiencing dependence on interaction with them. The dependence of some characteristics of violation of psychological boundaries and problematic Internet usage on the number of devices used was revealed. Teenagers who use 1-2 devices tend to violate psychological boundaries. This can lead to a loss of privacy and a decrease in control over consumer behavior on the Internet. Teenagers who have from 3 to 6 devices have a higher risk of Internet addiction, associated with the appearance of personal and communication problems, health disorders due to constant stay on the Internet. A large number of "smart devices" used can lead to an increase in their vulnerability to cyber-attacks and the theft of personal information. The research was supported by RFBR (project No. 19-29-14029).

Keywords

IoT, Problematic IoT Usage, Adolescents, Information Security

INTRODUCTION

In the seventies of the last century, from the time when computers stopped to be single and unique products, mass automation began in two practically independent areas. The first is the automation of business processes, which was called Information Technology (IT). Another is the automation of technological processes, this direction, as opposed to IT, was called Operational Technology (OT). It is worth clarifying that IT is not dealing with information, but with data, so it would be more accurate to call it "Data Technology". IT combines computers, storage systems, and networks with the processes of creation, processing, storage, security, and the exchange of any form of electronic data. OT is also a

complex of hardware and software but designed to control and to manage physical processes. In the USSR, the terms ACS (Automated Control Systems) and APCS (Automated Process Control Systems) became very popular. For more than forty years, IT and OT have developed independently, and during this period, they have acquired features that distinguish them significantly. However, in the second decade of the 21st century, under the influence of several factors, including the sensory revolution, the development of network technologies, cloud computing, big data analytics, and other modern trends, the convergence process began with combining of two approaches: data orientation and event orientation in the physical world. (Ulezko, 2012). In the long term, we should expect the emergence of a single whole, consisting of traditional technologies for working with data and of industrial control systems. At the marketing level, in the media, the term "Internet of Things (IoT)" is most often used to refer to solutions aimed at designated convergence. The Internet of things consists of loosely bound disparate networks, each of which has been created to solve its specific problems. For example, in modern cars several networks work at once: one controls the engine, the other controls the security systems, the third communicates, etc. In-office and residential buildings, many networks are also installed to control heating, ventilation, air conditioning, telephone communications, security, illumination. With the development of the Internet of things, these and many other networks will connect and gain more and more opportunities in the field of security, analytics, and management. As a result, the Internet of things will gain even more opportunities to open to humanity the new ones, broader perspectives. (Vlasenko and Musienko, 2018) However, along with these new perspectives, new problems arise. They are caused by information security problems. The experts insist that the providers of services and devices of the IoT market violate the principle of end-to-end information security, which is recommended for all ICT products and services. According to this principle, information security should be laid at the initial stage of designing a product or service and maintained until the end of their life cycle. The researchers of information security problems pay attention to problems on the side of both developers as well as device owners. The scope of the Internet of things applications is extremely vast. They include industrial systems, corporate systems, in which specially trained personnel (transport, smart city, medicine, etc.) deal with information security issues. Nevertheless, some systems are focused on the end-user, whose behavior largely determines the conditions of information security (smart home, housing, and communal services, etc.). Therefore, the social aspects related to the behavior in the electronic environment of the Internet of things owners, who manage their devices through the mobile gadgets (smartphones, tablets, etc.), put in the forefront. Of particular importance in this aspect is the problem of risk analysis of information security of adolescents who are users of the Internet of things. The modern adolescents are active users of the Internet, quickly master new technologies (Timchenkova, 2019). They widely use the Internet of things in various areas of life (Koroleva, 2016; Montag and Diefenbach, 2018). Mobile technologies and data mining are being introduced into modern education systems (Sobkin, 2017; Burianova, et al, 2018; Drlik et al, 2018). Simultaneously, the interaction of modern adolescents with various technologies is often excessive, non-functional (Anderson et al, 2017; Reiner et al., 2017; Khodakovskaia, Bogdanovskaya, Koroleva, et al., 2018; El Asam et al, 2019). Besides, the modern "digital generation" is characterized by a "technological literacy paradox": the possession of information security skills among adolescents is significantly behind the ability to learn new devices and gadgets (Soldatova and Rasskazova, 2016; Yudina, 2019). This makes a special

vulnerability of teenagers to cyber threats and risks (Budykin, 2017; Soldatova et al, 2017; Nesi and Prinstein, 2019; Khan et al, 2019). In this regard, the problem of analyzing the manifestations of the problematic use of the Internet of things as indicators of Internet risks and threats to information security in adolescence is of particular relevance. Based on this, we formulated a research question: does the number of devices with Internet of things technologies affect the change in psychological boundaries and problem use of the Internet among adolescents?

METHODS

Participants

Participants were pupils in grades 8-11 of secondary school in Velikiy Novgorod Russian Federation). All the pupils were invited to participate in the study. Pupils from math, humanities, socio-economic, and technical classes were selected to participate in the study to reduce the impact of educational orientation on the results of the study. The final sample consisted of 7- adolescents (37 males, 33 females; $M = 16.03$ years, $SD = 1.26$).

Measures

The survey method and psychodiagnostic testing were used to collect empirical data. The study was organized by comparative type. The total sample of adolescents was divided into three groups according to the used number of IoT devices. The 1-st group (20% of the total sample) includes respondents with 2 IoT devices; the 2-nd group (56% of the total sample) includes respondents who have from 3 to 6 IoT devices; the 3-rd group (24% of the total sample) includes respondents who have from 7 to 12 IoT devices.

Demographic items and IoT usage. A questionnaire was used that incorporated demographic questions, and others measuring IoT usage. Demographic questions: 1) Gender: Male/Female; 2) Age, 3) Grades of secondary school. IoT usage items included questions about the number of smartphones, personal computers, tablets, smartwatches, smart speakers, video game console, eBooks readers, fitness trackers, internet applications for home appliance management-owned, and total IoT count. The survey also included questions on types of IoT personal meanings: 1) The value of the IoT for a person (1 item); 2) IoT usage and maintenance of health (2 items); 3) IoT usage and home appliance management. The results of the survey determined the total number of IoT devices ($M=4.79$, $SD=2.61$, $min=2$, $max=12$)

Technique for measurement of changes of psychological boundaries while using technical devices (TPB-TD) (Emelin et al, 2012). The questionnaire consists of 32 statements and comprises 9 subscales combined into three domains:

1. Formation of IoT addictions: a) Impossibility of refusing IoT (3 items, Cronbach's α : 0.797); b) Excessive use of IoT, neglect of other matters, etc. (3 items, Cronbach's α : 0.684).
2. The change of psychological boundaries: a) expanding the boundaries in the sphere of communication (the illusory experience of the availability of other people using technology, as well as the expectations and actions associated with this experience) (3 items, Cronbach's α : 0.752); b) border violation reflection (awareness and negative emotional reaction to the violation of one's psychological boundaries as a

result of using IoT) (3 items, Cronbach's alpha: 0.635); c) preference for IoT due to its simplicity (3 items, Cronbach's alpha: was not measured); d) preference for IoT concerning the opportunities it offers (3 items, Cronbach's alpha: was not measured).

3. The formation of new needs: a) functionality (subjective significance of a technological device performing its main function) (3 items, Cronbach's alpha: 0.646); b) convenience (the subjective significance of the convenience of the technological device and the availability of all necessary additional functions) (3 items, Cronbach's alpha: 0.541); c) creating an image (representing a technological tool as an important component of one's image) (3 items, Cronbach's alpha: 0.796).

The questionnaire has several forms: for a smartphone, Internet, or computer. In our study, we used a form for a smartphone, since teenagers most often use it as a means of communication between IoT devices (Koroleva, 2016). The smartphone as a simple and accessible device with the Internet of things application performs the functions of receiving, transmitting data, managing and configuring devices, and can be used instead of a hardware controller (as in smart homes).

Problematic Internet use. The adolescents completed a CIAS – the self-rating questionnaire comprising 26 items, with a four-point Likert scale ranging from 1 (Does not match my experience at all) to 4 (Definitely matches my experience). The questionnaire was specially developed for assessing internet addiction (Chen et al, 2003). The scale (IA) is made up of five subscales: 1) compulsive use (5 items); 2) withdrawal symptoms (5 items); 3) tolerance (4 items); 4) interpersonal and health-related problems (7 items); 5) time management problems (5 items) and two integral indicators: 6) key symptoms of IA ($IA-Sym = (Com+Wit+Tol)$); 7) negative effects of Internet use ($IA-Rp = (In+Tm)$). The CIAS was adapted for use in Russia by V.L. Malygin et al. (Malygin et al, 2011). Cronbach's alpha fell in the range of 0.757 the scale of compulsive use to 0.9 on the scale of time management problems. IA test/re-test correlation on all subscales showed a good performance on reliability (a Pearson's correlation coefficient not less than 0.7–0.75).

DATA ANALYSIS

First, we calculated the percentages associated with the use of IoT devices and clarified the value of IoT usage for a person. We conduct the ANOVA to examine the indicators of changes in psychological boundaries and the CIAS scores in different groups of independent variables (total number of IoT devices). The independent variable was represented at three levels: 1) 2 devices, 2) 3 to 6 devices, 3) more than 7 devices. The Scheffe test to correct alpha to account for multiple comparisons. Then we compared the empirical results on changes of psychological boundaries while using technical devices with the normative data obtained in the study of Emelin et al. (2012). The empirical results of the CIAS scores were also compared with the normative data obtained by Russian researchers. The CIAS was adapted for use in Russia by V.L. Malygin et al. (2011). According to their report, the cutoff point at a score of 65 was used to define IA; ranges of 27–42 and 43–64 respectively were classified as normal internet use and problematic internet use (PIU). Statistical significance was set at a level of $p < 0.05$. The Statistica 10.0 software package was used for analyses in this study.

RESULTS

As a result of questionnaires among adolescents, it was revealed that adolescents use the Internet to implement various types of activity. So, 28% of adolescents define the Internet as a "limitless source of information", 25% as a means of communication, 17% to help with study and rest (recreation). 11% of teens can purchase various products online. However, only 2% of the study sample considers the Internet a space for selfrealization. The teenagers make extensive use of a variety of mobile devices and gadgets. 28.57% of adolescents use the tablets, 14.29% use electronic watches, and 14.29% the smart speakers. More than half of adolescents (57.14%) use e-books. 40% of them have 2 or more e-books. 50% of respondents wear fitness bracelets, of which 16.67% have 2 or more bracelets. A small proportion of teenage respondents use Internet applications for managing household appliances, only 7.14% of the total sample. They remotely control such devices like air conditioning and TV. However, the majority of adolescents (71.42%) use applications to track their health and emotional state. The most popular among teenagers is the measurement of the number of steps (32%), heart rate (29%), and the number of consumed calories (20%). 13% of teens track mood changes using online apps. The least popular is tracking the arterial pressure and the menstrual cycle of girls (3% of respondents each). Table 1 presents the results of the diagnosis of changes in psychological boundaries in the process of using mobile devices (the MIG-TS-2 technique). The total sample of adolescents was divided into three groups according to the used number of mobile devices (group 1 - 2, group 2: from 3 to 6, group 3: 7 or more devices).

As can be seen from Table 1, adolescents generally consider their life virtually impossible without mobile devices, cannot refuse them. At the same time, teenagers who have no more than 2 gadgets are experiencing the most inability to refuse to use the Internet of things. All the studied teenagers are characterized by a tendency to use mobile devices and the Internet of things: they feel uncomfortable if they are somewhere without a gadget, they want the devices to serve them as long as possible. The problematic use is also expressed in the subjective addiction on devices, their frequent use without any goals, in a large amount of time spent interacting with gadgets. In the communication process using mobile devices, adolescents of all groups experience an expansion of boundaries in communication, which is expressed as ideas about the greater accessibility of interaction partners, about the easiness of establishing and maintaining contacts. At the same time, adolescents using a small number of devices (no more than 2) are more likely to violate psychological boundaries in the process of using the Internet of things. They are less aware of breaking psychological boundaries when interacting with gadgets.

Table 1: Means and SD of changes psychological boundaries while using technical devices

Variables	2 devices		3 to 6 devices		more than 7 devices		Adj. pvalue	The data obtained Emelin et al. (2012)	
	M	S	M	S	M	S		M	S
Impossibility of refusing IoT	10.67	1.95	9.75	0.98	10.33	0.49	0.03	8.62	2.49
Excessive use	10.00	1.46	9.50	3.12	9.67	1.76	0.82	6.21	2.36
Expanding the	9.00	2.54	9.38	0.87	8.67	2.97	0.45	8.44	2.32

boundaries									
Boundaries violation reflection	6.67	0.98	7.75	1.10	7.67	1.76	0.02	7.35	2.32
Preference for IoT simplicity	9.00	2.24	6.50	2.09	6.67	2.44	0.00	5.78	2.11
Preference for IoT opportunities	10.33	1.29	8.38	1.43	7.00	0.85	0.00	6.91	2.26
Functionality	10.33	1.29	9.88	1.07	8.67	0.98	0.00	9.3	1.8
Convenience	9.33	0.49	9.75	0.84	9.67	1.29	0.31	8.92	1.51
Creation of image	7.67	0.98	7.25	1.94	6.33	2.97	0.19	6.38	2.54

They value simplicity, convenience as well as new features that the device provides. In this group is observed a change in needs. Of great importance is the need for the device functionality, for convenience and the presence of various additional functions. The gadget becomes a part of the personal image of such adolescents. In adolescents with a large number of different mobile devices, violations of psychological boundaries are less pronounced. Table 2 presents the parameters of problematic Internet usage in groups of adolescents with a different number of mobile devices.

Table 2: Means and SD of subscales CIAS

Var.	2 devices		3 to 6 devices		more than 7 devices		Adj. pvalue	The data of Malygin et al. (2011)		
	M	S	M	S	M	S		NIU	PIU	IA
Com	11.00	1.46	11.63	3.65	11.67	2.13	0.77	7.5	9.8	13.5
Wit	11.33	2.97	12.13	2.17	11.33	1.76	0.36	7.8	11.5	17.5
Tol	9.67	2.97	9.88	2.45	9.67	0.98	0.94	6.5	7.9	11.6
IH	10.67	3.20	13.88	4.82	13.00	2.54	0.04	8.8	11.9	17.2
TM	10.67	2.58	10.13	3.97	10.33	2.72	0.87	7.25	10.6	15.8
IA-Sym	32.00	6.09	33.63	7.63	32.67	1.76	0.69	21.8 7	29.4 7	42.6 6
IA-RP	21.33	5.75	24.00	8.24	23.33	3.99	0.46	16.1 2	22.8	33
IA	53.33	11.4	57.63	15.5	56.00	5.54	0.56	27-42	43-64	65 or more

Com - compulsive use; Wit- withdrawal symptoms; Tol - tolerance, IH - interpersonal and health-related problems; TM – time management problems; IA-Sym - key symptoms of IA; IARP - negative effects of Internet use; IA – Internet addiction; NIU – normal internet use; PIU

– problem internet use; IA- the overall level of internet addiction

Following the data on the results of the adaptation of the CIAS scale provided by

Malygin et al. the cutoff point at a score of 65 was used to define IA; ranges of 27–42 and 43–64 respectively were classified as normal internet use and problematic internet use (PIU). In the studied population only 15% of participants are characterized by normal Internet behavior, 64% by problematic Internet behavior, signs of Internet addiction were detected in 21% of schoolchildren.

The results of a comparative analysis of problematic Internet use showed that in the group of adolescents with 3 to 6 gadgets, the difficulties in interpersonal interaction and health problems associated with the Internet usage are pronounced most of all. The extent of other parameters of problematic internet usage does not depend on the number of the used gadgets.

DISCUSSION

The data obtained showed that adolescents are characterized by the use of a variety of mobile devices and gadgets, which make it possible to almost constantly access the network. They perceive the Internet mainly as a source of information and a space for communication. The Internet of things is used by them primarily for obtaining information, recreation, shopping, monitoring their health and entertainment, and much less often for controlling household appliances. In the process of interaction with smart devices and gadgets, adolescents experience changes in psychological boundaries. They are manifested, firstly, in the impossibility of abandoning devices, in experiencing dependence on interaction with them. In adolescents using a small number of mobile devices (no more than 2), changes in psychological boundaries are pronounced most of all. The gadgets and the Internet of things have a higher value and subjective value for them and play a significant role in the image creating. In general, adolescents, regardless of the number of the used mobile devices, are prone to problematic, non-functional use of the Internet. However, with the systematic use of several (from 3 to 6) gadgets, the adolescents experience more pronounced intrapersonal and communicative problems, as well as poor health due to their online presence.

CONCLUSION

The data obtained show that the main threats and risks of using the Internet of things and various gadgets for adolescents are their excessive, problematic use, which causes psychological dependence and a change in psychological boundaries. At the same time, the dependence of some characteristics of violating psychological boundaries and the problematic use of the Internet on the number of the used devices was revealed. The teenagers using 1-2 devices are prone to a personalized attitude towards them; attach great importance to convenience, simplicity, functionality; perceive gadgets as part of their image, and less reflect violations of psychological boundaries when interacting with the Internet of things. This can lead to a loss of privacy, a decrease in control over consumer behavior on the Internet. The teenagers with 3 to 6 different gadgets have a higher risk of Internet addiction associated with the emergence of personality and communication problems, health problems due to a constant stay on the Internet. A large number of "smart devices" used by adolescents can also increase their vulnerability to cyberattacks and theft of personal information. To prepare future teachers to ensure the information security of

students at the Department of Digital Education of the Herzen State Pedagogical University of Russia, the questions of information security of the person are studied in the framework of the course "Information Technologies" for Bachelors of pedagogical education of all faculties. The future teachers use the acquired knowledge not only to ensure their Internet security but also for transferring this knowledge to their future students. The main burden of preparing students for safe behavior on the Internet rests with the Computer Science teacher. Therefore, in the training of future Computer Science teachers in the courses of the department provides a special module "Ensuring the information security of the individual and educational institution" (Noskova, 2016). The module analyzes the threats to information security, classification of information threats, and counteraction to these threats. The issues of personal information security are analyzed in detail (information impact threats, image threats, psychological state of a person, norms of information culture, addictive behavior, etc.). A future Computer Science teacher should take part in ensuring the information security of an educational institution in the context of globalization. He/she should prepare his/her students for IoT information security measures. A feature of the modern educational and upbringing process is the formation of the student's ability to independently make decisions aimed at ensuring personal information security; the development of the way of thinking, attitudes, and views characteristic of the information society member. The information security of the student's personality can be ensured through the formation of the ability and willingness to recognize and regulate information hazards.

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Comparison of the Learning Outcomes and the usage of the E-course by Students through Residual Analysis

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Abstract

Nowadays, e-learning is an increasingly used concept. Therefore, it is important that the used ways and methods are constantly evaluated in an appropriate form. It is important for the teacher to have continuous feedback from the students. By means of the given educational system those feedbacks can be easily evaluated. They can be made through various approaches. Our selection in this research was to collect these records from the database of the given system. First of all, we cleaned, collected and after all we analysed these records in detail and extracted some recommendations for the teacher. We determined the provided activities of students from the -learning system. In this article we are dealing with an application about residual analysis over the educational data. We presented a simple methodology for students' identification who may have potential study difficulties. By means of the residual analysis we compared the records about the student's activities with their final grade from course in the e-learning system. At the same time, we introduced a simple approach to identify students with different levels of theoretical knowledge and practical programming skills.

Keywords

Residual analysis, Activity measurement, Course fulfilment, Analytical support.

INTRODUCTION

The basic concept of the data analysis in a specific virtual environment is primarily the data collection and the student performance indicators (Młynarska, Greene and Cunningham, 2016). Other perspective for the course evaluation is approaches from the data mining area (López *et al.*, 2012) (Abeer Badr El Din Ahmed and Ibrahim Sayed Elaraby, 2014). The received results can be highly helpful to make decisions and statements for the course improvement. The main goal of these kind of improvements is the betterment of the final grade and the knowledge base of the students. In the entire educational process is extremely important for teachers to understand the behaviour of students during their studies. There are many and various accesses, which values and how to measure them. One of the given solutions is to develop an own appliance (Robbins, 2011). By means of the appliance of these recommendations and own explanations we can measure the student's

engagement and the course appropriateness in the education. The goal of these previous metrics is to know which activities and which offerings to use in the given course. We can use various supports which is offered concretely in Moodle. This system represented an essential part of the given research, because it is a great tool for tutors to easily create and save teaching material on a collaborative online platform (Chaurasia *et al.*, 2011).

The given decisions in the course management should be stated on previous observations or statistically evaluated data records. These decisions are closely connected to the data analysis by means of the detected accuracies (Stencl and Stastny, 2010) (Skalka, 2018). These decisions should be proved over a pre-processed and evaluated dataset or identified accuracies.

The aim of the article is to refer the possibilities of a simple comparison from the available data about students. In our case it will be the data from the specific virtual learning environment (VLE) (Skalka, 2018) about the student activities. These are compared with the test results. We described a simple methodology for students identifying in the first part of the article. The methodology should identify for the teacher students who are not using the given possibilities of the VLE sufficiently in their studies. After this approach the teacher can find out the reason of the atypical behaviour of students in the course and can find opportunities for their motivation in further studies. The second methodology will focus on the theoretical and practical knowledge of students. We will try to identify students, who have considerable differences between theoretical and practical knowledge. Both described methodologies are inspired by residual analysis, that compares expected and observed values. In our research these values will be established from VLE data and final evaluations of students.

RELATED WORK

The basic related step for our work is the data extraction from the system or course. This task can be done over a beforehand defined web service (Felermino M. D. A. Ali, 2015). Similarly (Capay, Skalka and Drlik, 2017) have analysed the stored data about the students, who has access to a concrete course and they have access to a constructed curriculum. According to (Skalka, 2018) the data processing is an essential part of the content building and improvement in the given course. Thanks to (Drlík *et al.*, 2014) the fulfilment of the given course is very important. The authors summarized the beneficial perspectives from the directly analysed data. The descriptive statistics is a good form how to inform the teacher about different learning materials and activities (Martin, Adana and Asuero, 2017). According to previous statements the authors (Skalka, Švec and Drlík, 2012) defined three milestones of a course development lifecycle after the data evaluation process and they also split the important factors to three groups.

The intent of the residual analysis is to find appropriate indicators, which can differentiate two or more separated groups of students. The main goal of these analysis is to gain an insight into classroom characteristics (Papanastasiou, 2008). The achieved findings represent a useful guideline for teachers how to apply improvements to increase student's knowledge (Delavari, Beikzadeh and Phon-Amnuaisuk, 2005). Statistical identificatory represent a reliable result, which was used in comparison of the final grades and course usage statistics, by means of the surveys (Bachman and Bachman, 2011). One of

the applicable approach how to receive the previously declared accuracies is by means of the usage of the neural networks (Stencl and Stastny, 2010).

Our work deals with the data analysing and learning outcomes, which is linked to the field LA (Learning Analytics). LA is a useful approach to access and monitor the students learning and the quality of the given course in the concrete virtual environment. By means of the LA we can evaluate the quality of different course components as it was stated in the research (Demazière and Stöhr, 2015) (Shaun, Baker and Inventado, 2014). LA is primarily based on data analysis, therefore similar classification methods were presented in research (Minařík and Št'astný, 2008).

RESIDUAL ANALYSIS AS A STATISTICAL VERIFICATION FOR STUDENTS EVALUATION

Data preparation

We used the stored data from the course "Markup languages". The data was from the academic year 2019/2020 based on the given curriculum. More precisely we evaluated the first semester in the given academic year from September to December. This course is a part of our portal for the education available on: <https://edu.ukf.sk/>.

Course "Markup languages" contains various parts and areas. These areas were:

- discussion forums;
- lectures;
- sources;
- testing activities;
- mandatory assignments.

In the given course these were the key sections with sources. Students downloaded these materials from this course. The course represented the storage for these educational materials during the entire examined time period. We retrieved the data about all students of the course. The subject "markup languages" is a part of the bachelor's degree curriculum. The logged in students in the course were from the first year from their studies. In our experiment 88 students were included, and they were included into 4 groups of them during the semester. The data had to be pre-processed in the following way:

- external students' records removal;
- Moodle administrator records removal;
- data filtering and removal outside the given time horizon.

With this data preparation process we received the provided actions over each course module activities in the course. We created a contingency table, which represented the expected frequencies. The expected frequencies were calculated by means of the given formula:

$$E_{ij} = \frac{T_i \times T_j}{N} \quad (1)$$

This equation is to calculate the frequency where:

- E_{ij} – is the expected frequency for the i -th row and j -th column;
- T_i – total in the i -th row;
- T_j – total in the j -th column;
- N – total count of the records.

By means of the calculated frequencies we can detect how many times were the activities viewed by the selected and evaluated users.

We implemented data transformation, where we converted the final grades of students into percentages. This data transformation was made over the count of clicks in the course too.

The data for our analysis was the follows:

- multiplicity of the activity clicking in the course by students;
- the final grade from the theoretical test and the final grade from the practical assignment;
- result of the theoretical test and the evaluation of the practical assignments.

The results of the theoretical test and practical assignments established the overall grade from the course.

Table 4: Descriptive statistics from the source data

	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile
Theoretical test in %	51,9855	52,8351	0,00	92,000	42,0000	64,6031
Practical assignments in %	58,5940	61,5789	0,00	100,000	42,1053	76,9737
Final grade	46,8182	40,0000	0,00	100,000	20,0000	80,0000
Sum of activities	433,8068	391,0000	0,00	1001,000	287,5000	546,5000

The accomplished results from the theoretical and practical assignments were in the range from 0 to 100 % and the detected clicks in the given course was in range 0 to 1001. The clicks from students in the given course was not limited at all, but from them we can detect the visits of each activity. We can easily compare the students between each other, which helps us to rate them more objectively. The low value of the final grade is caused by that more than 17% of students did not pass the subject. The reason for that is they were not active in the course and they did not pass through the theoretical test. The practical projects were nearly related to the questions from the theoretical test, and in this case they indeed did not get the sufficient score from the final projects.

For the data comparison, and the data evaluation the data had to be arranged into an observable form. For this reason, we used data scaling, because the data were in different ranges and the figure was not quite interpretable.

$$Y = X - \mu \quad (2)$$

This equation is to calculate the mean centering of the observed data:

- Y is the received value after the scale;
- X is the data for scale;
- μ is the mean for the centering.

In the Figure 1 we are presenting the visualization of the outputs of descriptive statistics for the examined values.

For the comparison of examined values (count of clicks, final grades, theoretical test results, practical assignment evaluation), we were inspired by residual value analysis (Munk and Munkova, 2018; Munkova and Munk, 2015). This is established on the given concept:

$$data = model\ prediciton\ (function) + residual\ value \quad (3)$$

If we subtract the values obtained from the model (expected values) from the data (observed values), we obtain errors (residual values). By means of their analysis we can reconsider the constructed model. Selection residuals e_i are defined as:

$$e_i = y_i - \hat{y}_i \quad (4)$$

- where \hat{y}_i are the expected values predicted by the model;
- y_i are the observed values.

The residual values analysis serves to validate the given model and improve it by helping to identify the aspects of relationships that the model does not take it into account. For example, we can verify the stability of the regression model, by residual values analysis, i.e. identify the misstatement of the selected model – by displaying a correlation/scatter residual plot and independent variable. Residuals are a suitable indicators, by means of we can detect the differences between the actual and the predicted scores (Papanastasiou, 2008). It can give us an overview how huge is the disproportion of the selected and measured values. Residuals are difference between the examined quantities.

We used the following methodology to compare the data from the “Markup language” course.

1. Data acquisition – extraction and calculation of activities from the VLE log file for the investigated course. We were focused on records, which were marked as “viewed” and belonged to a specific student and activity in the log record.
2. Creation of data matrixes – number of clicks from log file and results from the theoretical test, practical tasks and final evaluation. These matrixes were created by means of the contingency tables. We included all of the activities and students clicking from course.
3. Data preparation – data centering and scaling.
4. Data analysis – residual analysis.
5. Results understanding.

Over these methods. After that we

RESULTS

The residual analysis is performed from two points of view:

- residual analysis of the number of course clicks and the final mark of the course. Its aim is to identify students, who were active in the course, but their final grade was weak. or students who were successful in the result, but their course activity was weak. The expected values for the residual calculation will be the count of clicks at the activities in the course. We assume that the dynamically usage of the course at studies will improve the final evaluation. The observed values will be therefore the results for the final evaluation.
- residual analysis of practical and theoretical knowledge from the examined course. We assume that the course is balanced in the terms of practical and theoretical knowledge. Students who have a good theoretical knowledge can handle the practical assignments in the course and the other way around. The analysis identifies students who have sizable differences between practical and theoretical knowledge. Their identification will help the teacher to further analyse these students and the teaching direction.

Residual analysis between the student's activities and final grade

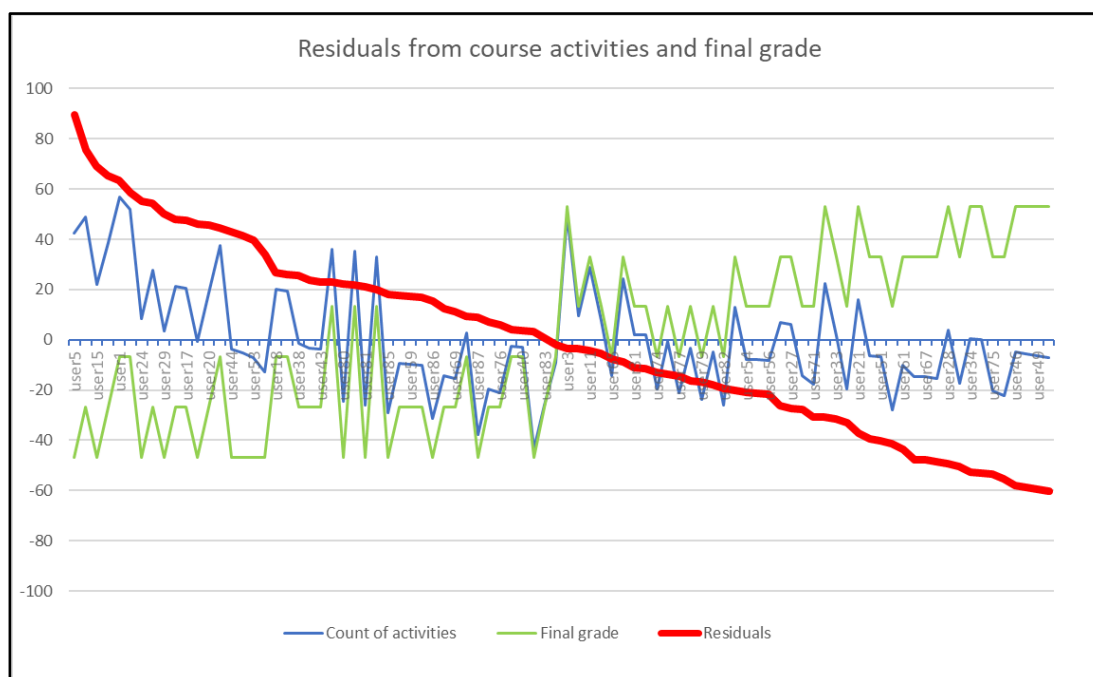


Figure 15: Residuals from the final grade and provided activities in course

The \hat{y}_i (expected values) are the count of the activities, which is provided by students in the given course. The observed values are represented by the final grade of the students. In other words, we examined how different is the clicking count due to the received final grade of students.

Our goal was to identify the students whose differences were extremely high in consideration of their final grade.

Residual analysis between the theoretical and practical knowledge of students

We examined another point of view for our analysis. Other measurable perspective is the relation between the theoretical test and the submitted assignments. The theoretical test contains 64 questions and the theoretical assignments were continuously submitted into the course. These measurable data were transformed into percentage values.

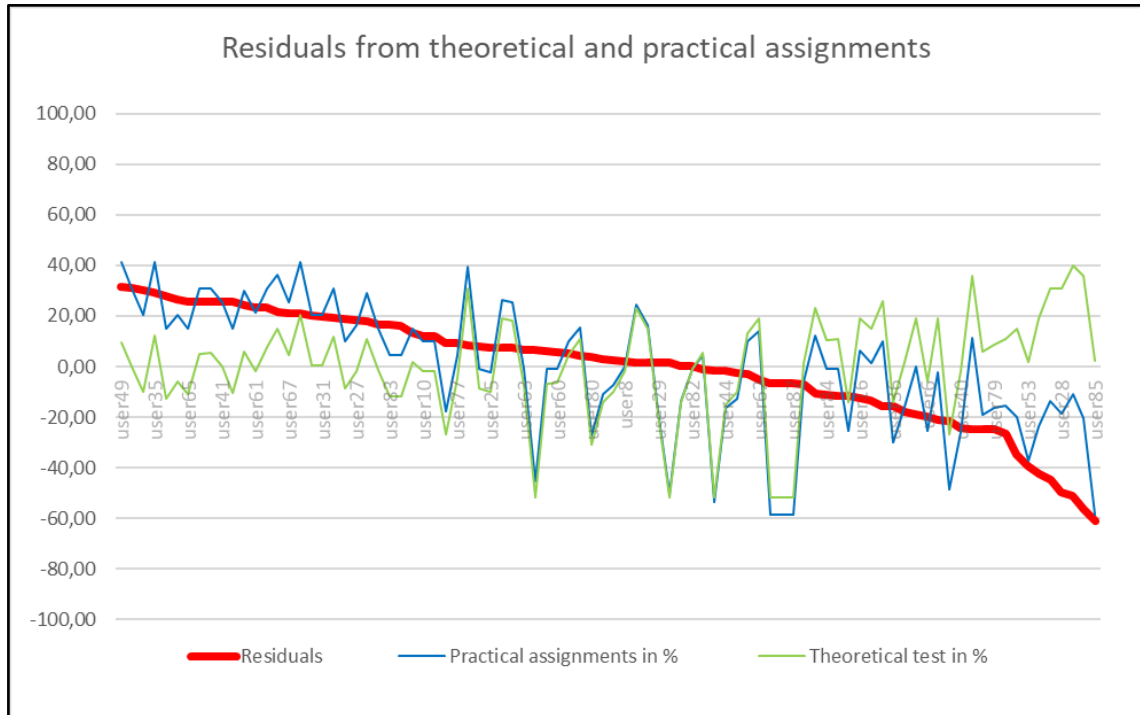


Figure 16: Residual analysis between the theoretical and practical knowledge

The \hat{y}_i is the percentage of practical assignments (expected values) in the course. The observed values are presented as a result of the theoretical test.

The aim of the residual analysis is to identify extreme cases. Extreme case identifies non-standard students. In our case on (Figure 1), these are students whose activity in course was high, but their final grade was not sufficient (user5, user15, user1, ...). The opposite were students with low activity but excellent results (user49, user46, user75, ...).

Similarly, on (Figure 2), by means of the residual analysis we can identify students with different levels of practical programming skills and theoretical knowledge. The Figure 2 describes students whose programming skills was sufficient, but the theoretical skills was flat (user49, user35, user65, ...). On the other side were students with low practical and more theoretical skills (user 85, user28, user53, ...). The extreme cases identification is possible from the residual graph (Figure1 and Figure2). We provided a very simple identification (the first three student with the maximal residual value and the first three with the minimum value). In case of the residual theory the extreme cases are determined by the rule $\pm 2\sigma$, what intend about cases outside the given interval.

$$\text{Average of differences} \pm 2 \text{ standard deviation of differences} \quad (5)$$

Another way of identifying the extreme cases is the quartile interval:

$$(Q_I - 1,5Q; Q_{III} + 1,5Q) \quad (6)$$

If we use any finding of extreme cases, even our simple ones a similar analysis should always result in identifying the problems of the identified students and the reasons that caused their “disproportionality” in teaching or in theoretical and practical training. This is the main reason for residual values calculation.

CONCLUSION

The main goal of our research was a statistical overview over the recorded data in the given course of “Markup languages”. After the data collection we had to use contingency tables to get the multiplicity of the measured values. After the adjustment and collection phase we had to provide data scaling, because the measured values were not from the same interval and the visualization was not quite understandable. We performed residual analysis, where we examined the accuracy of the subtracted values and we proved the stated expectations in our research. The provided activity by the students were an independent variable, but we took it into account with the received final grade of student. Our goal was to detect the degree of disproportionality of residuals to the observed values. We hope by this approach we can timely identify the students in which these differences between the theoretical and practical point of view are extremely high.

Our paper presents and overview study of the possibilities of residual analysis in educational data. In the future, we are planning to integrate the residual analysis capabilities and functionality into VLE Moodle teacher environment. The solution should provide a tool for the teacher to improve the educational process and to make better managerial decisions in the concrete VLE. The reason why we used the residual analysis for the goal of our article, was the simplicity of the interpretation of the extracted results. We can plainly identify the students whose valuation was somehow weird and it is not in concern with their provided activities and results during the semester. At the same time we can discuss about the subjective evaluation of the teacher, or the made course for the subject is inappropriately deployed and it requires modifications in the future.

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Social Network Analysis of Politician Statements on Social Networks

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Abstract

Social networks are an integral part of our lives these days. Most people have an account on some of the many social networks. Social networks are used for various reasons such as to express some opinion or to spreading this opinion. Many subjects take advantage of this situation and one group of such subjects are politicians. This paper aims to analyze the behavior of Czech politicians on social networks. The paper focuses primarily on the statements of politicians on social networks with related characteristics and with specific posts on social networks. The reason why we should be interested in this topic is to control politicians' behavior that affects also the way they express themselves and how they communicate. We used basic statistical tools and some metrics used for social network analysis to find out how this was done. The outcome of the paper expresses mainly the connection between the individual politicians and length of their posts on social networks. The result in the paper also shows the time distribution of individual posts on social networks.

Keywords

Social networks. Social networks analysis. Politicians. Social media.

INTRODUCTION

Social media (SM) represents an integral part of our lives. The individual services offer a great deal of power to control the crowds and convey information to them. Services such as Facebook or Twitter have a wider reach compared to interpersonal communication. SM offers two or more ways to communicate, unlike traditional mass media. SM represents an opportunity for both social interaction and product sales promotion. Twitter might have played important role in various social movements such as protests. A great example is the use of Twitter in the case of the Arab Spring (Khondker, 2011), where using of the network could speed up democratic processes. Recent changes in society give rise to scientific disciplines such as digital mobilization or social change. Not all participants are active or important in these changes of course. They also have a specific involvement in social movements and information transfers however.

The aim of this paper is to introduce possibilities how to identify the most important players in the social networking field using methods for social network analysis and assigning them some common characteristics in order to get an idea of how they can be further analyzed. The paper is focusing on the statements of politicians on social networks.

The paper analyzes important metrics such as betweenness centrality, indegree, out-degree, closeness centrality etc. We analyze each metric and assign each value to a given name. A more detailed description of the research area is describe in the next chapter.

This analysis will help to discover why some individuals are more important and what led them to do so. We can identify significant influencers for spreading information and influencing politician developments. It is possible to make a better prediction of the individuals' behavior and their influence on their social network based on this analysis. An important element is the analysis of the content, which we only touch briefly. A very important part is the analysis of the interaction, which we will not discuss in this article.

THEORETICAL BACKGROUND

Related work

Social Network Analysis (SNA) is used to look for structural relationships or networks that are formed by different organizations or participants (Knoke & Yang, 2019). SNA generally assumes that individual actors are involved in networking by connecting with other actively communicating actors. The behavior of individuals is an important element in establishing further contacts. Such actors could be individuals or social groups, organizations or statuses. The cluster is then a group of elements (actors), where a network of relationships forms further spreads of relationships between other actors. Each network is a living organism, which is constantly changing and creating new relationships. In the case of social media such as Twitter or Facebook, the network element is a specific account, and the cluster is a subset of different accounts linked with each other. It is possible to distinguish individual clusters according to different criteria and then divide them. Each account can create different connections even to unrelated clusters. It is possible to have a few nodes within the cluster as well as several thousands of nodes (accounts). It is generally assumed that individual accounts are communicating within a given cluster rather than outside of the cluster. However, such nodes create an environment for the further dissemination of information throughout the network. Such relationships then have a specific type of connection between nodes (Knoke & Yang, 2019). Relationships can be directed either when interacting or non-directed (mutual friendship). We will talk about the social network account as a node and the connection to another person mentioned below as an edge.

The position of the node within the network can then determine the influence that the node has on the network itself (Burt, Kilduff, & Tasselli, 2013). Influence can be characterized as the effect that someone or something has on the way someone else or something else works or develops (Monge, Peter, Contractor, Contractor, & Noshir, 2003). Nodes can focus on strengthening relationships or building bridges between other nodes or between other clusters (Burt et al., 2013). It is believed that the strength of interaction within a cluster is usually stronger than a connection that is outside the cluster. Strengthening the relationship between the nodes then leads to an improvement in the overall cluster, but it can also have a negative impact that the node can often receive redundant information. On the other hand, if a node is outside the cluster, it can lead to better dissemination of information, because a node that has links to other clusters has the advantage of receiving various information that may not exist within the cluster. All of this,

of course, compared to other nodes within the cluster. In this way, an individual who has a weak connection within the cluster but has a connection outside the cluster can affect events in two clusters.

There are a number of centralities in the literature to analyze the behavior of individuals within a social network (Knoke & Yang, 2019; Newman, 2004a, 2004b). Indegree centrality (Hajian & White, 2011) serves to inform about the number of directional links to the actor from other actors whereas out-degree centrality refers to the number of directional links from the actor to other actors.

Betweenness index (Carrington, Scott, & Wasserman, 2005) is another important measure of node's influence in the network. This index means shortest path between pairs of vertices in a network that pass through a vertex (Newman, 2004b). The higher the value is the more influence a node has with spreading information in the network. Such a node is called a broker (Freeman, 1978) or a bridge between different subgroups (Gould & Fernandez, 1989). Communication between subgroups may be very difficult due to different specialization of such groups. Betweenness centrality is more important metric compared to degree centrality.

Closeness centrality is another important metric that measures average distance to all other nodes in the network. The higher score is the shortest distance is to all other nodes. Individuals with high closeness centrality are in position to control and acquire information within the organization (Krebs, 2002). Closeness centrality is possible to interpreted as an estimated time of arrival of information within telecommunication or package delivery networks (Borgatti, 2005).

This paper should bring new view on social media communication between politicians in Czech republic. Paper combine different statistics for measuring activities on social media.

EMPIRICAL RESEARCH

Method

For the purposes of this work, we have analyzed the statements of politicians on Czech social networks, specifically on Twitter and Facebook. The data comes from a database of politicians' statements (Bláha, 2020), which is constantly updated. Due to the large amount of data, we have analyzed only the data available for the entire year 2019. The database collects individual statements (or posts) of all politicians who have an account on social network. The database contains 172 819 records for the entire period which is from 2009 to the present days. The activity of politicians was not at the same level at the beginning as it is in these years. We selected such records where individual politicians refer to another politician for the purpose of this paper. We conducted basic statistical analysis and social network analysis based on this data. The total number of these records is 88 297. Therefore, analysis performed only for records that were conducted in 2019 and the number is 28 858.

We created a JSON file from these data and we analyzed primarily using applications that are suitable for social network analysis. We used C # language in the Visual Studio development environment and subsequent analysis was performed in NodeXL application that processes data in MS Excel. Based on this data, we then generated a network of elements that depicted specific links to each politician. Due to the large number of both

politicians and references, we have made a reduction, which is particularly evident in the following tables. We have always selected only the most active politicians to show individual results. In some cases, there is only one politician reference, and a graph that depicts such a situation would be very confusing. All data and descriptions are then based on the default database (Bláha, 2020), so as not to disturb the overall order of the data. Therefore, we kept the names of politicians in the format provided by the database. Another essential part of the analysis of the politicians' statements is the analysis of the textual part. We show basic statistics in this paper and we discuss this statistic in the next chapter.

Model testing results

Table 1 shows the total number of words that each politician wrote for the year of 2019 on both social networks that we followed. As you can see, the most active politician is Tomio Okamura, with 649 889 words, with the greater part occurring on Facebook (more than 95% of all written words). In second place is Prime Minister Andrej Babiš with a total of 251 111 words, with Facebook posted over 83% of all words. In any case, the total number of words is only 38,6% of what Tomio Okamura wrote. Other places are followed by Petr Fiala (13,8% of total words against Tomio Okamura), Miroslav Kalousek (9,5% of total words against Tomio Okamura) etc.

From the overall overview, it is clear that most politicians are more active on Facebook rather than Twitter. One important reason is that only 140 characters it is possible to write to one post on Twitter, while the length of text on Facebook is virtually unlimited. However, one of the exceptions is Miroslav Kalousek, who is more active on Twitter. This may also be because the target group of voters appears more on Twitter where Kalousek is very active.

Table 1: Number of words for each of social media

Politician	Count of words		
	Facebook	Twitter	Total
tomio-okamura	620020	29869	649889
andrej-babis	208548	42563	251111
petr-fiala	64593	25694	90287
miroslav-kalousek	15066	47023	62089
alena-schillerova	37068	23400	60468
vladimir-kremlik	39570	13993	53563
jan-zahradil	14374	37475	51849
jana-vildumetzova	46640	935	47575
adam-vojtech	31071	15439	46510
jan-hamacek	20503	21315	41818
karel-havlicek	7445	33089	40534
zdenek-hrib	29807	5201	35008
radek-vondracek	21595	11174	32769
jan-bartosek	18365	13116	31481
alexandra-udzenija	22933	8181	31114
vera-jourova	0	30791	30791

Table 2 shows the average number of words per post. Word count affects how a particular post is perceived (Yoon, Syn, & Tippet, 2019) and it is definitely not appropriate to have very long posts. However, there are politicians who do not perceive this and have long contributions. A typical example is Tomio Okamura with an average of 231,85 words per post. This is followed by Petr Vokřál with 155,53 words per post (approximately 67% of what Okamura), Jaroslava Jermanová (about 59% of what Okamura) etc. Andrej Babiš has very long posts, but with an average of 79,54 words per post occurs only in 10th place.

Table 2: Average number of words per post

Politician	Count of words		
	Facebook	Twitter	Total
tomio-okamura	335,87	31,21	231,85
petr-vokral	158,21	43,00	155,53
jaroslava-jermanova	138,48	0,00	138,48
radek-holomcik	147,84	16,00	119,30
jana-vildumetzova	127,08	29,22	119,24
jana-pastuchova	113,11	0,00	113,11
milos-zeman	103,35	0,00	103,35
ondrej-kolar	101,56	0,00	101,56
klara-dostalova	99,49	0,00	99,49
andrej-babis	134,11	26,57	79,54
vladimir-kremlik	133,68	33,48	75,02
herbert-pavera	74,82	36,31	69,86
zdenek-hrib	93,15	26,67	67,98
jan-farsky	65,51	0,00	65,51
vlastimil-valek	118,85	28,37	62,01
petr-hladik-11	80,30	25,42	61,46

Figure 1 shows the total number of words per month for the five selected politicians. They are mainly the most active. As is evident, for example, Andrej Babiš was not so active on Facebook throughout the year, but the total number of his comments rose during September. This activity may have a reason in a published case with subsidies from Agrofert. Tomio Okamura has been more or less active throughout the year, but he also rose significantly at the end of the year. Other politicians are no longer so active. Data for December is low, which may be because Christmas season when activity of politicians on social networks is declining.

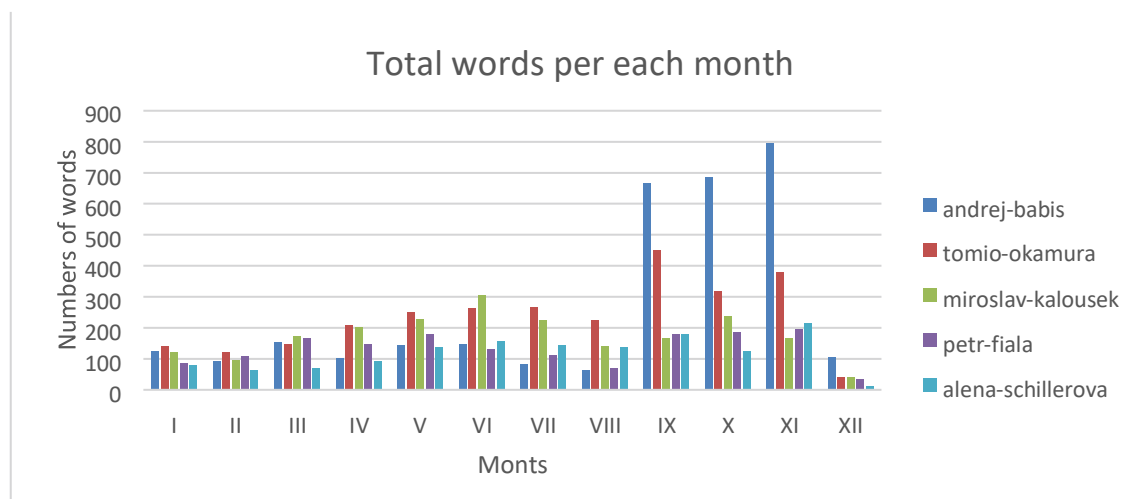


Figure 1: Total words per each month for five most active politicians

An important element is the analysis of connections with other nodes within the network. The following table 3 is sorted by in-degree centrality, which expresses how many other politicians referred to that politician. Table shows only chosen politics, total number with this centrality would be 36. Prime Minister Andrej Babiš has the higher score of in-degree centrality. Results show that politician do not use the opportunity to connect to other politicians much. However, what the use is an indicator of out-degree centrality - how many other politicians refer to specific politician. Tomio Okamura is very active, he is referring to up to 255 different politicians. Andrej Babiš is on second place.

The highest score of betweenness centrality has Tomio Okamura again and Andrej Babiš is on second place. High value of Okamura's score is given by his activity not by activity of other politicians. The reason is his very low in-degree centrality score. The high value of Andrej Babiš is given by the fact that he is the prime minister and he is also part of problematic cases at the same time. Closeness centrality scores are very low generally, which is mainly because individual politicians are not closely connected to each other and because there are a large number of politicians in the network who refer to only one other politician.

Table 3: Metrics for chosen politician

Politician	Indegree	Outdegree	Betweenness centrality	Closeness centrality
andrej-babis	38	153	103242,8293	0,00105
jan-hamacek	17	41	14540,34118	0,000864
alena-schillerova	15	26	9866,758064	0,000833
adam-vojtech-1	14	19	6340,65711	0,00083
vera-jourova	8	2	935,222259	0,000786
petr-fiala	8	67	16936,43958	0,000847
tomio-okamura	8	255	143845,9421	0,001041
jan-zahradil	7	34	11394,53385	0,000812
radek-vondracek	4	22	5319,925898	0,000743
alexandra-udzenija	0	17	796,290424	0,000708

jana-vildumetzova	0	26	8553,50389	0,000696
karel-havlicek-30	0	10	68,237207	0,000678
vladimir-kremlik	0	25	7250,926622	0,000702
zdenek-hrib	0	34	6272,728734	0,000709

Figure 2 illustrates the visualization of communication between politicians. Due to the large amount of data, it was necessary to make some reduction. Politicians have been selected with an in-degree centrality higher than eight. Arrows represent directionality in the graph. The strength of the link then expresses the value of in-degree centrality, the stronger the link is the greater the in-degree value. It is possible to create many similar graphs but we chose just this such an illustration of better orientation in the given network.

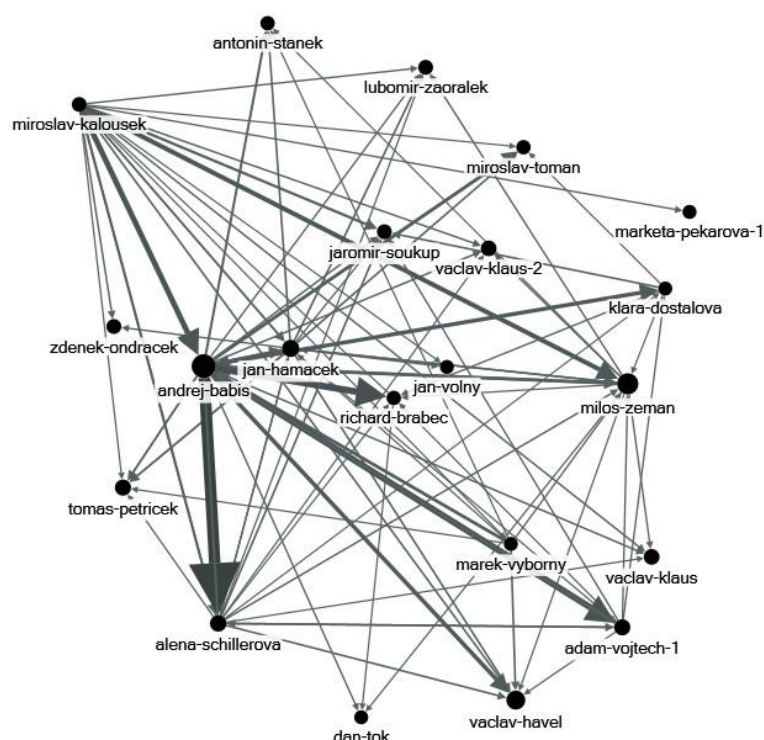


Figure 2: Visualization of communication between politics

DISCUSSION

We conducted an analysis of the communication of Czech politicians on social networks in this paper. Facebook and Twitter were chosen as social network because these networks are widely used in Czech Republic. The data were obtained for the year of 2019 and include individual posts on social networks, date of origin, number of words in each post and links to other politician. We performed basic statistics analysis and subsequently analysis of behavior on social networks. It is recognizable which politicians are active and how they

express themselves on social networks. Obtained data show mainly the number of words in one post and in what period politicians are active. The reference to other politicians is also an important aspect. However, they do not use much of this feature of social networks.

The data show that a very active member is the Prime Minister. It is known that his account manages more people. Tomio Okamura is also very active on social networks. The Prime Minister is also an active element in referring to other politicians. This fact may be due to ongoing cases around Andrej Babiš.

Betweenness centrality means the shortest path between every pair of vertices in connected graph. The betweenness centrality for each vertex is the number of shortest paths that pass through the vertex. The higher value is the more important the vertex is in meaning of connecting some subgroups. High value of the betweenness centrality has Tomio Okamura and Andrej Babiš.

Closeness centrality measures the mean distance from one vertex to another vertex and means shortest path through a network between two vertices. The lower value is the better access information at other vertices is. Actually, the closeness centrality is very low in our study. It means that politician does not have strong connection between each other. A very interesting element of further analyzes would certainly be the content analysis, especially with regard to finding the topic of the text with further analysis designed to determine the temporal and spatial aspects. It would be very interesting to find out whether there are certain patterns in the written text and whether these patterns are using to deduce who the politician is. Another interesting way could be to find out the mood in the context with corresponding mood of politician's electoral base.

We selected data just for year of 2019 but previous period data are available also therefore it would be interesting to find out how the relationship between politicians evolved through the time. It is possible to deduce politicians' behavior from data on current political cases but we should verify this statement. A typical example is the increased activity of the Prime Minister of the Czech Republic in the period of September - November, when an effort to transfer attention to other topics can be expected. This would be suitable for text and content analysis. In the future, it is assumed that I will focus more on these topics.

CONCLUSION

The data collected and analyzed provide a better picture of the overall society and the behavior of politicians on social networks. The analysis confirms the validity of both the data obtained and the analysis itself, which is appropriate to understand how individual politicians create their image outwardly. The analysis also confirm that politicians should use social networks for their promotion and better control of their behavior. If the textual and content analysis were also carried out, it would be useful to review them and draw attention to what they have published in the past. Politicians also mostly focus on Facebook, which is also because this social network is the majority of the population of the Czech Republic. However, it is also possible to focus primarily on other networks. However, this would be for further analysis, especially for the behavior of the electoral base of individual politicians. In the future, I would like to focus primarily on the content analysis of individual messages and on the comparison of behavior over time.

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Can Fake News Evoke a Positive/Negative Affect (Emotion)?

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Abstract

People meet almost daily with information from various sources. Whether it is television, radio, newspaper or internet. Most of the information is taken as reliable but some do not contain only truth. Fake News influences also university students and sometimes the news comes even from politicians. This paper deals with the analysis of student's reactions to Slovak politician's verdicts. The students evaluated the truthfulness of the politician's verdicts of the migration crisis topic. The students also selected what affection the politician's verdict made on them (positive, neutral or negative). Each politician's verdict was rated using the sentiment analysis. Several interesting results have emerged in the field of perception of politicians and their verdicts by university students of Applied Informatics. In general, verdicts were perceived rather negative but verdicts, where the author was known, were perceived even more negatively, as confirmed by the analysis. The correlation analysis showed that students tend to trust the verdict even if it is not true because they have judged true verdicts fairly often, but misleading (false) verdicts are more often misjudged than the true ones.

Keywords

Emotional Response. Fake News. Sentiment Analysis. Affect. Migration Crisis.

INTRODUCTION

Dissemination of fake news has a bigger impact now than ever before. Social media and the internet serve as a great place to spread any information. Often it depends on the user whether he/she trusts the information or not. The main point for every user is to check the source of the information. If the source is reliable then it is assumed that also the information can be trusted. The problem is when the source of the information is a politician. Some politicians do not speak the whole truth or misinterpret the information given to the people. Sometimes it can take years to discover the truth or lie.

Many people trust politicians blindly and do not doubt their words. In Slovakia, this has proven many times that people do not mind politicians that misinterpret the information. It is not said that all politicians lie or misinterpret the information but some of them do. The study of this paper is focused on Slovak university students and their trust in the words of Slovak national politicians. It is said that younger people work with smartphones and computers a lot. This research is focused on students of Applied Informatics that should be

even more versed in working with information. The paper aims to discover how the politician verdicts influence the university student's trust. Whether the students trust anything blindly or do have critical thinking and can work with information.

The rest of the paper is structured as follows: Section 2 is focused on the related work dealing with emotions and fake news. Section 3 describes the materials and methods used for the research. Section 4 presents the results of the experiment. Subsequently, the discussion and conclusion are offered in the last section.

RELATED WORK

Charles Darwin has already studied the emotions and their effects on human behaviour. However, his work had focused primarily on the physiological manifestations of emotional states that can be observed on the human face. Darwin's theory was subsequently verified during the 20th and 21st centuries by several extensive studies (Ekman et al., 1969; Ekman and Friesen, 1971; Matsumoto et al., 2008; Matsumoto and Assar, 1992; Røysamb et al., 2018; Songa et al., 2019) and different models of emotion classification have been defined—from universally experienced basic emotions to unique and complex emotions (Balogh and Kuchárik, 2019; Francisti and Balogh, 2019; Lövhelm, 2012; Plutchik, 1980; Weiner, 1980; Wundt, 2017). However, two models differed from each other: the basic classification of the six emotional states according to Ekman (Ekman, 1992) and the Russel circular complex model of emotions (Russell, 1980).

Bakir and McStay (Bakir and McStay, 2018) considered the correlation between fake news and emotion. The authors claimed that what is most important in today's false reports is their emotional focus on the reader (potential report recipient). As an example, Bakir and McStay mention the so-called emotional economy that was also used in Donald Trump's 2016 presidential campaign on Facebook. The basis of the emotional economy is in the emotions that are used to gain attention and time in advertising or reading messages (EdgeRank machine learning algorithm from Facebook from 2010). Silverman reports that populist, mostly pro-trump, fake news stories spread during the 2016 presidential campaign, especially on Facebook. In terms of the truthfulness of the statements, they have often generated more audience engagement than real news (Silverman and Lawrence, 2016).

Bhutani et al. (Bhutani et al., 2019) proposed a solution for fake news detection by combining fake news and sentiment analysis. The authors evaluated their approach on three different datasets and combined different methods of fake news detection. Sentiment analysis can offer a different approach to the analysis of texts. In this regard, Allen and McAleer (Allen and McAleer, 2018) published interesting research in terms of spreading fake news and linking it to emotions, entitled *Fake News and Indifference to Scientific Fact: President Trump's Confused Tweets on Global Warming, Climate Change and Weather*. Analysis of President Donald Trump's tweets on global warming was done using a method that calculates the sentiment rate of individual words from tweets. The algorithm divides strings into words (based on spaces) and looks for affinity scores for each word (within a scale from -5 to +5). This way the authors were able to categorize five different emotions of sentiment, namely joy, sadness, anger, fear, and surprise, to reveal information about the emotional nature of the analyzed text or string. However, Allen and McAleer (Allen and

McAleer, 2018) also point to the limitations of the analysis, which is the context of “natural language processing”. For example, the use of sarcasm and other types of ironic language is itself problematic for the processing of sentiment. This problem was particularly evident when analyzing President Trump's tweets.

Fake News influence not only adults but also students. Younger people are more prone to trust fake news. Working with information is part of their study during high school and also at university. Giroux (Giroux, 2018) dealt with this issue in his article in more detail. The paper is focused mainly on the USA education but can be also applied to other states. The students should be learned not to trust any information that is placed on the web without a reliable source. Already in high school should the teachers educate the students to work with information and improve their critical thinking. The impact of the fake news on students could result in more extreme point of view. This could also influence the results of national or regional elections. One of the solutions to this rising issue could be in organizing workshops with the need to educate the teachers as proposed by Summers and Riley (Summers and Riley, 2017). Surjandy et al. (Surjandy et al., 2017) analyzed the university student game player dissemination of fake news and the awareness of receiving fake news by the university student game player. The authors focused on the use of smartphones for the dissemination of fake news. The results of their experiment showed that university student game players or not mainly do not participate in adding fake news to forums or put misinformation on the web. Chandra et al. (Chandra et al., 2017) dealt with a similar issue as the previous research. The authors focused on the usage of a LINE mobile application that connects people with numerous groups. The research aimed to measure the awareness of spreading and receiving fake news by higher education students. The results of the research showed that higher education students do know that they need to do advanced research on the news and that the news should contain a reliable source. Khan and Idris (Khan and Idris, 2019) surveyed to analyze the ability to recognize false information and the behaviour of sharing information without verification. The authors found out that the perceived self-efficacy to detect misinformation on social media is predicted by income and level of education.

METHODS

The research was conducted with 108 university students of Applied Informatics that were given a questionnaire containing 53 questions. The questionnaire contained Slovak politician verdicts that were recorded on an online website demagog.sk. This website evaluates the Slovak politician verdicts whether the verdict is true, false or half-truth. The website contains more than 3 000 Slovak politician verdicts from which were chosen 50 verdicts of one specific topic. The chosen topic was politician verdicts about the migration crisis in Central Europe. In 2015 and 2016 the EU experienced an unprecedented influx of refugees and migrants where more than 1 million people arrived in the EU (The European Union Publications Office, 2017). Most of the refugees were fleeing from war and terror in Syria and other countries. This topic hit Central Europe hard and many politicians started to abuse the ignorance of people and plant the seed of fear into the people. There was much false information about economic migrants or terrorists placed between the fleeing refugees. Nowadays we can say that Slovakia was not hit hard by the migration crisis and many politician verdicts were just more of a hoax than truth.

The questionnaire was divided into two variants. Both questionnaires contained 3 general questions about the student's age, gender, and political party affection. Next, there were 50 Slovak politician verdicts of the migration crisis topic. One variant of the questionnaire contained the politician verdicts with the politician's name and party affiliation and the other one was without the politician's names and affiliation. The variant with the politician names was undertaken by 52 university students and the variant without the politician names by 56 university students. The politician verdicts from the website demagog.sk were divided into truth, not true (lie) or half-truth. This was information not known to the students undergoing the questionnaire. The student would choose whether he/she thinks that the verdict is *true/false/can not decide*.

In addition to the *true/false/can not decide* the question, each verdict was evaluated also by affection (emotion). The student was to decide whether the politician verdict affects him/her positive, neutral or negative. This could be then compared to the sentiment rate of each politician verdict. Research of positivity or negativity of the examined verdicts, the so-called sentiment of verdicts. The verdicts were divided into words that were prepared using TreeTagger software (Schmid, 1994). It was necessary to convert all the words to base form (lemma) and also exclude the stop words from the analysis. This was done using TreeTagger that supports the morphological analysis of Slovak language and exports the results in the form: source word, morphological annotation, and lemma. After the data preparation, the sentiment rate for each verdict was calculated using an algorithm created in the Python programming language. The sentiment analysis was done using the basic method of determining the sentiment based on the difference between positive and negative words in the verdict. It was assumed that the sentiment rate of the examined verdict should correspond with the measured student affection for the verdict.

The student's sample was represented by the students of Applied Informatics. The experiment included 17 female students (15.74%) and 91 male students (84.26%) from the age range of 17-26 years old. These students represent all university grades. It was assumed that this sample would result in a high success rate of evaluating the politician verdicts of a topic that is already closed. It was assumed that there should be significant differences in the success rate between younger and older students.

The results of the questionnaire were processed into a data matrix and variables were created for each politician verdict (Magdin et al., 2019b). The data matrix contains also the information about the age, gender and preferred political party and also sentiment rate calculated for each verdict. It contained also the recorded student reaction for each verdict, recorded emotion, and the real truth value for each politician verdict obtained from the website demagog.sk. Statistical evaluation was done by creating groups based on the examined parameters. The results for the groups were compared using Independent Samples t-test and Kruskal-Wallis test. The correlation between individual variables was examined using Pearson's correlation coefficient.

RESULTS

The experiment was focused on exploring various aspects of university student's perception of international as well as domestic political and social events. In the questionnaires filled out by the students, it was found out how the students were

emotionally influenced by the verdicts of politicians on the subject of immigrants coming to Europe. The students were to assess whether they considered the verdict as positive or negative information/fact. The students were also asked whether the verdict was true or false. During the experiment were tested several hypotheses using appropriate statistical methods.

The questionnaire contained 50 verdicts from Slovak politicians from governmental and non-governmental political parties. This was followed by the verdicts of the politicians themselves which the students were supposed to evaluate with the values True/False/I cannot judge, and also whether the verdict affects the students in Positive/Negative/Neutral way.

Each verdict was assigned a truthfulness, i.e. whether it is the truth, false, or half-truth. This information was hidden from students. Before the data was collected from the questionnaires, for each verdict was done the sentiment analysis (Table 1), using which was assigned a rate (coefficient) to the verdicts that expressed the sentiment of the given political verdict. The coefficients were from -1 to 1.

Based on the truthfulness of the verdicts they were divided into three groups: Truth - T, False - F, Half-truth - H. Based on sentiment values, the verdicts were divided into two groups. If the sentiment value was negative, the verdict was put into the group “-1”, if the sentiment was higher than 0, the verdict was put into the group “1”. For these groups, were compared the averages of responses focused on the emotional impact (affect) of the verdict using the Mann-Whitney U test, because the condition of equality of variances of both groups for this variable is not met and it is necessary to use one of the nonparametric methods. This also applies to all subsequent analyzes.

H0: There is no statistically significant difference in emotional perception (affection) of verdicts with negative and positive sentiment.

Table 1: Analysis of differences in average emotional perception of the verdicts based on sentiment (Mann-Whitney U test)

Variable	-1	1
Average Affection	71	280

p-value = 0.006493

Table 1 shows that the Average Affection for both groups is negative, suggesting that the general perception of the selected verdicts was rather negative. Based on the Independent Samples t-test, the H0 hypothesis is rejected. It means that the emotional perception of the students of the given verdicts corresponds with the results of the sentiment analysis. Thus, the perception of negative sentiment verdicts was more negative than the perception of positive sentiment verdicts. This analysis confirms the accuracy of the Sentiment Analysis rates which were calculated independently of the results of the questionnaires.

The source set containing answers that were analyzed was structured as can be seen in Table 2. In addition to the above statistics, each record contained the information about the age, gender and preferred elected political party for each student. This information is not included in the Table as there is already too much information depicted. Each student's record contains the information whether he/she will go to the elections, whether he/she knew the author of the verdict, how many answers were correct, incorrect and how many

were answered and not answered. The variable *AVG affection* (E1-E50) contains the average value of the student's answers to question how the verdicts affect him/her. The variable *AVG answer* contains the average of all student's responses to the question of whether the verdict is true (F1-F50). The success rate is the ratio of correctly identified true verdicts to incorrectly identified verdicts (based on FC1-FC50). The data contains each student's answer that can be seen in the dataset (Magdin et al., 2019b). The variables F1 – F50 have values of the student answer to the truth of the verdict (*True* = 1, *False* = -1, *Abstain* = 0). The following variables FC1 – FC50 evaluate the answer of the student to the verdict (*Correct* = 1, *Wrong* = -1, *Abstain* = 0). Furthermore, the variable E1 – E50 deal with the evaluation of the affect the student had to the examined verdict (*Positive* = 1, *Negative* = -1, *Neutral* = 0).

Table 2: Sample basic file

Id	Will vote	Know author	Correct	Wrong	Abstain	Answered	AVG affection	AVG answer	Success rate
49	Y	1	5	6	39	11	-0.14	-0.22	0.45
50	Y	1	11	16	23	27	-0.36	0.06	0.41
51	Y	0	15	22	13	37	0.12	0.1	0.41
52	Y	0	15	12	23	27	-0.2	0.46	0.56
53	Y	0	1	5	44	6	-0.04	0	0.17
54	Y	0	14	27	9	41	-0.12	0.14	0.34

Next, was analyzed whether there was a difference in the emotional perception of politicians' verdicts based on whether they knew who pronounced the verdict.

These differences were analyzed using the Mann-Whitney U test. This was verified by comparing the average response to the question of how the students were emotionally affected by the verdict. When the students were divided into groups according to whether they knew the author of the verdict, there were statistically significant differences. The following null hypothesis was verified:

H0: There is no statistically significant difference in the emotional perception of verdicts between students who knew the author of the verdict and students who did not know the author of the verdict.

Table 3: Analysis of differences in average emotional perception of the verdict according to whether or not the student knows the author of the verdict (Mann-Whitney U test)

Variable	Rank Sum for group <i>Know</i>	Rank Sum for group <i>Did not Know</i>
Average Affection	2431.5	3133.5

p-value = 0.0375

The obtained results mean that the emotional perception of the verdict is also influenced by the person who made the verdict. Table 3 depicts that the average values of both groups are negative and there is a statistically significant difference in the emotional perception of affection between the two groups. I.e. despite the significant difference, verdicts are generally rather negative.

Similarly, or even more significantly, the difference between groups that *Know* and *Did not Know* the name of the politician is based on the answers about the truthfulness of the

verdicts (this is not about the correctness of evaluation of the truthfulness of the verdicts), i.e. whether the verdict is considered true.

Table 4: Analysis of differences in the average evaluation of the truthfulness of the verdict according to whether the student knows or does not know the author of the verdict (Mann-Whitney U test)

Variable	Rank Sum for group <i>Know</i>	Rank Sum for group <i>Did not Know</i>
Average Answer	2366.5	3198.5
p-value = 0.012548		

Table 5: Analyzing the accuracy of the evaluation of the truthfulness of the verdict based on whether or not the student knows the author of the verdict (Mann-Whitney U test)

Variable	Rank Sum for group <i>Know</i>	Rank Sum for group <i>Did not Know</i>
Success rate	2756.0	2809.0
p-value = 1.000000		

As can be seen from the analysis (Table 4), the Mann-Whitney U test shows that the knowledge of the author of the verdict significantly influences the evaluation of the truthfulness of the verdict. This may have even more impact than the verdict itself and the meaning/understanding of the verdict. On the contrary, Table 5 can be seen that the correctness of evaluation of the truthfulness of the verdict does not affect the knowledge of the author of the verdict.

Therefore, it was assumed that student's knowledge of the author, the politician (whether popular or unpopular), who has pronounced the verdict, has a significant influence on the affection (emotion) that the verdict evokes in the students. Also, it has a significant influence on whether they perceive the verdict as true or false. Table 3 describes that there is a statistically significant difference between the groups and that the higher values of the evaluation of truth are in the group that did not know the author. This may mean that if the student knows the author of the verdict, he/she is already more sceptical and distrustful of the verdict.

Table 3 shows that the average values for both groups are negative. This means that the issue of immigration to Europe is perceived by students more negatively than positively. This fact is confirmed by the total number of averages of responses focused on perceived affection (emotion), where out of 50 questions asked, the negative average of answers was at 46 questions, zero at 1 question and positive average at only 3 questions.

The next analysis has not examined the data from the interviewed students but the verdicts themselves. This means that the average responses to the verdicts were examined, or whether they were correctly evaluated by students. I.e. if the student judged the verdict correctly, the student was assigned a value of 1 for that question, if it was incorrect (−1) and if he did not answer, then the value of 0 was assigned. The data obtained from the website demagog.sk was already evaluated whether it was a true, false or half-truth verdict. It was examined whether there is a relationship between the correctness of the judgment and the truthfulness of the verdict. The relationship of the truthfulness of the verdict was observed with two versions of evaluation of the truthfulness of the verdict:

- according to the original division from the website demagog.sk, i.e. Truth/False/Half-Truth (TFH);
- with the unification of False and Half-Truth because half-truth is also a partial lie, i.e. Truth/False (TF).

Correlation analysis, in particular, the Pearson correlation coefficient, was used to assess the dependence between these variables. Pearson correlation coefficient between the Accuracy of responses & TF was 0.6257 and between Accuracy of responses & TFH was 0.4964.

Correlation analysis shows that there is a statistically significant correlation in both cases, which means that whether the verdict was true or not has a significant impact on whether or not the question is assessed correctly. Because the correlation is positive, they have made true verdicts often but more often have assessed false verdicts wrong. This means that students tended to believe the verdict rather than not believe it.

DISCUSSION AND CONCLUSION

Based on the results of the research analysis, it can be said that the sentiment analysis evaluates the verdict in positive or negative sentiment. These values also confirmed the results of the questionnaire. Several interesting results have emerged in the field of perception of politicians and their verdicts by university students of Applied Informatics. Analysis of the data obtained from the questionnaires showed that age, gender, preferred political party, and whether or not the respondent would vote, did not affect the truthfulness of the verdicts (i.e. there were no significant differences in the proportions of judging the verdicts as true or false). If the student knew the author of the verdict, it also did not affect the ability to judge the truthfulness of the verdict, but it was more prone to disbelieve the verdict. It says that the perception of a verdict in the context of its topic and its truthfulness is less relevant to the perception of the verdict itself than the one who said the verdict. However, the knowledge of the author of the verdict had a significant impact on the emotional perception of the verdict. In general, verdicts were perceived rather negative but verdicts, where the author was known, were perceived even more negatively, as confirmed by the analysis. The correlation analysis showed that students tend to trust the verdict even if it is not true because they have judged true verdicts fairly often, but misleading (false) verdicts are more often misjudged than the true ones.

Based on the obtained results in comparison with (Chandra et al., 2017; Surjandy et al., 2017) it can be said that the Slovak university students are not as successful as the students in the other research in revealing the fake news. Politics is a specific topic that could have influenced the results. It can be said that this could have happened because the Slovak students do not take an interest in politics or the examined topic of the migration crisis. The identified results showed that there were almost no differences between the students. It was assumed that there would be at least some differences between the ages of students. This was not proven for the university students of Applied Informatics.

The future work could be done on a bigger and more varied sample of students. It would be interesting to compare the differences between university students from various study programs. The emotional reactions could be recorded using a better method than a

questionnaire, i.e. Magdin et al. (Magdin et al., 2019a). This could result in a more precise affection reaction and could improve the correlation with the sentiment analysis. The politician verdicts could be analyzed using morphological analysis (Benko and Munková, 2016) more deeply which could lead to discovering another connection to the truth or lie of the verdict.

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Evaluation of Personalised E-course in Computer Science Education

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Abstract

An important point of the successful implementation of a personalized e-course is the evaluation of the selected virtual learning environment. This article deals with the evaluation of using adaptive tools that are offered by Moodle when creating a personalised e-course. Part of the contribution is also a brief explanation of terms personalization and adaptivity, which are often mistaken or regarded as equivalent in practice. Authors represent a methodological framework using an adaptive approach of learning implemented in Moodle in order to improve students' grades in a tested area and make the learning process more efficient. The suggested methodology for creating personalised e-course adjusts the study content based on characteristics of each student stated by their initial knowledge, learning style, and motivation. The article presents the results of the evaluation of the suggested methodology on overall learning efficiency. The set presumptions are verified in the selected area of computer science education.

Keywords

E-learning. Learning Styles. Learning Management System. Moodle. Personalised E-course. Adaptive Approach. Effectiveness of Education.

INTRODUCTION

An upward trend of lifelong learning with the help of information and communication technologies (ICT) changes some roles and competencies of a teacher. The teachers have to flexibly respond to these changes and use modern methods in the educational process. Learning to the ability to use modern ICT effectively is becoming the most important competencies nowadays (Cápay, Magdin and Tomanová, 2012). According to many authors, digital competencies of teachers are the ones that create a connection between traditional learning and e-learning.

The educational process slowly starts to concentrate on the personality of the learner and the teacher becomes the tutor. E-learning has become a part of modern education thanks to various usages from presentation of digital content to LMS systems (Kostolányová, 2012).

Improving ICT and their application affects sharing and transferring knowledge (Mudrychová, et al., 2018). Today's students can study "anywhere and anytime ". They use

technologies not only for formal but also informal learning which they directly use in their study units at school or home using any device connected to the Internet. Using a virtual learning environment (VLE) affects planning, learning, proposing, checking and assessing educational process and providing educational content. Collective education in a classroom or via standard e-learning is not able to react to individual needs of students. Some students are able to get new information faster than this education form can do which leads to their dissatisfaction. On the other hand, for some, the pace is too fast and they cannot understand the problem in the needed extent.

Applications of ICT made it possible to connect the activities of a student with the requests of a teacher which enable the direction of gaining knowledge directly to the student. This was a presumption for accepting and creating a personalised approach to learners. Personalised teaching or personalised education means that the student takes over the responsibility for his or her learning and adapts to possible changes. Personalisation reacts to the needs and interests of students and it also teaches them how to manage their own learning – take over control and responsibility. It is not something that is done for them but something they take part in (Basye, 2018). Personalised learning is often drafted through instruction methods that involve adaptive technologies with the aim of helping all students achieve a high level of education, a so-called mastery (Basye, 2018).

The aim of this article is to evaluate the assumptions about the impact of the used methodology of personalized e-course. For this purpose, was chosen the subject from computer science education. Relevant outputs are results from a comparison of data taken from measures in control and experimental group of students

Personalisation of education in adaptive e-learning

In scientific publications that deal with the issue of personalised learning systems with adaptive methods, there is a certain differentiation in opinions about the terms adaptability and personalisation. This can be caused by multiple understandings of these terms. The terms adaptability and personalisation are not used in computer science education only, which can be the reason for various definitions. Firstly, it is important to realize that we are going to talk about activities that relate to teaching activities in computer science education, particularly to adaptive method of LMS. Kostolányová and Šarmanová (2016) understand the term personalisation as adaptation of solutions to various problems, situations, surrounding and other specific conditions and requirements of individuals. They also mention that when solving personalisation itself, these questions need to be answered:

- Who is it designed for?
- What is going to be adapted and in what way?

Personalised learning based on Klašnja-Milićević et al. (2017) is adaptation of methodology, syllabus and educational environment in a way it will suit the needs and learning style of individual students. Moreover, the difference between regular e-learning, which takes students as a homogenous entity, and personalised e-learning is that the latter one considers students as a heterogeneous mixture of individuals.

Mironova et. al (2013) divided students according to the results of the entrance test into 3 groups - beginners, intermediates and experts. The results were compared between a control and an experimental group of 150 students. Students of the experimental group

were tested for their preferences of learning styles by ILS questionnaire and based on the results they were recommended a study material.

Karagiannis and Satratzemi (2018) created 2 programming courses with the same content for their experiment, but an adaptive approach and progress bar were used for the experimental sample of the students. The aim of the analysis presented by the authors was to find out via attitude questionnaire whether their developed methodology helped students to improve their learning results, to learn more easily and whether the motivation of students to study was increased.

Evaluating the effectiveness of the educational activities used is an important aspect of e-learning. One of the possibilities presented by Balogh and Kuchárik (2019) is the correlation between the final evaluation of students and the materials and activities visited in the e-course. This kind of information can be used for changing e-course methodology or whole VLE if it is necessary. Therefore, in addition to the methodology used, it is necessary to evaluate specific VLE as suggested, for example, by Carvalho et al. (2011).

Suitability of using LMS Moodle in university environment

One of the serious shortcomings of new university students is their experiences with using VLE from previous secondary schools. While most of the schools in Slovakia use e-learning also via LMS Moodle, there are some school that do not provide this system or use a different LMS though. In the research that was carried out in 2019 with 133 students of 1st grade at DI at UKF was found that the majority (78.38%) have not used any LMS before studying at the university (Figure 1).

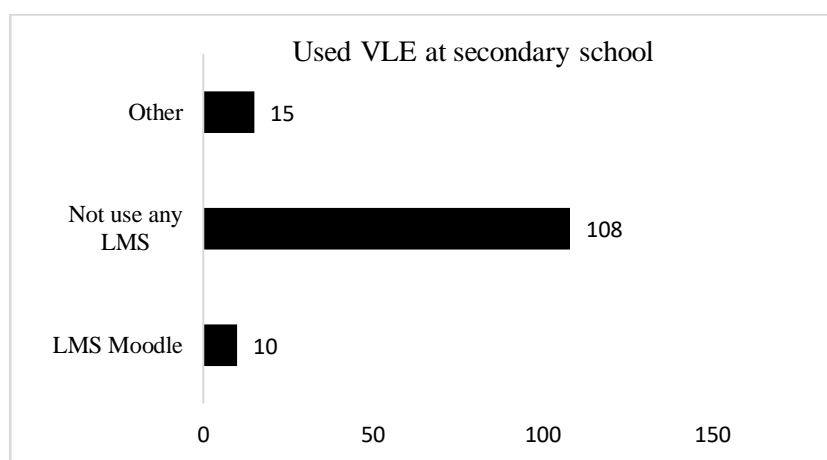


Figure 17: LMS used at secondary school, 2019 (source: own calculation)

It confirms that students do not have any experience with using VLE. This should be taken into account as a potential risk during acquiring new knowledge. There is a solution in implementing a school subject that would deal with the tasks in LMS Moodle environment and teach students to work effectively with e-learning environment at the start of the university.

Students also evaluated how satisfied are they with education via LMS Moodle at the end of the summer term. There was used a scale from 1 (totally dissatisfied) to 5 (totally satisfied). A positive preference of learning via LMS Moodle was chosen by 112 students (87.97%). As we can see in Figure 2, the results are in favour of the used LMS. Another

positive finding was that even though 7 students (5.27%) had negative preferences towards LMS, to the questions if they want a different VLE at the university, they answered no.

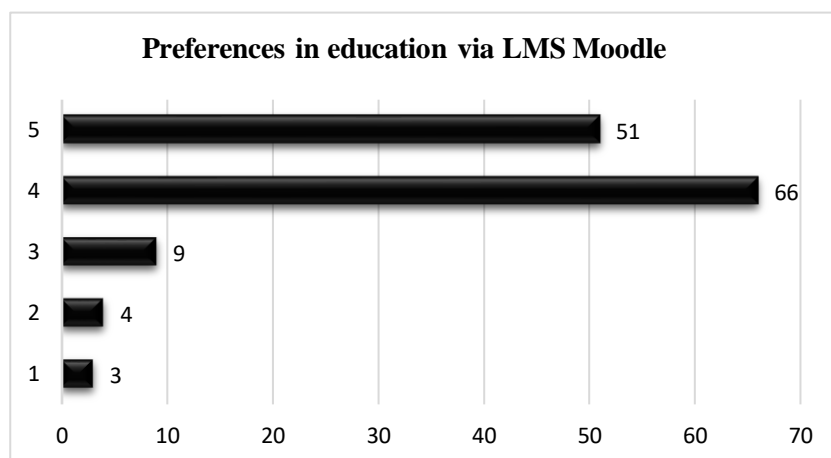


Figure 18: Preferences in education via LMS Moodle, 2019 (source: own calculation)

From the above findings, it is clear that most of DI UKF students are satisfied with the VLE used.

METHODS

Model of learning styles supporting personalisation of university education

Selection of an appropriate LMS system is only the first step in successful personalisation of education. In fact, it is a quite complicated process. It is necessary to make a complex analysis from various aspects that affect the educational process. An important step is to focus on the personality of a student and, while creating the learning content, respect his or her individuality. Every student is strongly characterized by the way he or she studies. One conceptions of learning styles that activates a wide variability of learning styles is Felder-Silverman's conception of learning styles. The Felder-Silverman learning styles model (FSLSM) is one of the last models of learning styles that was created in the environment of university education. Thanks to its strengths mentioned below it has become the most used model in the area of VLE. The advantage of this model compared to others is that R. Felder and L. Silverman describe learning styles in a more particular way, specifying the differences in learning based on 4 dimensions that reflect the typical learning behaviour (Kaliská, 2014; Karagiannis, Satratzemi, 2018).

Their model consists of 4 dimensions based on:

- processing information - *active* and *reflective* type,
- type of information noticed by student first – *sensing* and *intuitive* type,
- preferred modality when presenting the material: *visual* and *verbal*,
- way of solving problems – *sequential* or *global* approach.

They complement their theoretical model with the possibility to identify the preferred styles of students via Index of Learning Styles (ILS) questionnaire and also offer exact

manuals how to create education that would come directly from students' needs preferring a particular learning style (Kaliská, 2014). The ILS questionnaire developed by Felder and Soloman (2002), which is available for free at <https://www.webtools.ncsu.edu/learningstyles/>, can be used to identify the learning style. To designate a learning style, it is usually a long process that often needs using more diagnostic methods. The main advantage of using the ILS questionnaire is that it identifies the learning styles of students at the beginning of the term. It means it solves the time issue when diagnosing learning styles. As stated by Magdin and Turčáni (2015), the ILS questionnaire provides a very accurate quantitative estimate of students' preferences for each dimension of FSLSM. The ILS contains 44 items of dichotomic character, distributed in accordance with the four dimensions of learning styles of FSLSM where one option increases while the other decreases the score of each dimension.

Using adaptive mechanism implemented in LMS Moodle which adjusts the educational content to qualities of students expressing their learning styles are presented by Perišić et al. (2018). Learning style of a student is dynamically determined by tracking activities of a student during the learning process and finding out behavioural patterns that describe each learning style. To research the effectivity of the suggested model, they verify the differences between experimental (personalised educational content) and control (standard e-course) groups.

Some limitations of LMS Moodle are named by Caputi a Garrido (2015). One is no possibility to create complex relations between course activities and student profiles due to a lack of information in them. The next limitation is that it is not possible to make separate types of views of the e-course in a way that every student sees only his or her personalised content. To eliminate these flaws, they used standard functions of LMS Moodle. To check the methodology, they use quantitative analyses of an artificially created samples of students and e-courses. As a second experiment, they created a qualitative evaluation aimed at educational content planning in which smaller groups of teachers and students took part.

Methodology to create a personalised e-course

The authors aim with their suggestion to create an e-course with attributes of personalisation which will be integrated into LMS and will meet the requirements given by Paramythis and Loidl-Reisinger (2004). Based on a survey they conducted, a personalised educational system (personalised e-course) meets the following requirements:

- monitors activities of its users,
- interprets their activities by specific domain models,
- deducts requirements and preferences of users from their activities,
- appropriately represents them via connected user modules,
- appropriately reacts based on available information about its users to dynamically make the learning process easier.

From these defined requirements, it was necessary to analyse and identify the flaws of currently used e-courses in the computer systems (LSP) subject. LSP is a subject for first-year students at Applied Informatics study program (AI) during the summer term, each week via lectures and practical lessons. An elaborated didactical e-course with study content is

available for students in a form of multimedia. Content of the course is divided into study units per each week in the term. Every unit contains the edited *Book* activity consisting of text, pictures and interactive animations. The material is extended by external sources such as videos and websites. The output of each unit is a *Quiz* activity which contains a personalised feedback for experimental group. For experimental groups an adaptive navigation is created based on their learning styles and current knowledge.

The research sample was a group of first-year students at AI study program studying at UKF in Nitra. One experimental and one control group was created. In the experimental one there were two sub-groups of students. Students in the control group had unlimited access to all educational material during the term and studied based on the original methodology using the basic e-course. The authors give a more detailed description of the control group e-course transition in Mudrák, Turčáni and Burianová (2019) due to the size of the paper. Students in the experimental groups studied via the created personalised e-course based on the methodology suggested by the authors.

Passing the e-course by students of experimental group

For the EXP_S (experimental group – sequential (EXP_S)) student in order to access the *Quiz* activity, he or she is supposed to study the content of these activities containing the study material (*Book*, *Adaptive Lesson*, *external resources*, etc.). The *Quiz* activity was chosen as the main checkpoint of each unit to verify student knowledge and provide personalised feedback (Mudrák, Turčáni, and Burianová, 2019). In case of a sufficient number of correct answers (corresponding to the chosen level of mastery learning in the *Quiz* activity), the EXP_S student gets access to the next unit. If the student does not get sufficient points, after completing the *Quiz* activity he or she can learn about his or her mistakes via results in personalised feedback. After evaluation of the knowledge test of the selected unit, the system will refer the student to a specific place in the e-course, or to external sources, where all the information about that issue is located. It is only after re-studying the problematic issue that the student can take the *Quiz* activity again. In order to maximize the reliability of the *Quiz* activity, its content is limited by time, with the possibility of generating questions, selecting from a file and also limited by the number of attempts. Content of the *Quiz* activity also takes into account the pedagogical-psychological principles of forgetting. As the student progresses through the e-course, the *Quiz* activity contains randomly generated questions from previous units, which support systematic repetition of the already learned material. If the student fails in the *Quiz* activity more than twice, he or she is advised to consult a teacher personally using the interview method, to find out the reason for the failure. Based on the consultation, the teacher/tutor will modify the study recommendations for the student to eliminate failure in the next lessons.

The experimental group - global (EXP_G) students do not use the access restriction to each unit but have access to the entire content of the e-course. The teacher/tutor wants them to fulfil the appointed activities by a particular date and time.

RESULTS

Based on the above-mentioned research methodology, necessary research files were created to verify the presumptions. The sample was made of 61 experimental group students. A selection of compact groups was used, which were created using data recorded

in the Academic Information System (AIS) database. After passing the final *Quiz* activity, students were asked to evaluate the e-course in terms of efficiency in gaining knowledge. To be more precise, they responded with a scale to the question: "Using an e-learning course in connection with personalised feedback in *Quizzes* has allowed me to gain knowledge more effectively". Value range: 1 meant no agreement at all and 5 totally agreed. Most of the students expressed higher values, thus agreed to this question. Particular results can be seen in Figure 3.

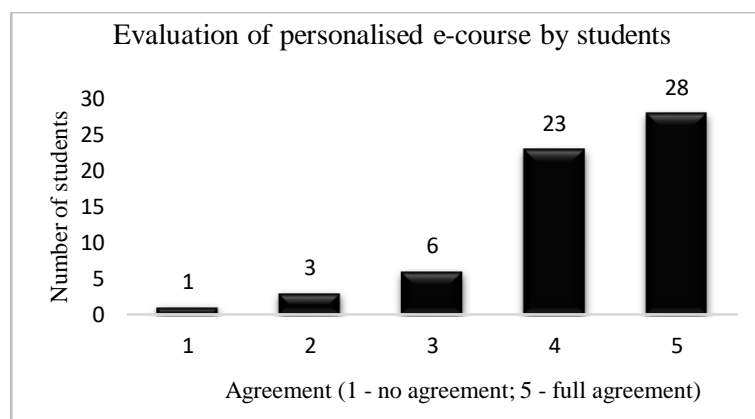


Figure 3: Evaluation of personalised e-course by students, 2019

The task of the proposed methodology was to use such tools that would motivate students to study at regular intervals and voluntarily, without any external influences such as credits and so on. One of the problems of the original e-course, which was created in the classical way, was that students accessed the e-course only before the exam. To avoid basing data only on logs obtained from LMS Moodle, an attitude questionnaire was used at the end of the term. Students evaluated the impact of the applied methodology on their motivation to study on a scale from 1 - no impact to 5 - significant impact. The results are shown in Figure 4.

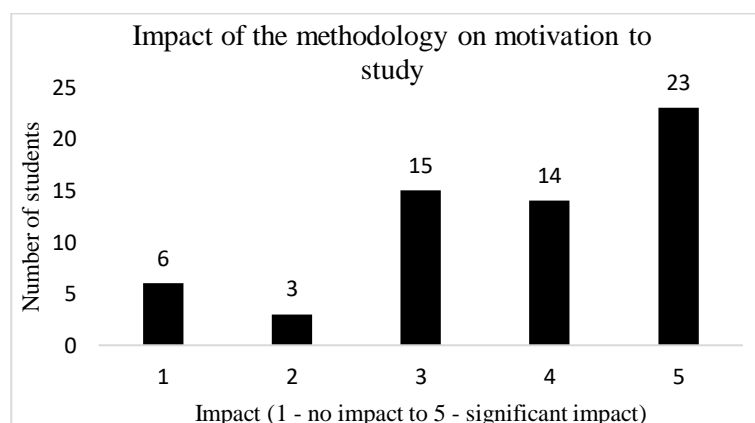


Figure 4: Evaluation of the impact of methodology on motivation to study, 2019

An important factor was to determine the extent to which the students' learning styles affect them. According to the FLSM, students were divided into 3 categories: balanced (lowest impact, value: 1-3), moderate (values: 5-7), strong (values: 9-11) (Mironova et al., 2013). The arrangement of the categories is shown in Figure 5. From Figure 5 it is clear that more than half of the students (54%) do not incline to any particular learning style within

the FLSLM. Furthermore, 35% of students have moderate preferences for at least one learning style and only 11% of students have strong preferences for at least one of the learning styles.

For each category, the count of students for each learning style listed in Figure 5 was also evaluated. For the Balanced and Moderate categories, there is a representation of each of the FLSLM styles.

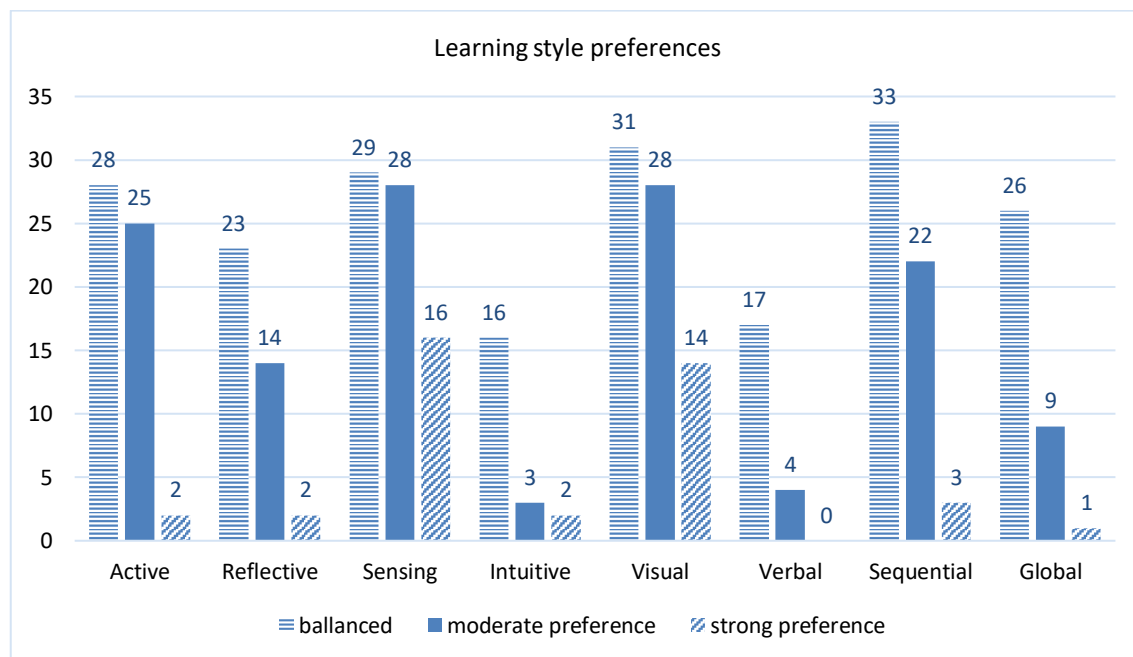


Figure 5 Representation of learning styles in each FLSLM category, 2019

However, the Balanced category is not really significant in terms of particular learning styles, as the learning styles contained in this category do not significantly affect the student's learning style for a particular dimension. More interesting were the results of the Moderate category, where the largest representations of learning styles were Visual, Sensing and Active. In the Strong preferences category, the most notable learning styles were Sensing and Visual.

Based on the above mentioned it can be evaluated the obtained results as quite logical for the studied subject of the AI study program. In general, this means that our students prefer mainly materials processed in graphic form (images, animations, videos, etc.), they like to work actively with the given study content and for their study it is appropriate to engage as many senses as possible. So, they are more practical. Concerning the continuity of the materials, they prefer a sequential approach, so they prefer to synthesize and prefer a logical continuity of materials.

DISCUSSION AND CONCLUSION

Many authors remain only in the theoretical model of personalisation of e-courses and their conclusions are based only on the simulation of the behaviour of virtual students in VLE. The results of the experiment presented in this article are based on real data collected during the summer term on a sample of students characterized in previous chapters. One

of the most commonly used LMS for the realization of personalised learning is Moodle, which after careful analysis was chosen in our case for experimental purposes. For this reason, there was an effort to select from the many publications dealing with this issue those ones, which also work with a physical sample of students in the LMS Moodle environment.

In the experiment conducted by Mironova et. al (2013) was found that their approach had a positive impact on the experimental group and their acquisition of new knowledge showed by better test results. Authors Karagiannis and Satratzemi (2018) found out in their first feedback that implementing adaptive techniques did not affect the usability of the system. Secondly in the latter case, they found a statistically significant difference between the experimental and control group in terms of study motivation. According to the results, the experimental group was more motivated to study and also assessed the use of adaptive techniques as helpful in gaining new knowledge. On the other hand, Kuchárik and Balogh (2019) used Book and Quiz activities in their experiment. In the end, however, they did not achieve such an improvement in the final assessment of students as they expected. A solution that could contribute to more improvement in learning outcomes could be the use of the Quizzes with personalized feedback which are recommended by Mudrák, Turčáni and Burianová (2019).

Data obtained from questionnaires were processed and evaluated in order to improve the education in the AI study program. These findings represent good direction in the area of computer science subjects education for students studying via the described methodology. During teaching activities in the educational process, we constantly encounter insufficient personalisation of education for students who come to university education with different quality and quantity of knowledge in the field of study they have chosen. Based on this knowledge it is necessary to devote more attention to the analysis of the student's condition, the level of his or her knowledge in the given subject as well as the procedures of the educational process. For this purpose, e-courses were created for selected subjects on DI at UKF, which were subjected to thorough analysis in order to identify and remove all the shortcomings affecting the quality of personalised content of provided e-courses. Using the methodology described in this article, we had the opportunity to evaluate the impact of the approach in the educational process of selected subjects.

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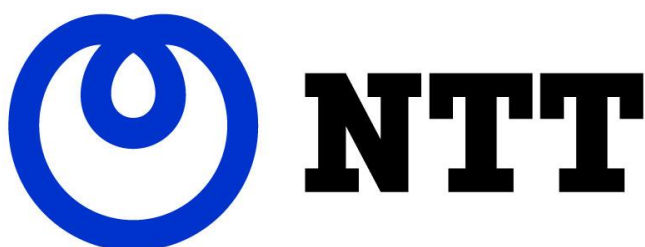
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- Multimedia and E-learning
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