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Processes, Materials, Resources

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TABLE OF CONTENT

THE CENTRE OF MEDIA EDUCATION IN ZIELONA GÓRA. INTRODUCTION

Looking through our old publications, one can find a phrase that has been quite often used (or used too often): a dynamically changing reality. When analyzing the phrase today, it can be concluded that it is absolutely true and the dynamics of civilizational, social and cultural changes, etc., have even accelerated. This acceleration has been affected by numerous factors, of which the emergence of the computer and the development of information and communication technologies (ICT) are the ones of the greatest importance.

The beginning of the twenty-first century has brought the supremacy of information technologies (especially computer science and telecommunications) over technologies used to produce material goods, which has and will have numerous significant effects. No culture can avoid being affected by technology. The most striking is the fact that practically no one has any influence on the direction and pace of changes that the world is experiencing as a result of the universal access to new ICT resources. The development of ICT is so dynamic that it precedes social and mental changes, and people's adaptation mechanisms to new conditions are just becoming activated. Therefore, the role of empirical research and scientific studies that analyze the impact of information and communication technologies on societies, economic development, and education is crucial.

Information civilization is characterized by the massiveness of the dissemination of methods and means of computer science, as well as high saturation of all processes taking place with information. The forms and standards of interpersonal contacts are adapted to the automatic way of information processing, and all technical means and social structures are organized and designed in such a way that certain skills and habits of the society in the use of information technologies are assumed in advance. On the other hand, the information society is characterized by individualization, decentralization of production and administration, and dispersion of communities. Therefore, the ability to communicate with other people and the products of their civilization is becoming an increasingly important issue.

A specific attempt of pedagogy to face the challenges of information civilization and the media society is the emergence of new subfields that try to expand pedagogical theories and practice with current social and cultural contexts. Media pedagogy is a new subfield of pedagogy that studies all pedagogically important activities related to the media, including their technological, theoretical and normative foundations. It centres around the educational media environment and the individual in this environment.

Media education is a social practice of media pedagogy, but it is also the key to understand and construct meanings in a reality dominated by media culture. It is possible through general media education oriented on media knowledge, media literacy in educational processes, preparation for critical media reception, development of the ability to participate in social communication through the media, that is creating, reading and understanding the message and building a coherent image of the media as sources of information, as well as constructing and understanding meanings in media messages.

Civilizational changes and the development of computer science and its applications caused a kind of fluidity of the research area for media pedagogy. Over the years there has been a repeated re-evaluation of our assumptions and goals, and new issues and priorities have emerged, which is a difficult but extremely interesting challenge for researchers.

The pioneering first stage (the turn of the 1980s and 1990s) was the appearance of computers and the first attempts to use them in education and social communication. The research task in this period was primarily to teach computer science effectively, that is its methodology, the use of computer technologies in teaching other subjects. Hardware limitations and available software made it impossible to carry out comprehensive and valuable research. However, a group of researchers emerged and they studied broad issues related to ICT applications and impacts. The scientists worked at the Institutes of Technology, Mathematics and Management, Higher Pedagogical School in Zielona Góra, and later, after the organizational changes, they worked at the Department of Media and Information Technologies of the University of Zielona Góra.

At that time, they conducted some interesting studies to identify barriers to the introduction and assimilation of ICT in the education system, both among students and teachers. The results showed that the main obstacles were English terminology, inability to understand the structures and ways of navigation in programs, as well as the fear of making a mistake and its consequences bearing in mind the costs of the equipment.

Along with the development of ICT tools and their wider use in university education, our main research task became the use of opportunities created by the computer in education. At the initial stage, the research object was a multimedia presentation as a compact structure containing the entire spectrum of means of

expression that represented the widest form of multimedia message, and could function autonomously or in the network. The studies determined its structure, composition, and the principles of its use in the teaching process. Other studies examined the optimization of the interface of an educational program, and the factors that affected the student's attention when they worked on their own.

The experience gained allowed us to propose the structure of a multimedia educational module in the form of the diagnostic block (determining the recipient's cognitive preferences), the substantive block, the control block and assistance block, as well as the determinants of the module effectiveness:

- on the subject level (content and formal features, e.g. intuition, cognitive style, prior knowledge of the recipient, their cultural experience);
- on the object level (syntactic and semantic aspects, for example, the characteristics of the message, the structure of the message, the type of construction, the ways of emphasizing the structure, taking into account markers, motion and the effect of the transfer);
- on the pragmatic level (methodological aspect, for example, the specific situation, the nature of the impacts, the type of tasks assigned to particular media).

The conducted research was based on a broad empirical verification of the adopted assumptions, and it helped to develop the media in education course for pedagogy students.

The scientific activity of the researchers resulted in their cooperation with leading research centres specializing in this field, including the University of Silesia, University of Szczecin, University of Toruń and the Pedagogical University in Kraków.

Undoubtedly, a very important element modifying the subject of our research was the emergence and existence of the internet in the social space and educational reality. Our research covered two large areas. One of them was related to education – we mainly focused on the educational possibilities of websites, in particular in the process of distant learning. The other area referred to social communication, with special interest in the impact and repercussions of having social communication in the net.

The emergence of the internet and e-learning platforms changed the possibilities of distant learning. The research proved, also empirically, that they gave a chance to create an educational environment and teaching situations identical with traditional education. The educational aspects of creating online courses, standards for creating and conducting online classes, requirements and tasks for creators, participants and administrators of e-learning systems were developed. The scientists were also interested in research possibilities of the Moodle platform and its use in social research. Our experience, practical knowledge and skills allowed us

to introduce elements of distant learning to the "Media and IT education" course launched in 2002.

Another area of our interest was interpersonal and social communication in computer networks. This rapidly growing communication created new problems related to changes in the communication process and became a key pedagogical issue in the process of shaping communication skills. Social communication is a symbolic process. This process generates and reconciles meanings. The symbols that we operate are directly related to the sender's experiences and competencies, including their media competencies. Popular culture, through its ubiquity and intensity of interactions, in a significant way creates and shapes our symbolic resources. The pictorial culture of mass media – television, cinema, the internet – displaces other symbolic forms and in this way becomes the dominant sphere of shaping our symbolic world. We can observe this especially in young people, as due to the lack their own experience they have not consolidated traditional symbolic forms. The research into the communication environment, especially the chatroom analysis, revealed new forms and structures of communication among young people.

In research into a new communication environment (info sphere) and its educational possibilities a special attention was paid to hypertext – not only as a technology allowing to organize media text, but also as the essence of networking that changes the philosophy of educational message. Hypertext, as a new communication technology, helps to break the usual communication canons by transforming them into non-linear structures of information transfer. The interactive capabilities of network communication, implemented with the hypertext mechanism, give the recipient the opportunity to actively participate in constructing the media message. They blur the traditional roles of the author and the reader, make it possible to individually determine the path of exploration of information resources and implementation of the feedback principle. It seems that the network idea implemented with hypertext has not yet been fully assimilated by the education system, where the linear transmission system still dominates.

The emergence of ICT and the internet brought a significant re-evaluation of the autonomy of the educational space and its penetration with the media space and cyberspace. This conclusion is justified by the fact that the possibilities of imaging the world offered by new technologies (in electronic image, e.g. television image) and the worlds created as part of virtual metamorphoses also introduce significant transformations within reality itself. All this affects educational processes and has an impact on shifting and combining the individual and external educational space of a human being, which, in turn, penetrates the media space.

Media and ICT create social, educational and educational opportunities, but on the other hand they are also a source of threats and dangers for children, adolescents and adults. These threats and dangers can occur in the sphere of psychological and educational interactions, as well as in the area of social impacts.

The issue of these threats is an important part of our research activity in its various aspects – computer games, contact with inappropriate content, cyberbullying, the use of network communication in seducing juveniles. These problems were reflected in the activities of our research team: in research projects, for example studies on network threats carried out together with the University of Nesna in Norway, in preventive action's – lectures for parents and teachers or in the form of a film on cyber violence, which was one of the first films on this problem made in Poland.

Although we appreciated the importance and scale of network threats, our main focus was on opportunities offered by ICT to children. Therefore, an important aspect of our research was the use of ICT in working with children in various aspects. We observe the spontaneous expansion of the media, which are already the dominant element of everyday life and have a huge impact on the educational environment as well. Many educators, sociologists and culture experts believe that the impact of the media, especially audio-visual media, on children and adolescents is stronger than the impact of school or even family. However, the impact of the media is often considered highly effective, but also completely uncontrolled by educators, thus it is thought to be a dangerous rival of school education.

Our research focuses on assessing to what extent ICT and media constitute a new educational environment for a child. The research also attempts to define what the child's cyber world is like and how it changes, who shapes the child's media reality and how they do it and whether it is done consciously. The conducted research has shown to what extent ICT can level out the child's educational deficits (dyslexia, dysgraphia, etc.), and how the computer can support the child's diagnosis and pedagogical therapy. The obtained results were used in educating future teachers and expert opinions on educational media.

The above description outlines selected research trends in media pedagogy conducted over the years in Zielona Góra. It presents its most important features, achievements and goal which is to perceive ICT and the media from the perspective of human needs and expectations.

* * *

The compilation has been created owing to international cooperation of many researchers and scientists from the following research institutions: Pedagogical University of Cracow, Nicolaus Copernicus University in Toruń, University of Zielona Góra University of Rzeszów, Cardinal Stefan Wyszynski University in Warsaw, Board of Education in Bydgoszcz (Poland); The National University of Water and Environmental Engineering, Lutsk National Technical University (Ukraine); Matej Bel University of Banská Bystrica, University of Economics in Bratislava (Slovak Republic); Nord University (Norway); University of Algarve (Portugal).

Each article (constituting a separate chapter) has been written according to the same structural pattern, i.e. introduction, subsections, conclusions, bibliography, as well as an abstract and a short note about the author.

The articles are an interdisciplinary view on ICT and discuss issues that are related to social/pedagogical sciences, as well as technical sciences, both in the theoretical and the empirical sphere. The researchers analyze the problems of designing and using ICT methods and tools also in the practical dimension, pointing to the wide use of new media in teaching and learning at every stage of education.

A large group of the authors refer to the results of their environmental research in their analyses and conclusions addressed to educational practice. Their empirical research covers the following areas: competencies of IT students in programming and effective problem solving (Magdalena Andrzejewska); implementation of new ICT trends – knowledge, understanding, activities and attitudes of children and adolescents towards cloud computing technologies (Eunika Baron-Polańczyk); building knowledge in the light of neoliberal school reform – training Norwegian teachers (Erik Bratland); digital competencies of teachers and assessment of students learning technology in primary school in the Slovak Republic (Milan Ďuriš, Ivana Pandurovic, Roman Stadtrucker); building knowledge in an educational environment created by the social media network – the student's perception of learning on the internet (Beata Godejord); pedagogical aspects of mobile learning – the students' perception of learning with mobile technology (Beata Godejord, Per Arne Godejord, Mauro Figueiredo, Rune Bostad); using an e-learning platform to create a knowledge base for students (Joanna Kandzia); interactive media in education – online courses and educational resources (Dorota Siemieniecka, Wioletta Kwiatkowska, Kamila Majewska, Małgorzata Skibińska); educational use of ICT and teaching programming in the context of proxemics (Kazimierz Mikulski); creating fully accessible websites for the elderly and the disabled – a tool supporting website accessibility research, according to the WCAG 2.0 documentation, the David Travis checklist and the Visible Foundation methodology (Anna Stolińska, Beata Wolińska); the use of cognitive imaging tools in the learning process in the forms of logic games – effective interaction of teachers and students (Iurii Tulashvili, Nataliia Oleksiv).

The article "Big Data and its role in streamlining the teaching process" (by Mojmír Kokles, Anita Romanová, Anna Hamranová, Michal Zelina) analyzes the current problem of using Big Data in education, based on specialist and scientific literature, to create a theoretical basis for future empirical research. Jacek Jędryczkowski writes about mass open online courses (MOOC). He reviews available offers and describes actions taken in Poland. The author concludes that the development of MOOC, especially in the USA, is already a real threat for academic centres in Poland, and the problem has been noticed relatively late. The evaluation of the possibility of using computer chess programs as educational tools was carried out by Renata Kasperska and Andrzej Kasperski. The authors emphasize the significant impact of chess on human development and note that computer chess programs are great teaching aids, but they do not develop students socially. At the

same time, direct interaction with sophisticated artificial intelligence can be very frustrating. The child and family in the media world is the subject of interest for Ewa Nowicka, who emphasizes the great role and responsibility of parents for preparing a young person to rationally and critically receive information in the ICT era. New media also play a significant role in therapeutic activities, especially when working with intellectually disabled children or children with various difficulties in learning to read, write and count (Ewa Nowicka, Elżbieta Staniec). The new media have also found a prominent place in the teaching and learning of mathematics. Paulina Woźniak-Chojnacka pays special attention to the wide range of possibilities offered by new, interactive educational materials – which allow the teacher to adjust teaching to the student's cognitive abilities, and help to shape and develop mathematical skills and attention concepts. Wojciech Walat has attempted to answer the question how the new information and communication technologies are changing the architectural space of education at schools. He claims that the so-called architectural space of education should be redefined. Forming theoretical assumptions, useful in building a modern educational architecture, requires finding a new philosophy of education that starts with clear references to the ideas of cognitivism and constructivism.

The monograph, in line with the direction of the "ICTinED" project, addresses problems related to designing of the educational process, to multimedia teaching materials (educational media) and to ICT infrastructure and resources. Thus, it is meant to target the readers who are interested in practical, efficient and economical application of ICT methods and tools in broadly understood education (see: „ICTinED" 2012, Vol. 1, pp. 13-36 and 2016, Vol. 9, pp. 9-36; www.ictined.eu). The problems presented in the publication may prove useful not only to researchers of the subject-matter, but also to students and teachers who are interested in introducing new technologies into their professional practice.

Special words of gratitude are directed to all authors and reviewers, to Professors Stanisław Juszczyk from the University of Silesia in Katowice (Poland) and Jan Stebila from the Matej Bel University in Banska Bystrica (Slovakia) for all valuable comments which gave the monograph its final shape.

Marek Furmanek
Eunika Baron-Polańczyk
Zielona Góra, 30 November 2018

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DIFFICULTIES IN LEARNING INTRODUCTORY PROGRAMMING – STUDENTS' PERSPECTIVE

Abstract

Introductory programming courses are both an important and difficult part of the education process of future professionals in the field of the computer science. Programming is not only an ability of coding connected with knowledge of the syntax of the selected language and such operations as editing a code, its compiling and running programs, but, first of all, it is a set of competences connected with effective problem solving. Teaching methods that would improve the process of understanding of concepts and acquiring programming skills by novice programmers have been sought for many years, although a generally accepted solution has not been found so far. The aim of this study was to know opinions of the computer science students (CS1) on difficulties that they experienced while learning introductory programming. Survey questionnaires, in which the respondents evaluated both the level of difficulty of the issues taught and competences acquired, were used. The obtained results confirmed that the issues which require understanding abstract or complex elements of the program and designing a solution (an algorithm) of the specific problem are the most difficult ones for the students.

Keywords: computer science, introduction to programming, learning to program, novice programmers, learning difficulties.

Introduction

Subject matters of teaching and learning to program have been of interest of many researchers from many fields, not only computer science educators, but cognitive scientists and psychologist as well. Programming is regarded as the basic competence in a scope of the computer science and it is the foundation of educating in the lines of the computer science at universities. Acquiring programming skills is a complex process, and problems with programming education occur in each

generation of students, out of which a lot of them do not achieve educational successes in that field (A.J. Mendes et al., 2012).

The following main sources of the difficulties in programming teaching process are indicated: teaching methods used by teachers, ways of learning by students, an insufficient level of basic skills and their attitudes, the multifaceted nature of programming skills and psycho-sociological factors connected with the perception of programming (A. Gomes, A.J. Mendes, 2007).

One of the basic aspects is complexity of the process of acquiring programming skills itself. In the psychological aspect, it is a cognitive activity requiring different types of mental models (A. Robins et al., 2003). The model connected with the problem solving mechanism, designing and representation of algorithms is of fundamental importance. However, programming science does not only include acquiring or developing competences from the problem solving area, but also it is a necessity of getting to know lots of abstract concepts connected with programming mechanics, with a sentence structure of a language – syntax and semantics of the code made (K. Ala-Mutka, 2004). Furthermore, according to the researchers, the greatest problem of the novice programmers is not to understand the basic concepts, but acquire ability to use them (A. Gomes, A.J. Mendes 2007; E. Lahtinen et al., 2005). Studies on the international scale conducted by the Michael McCracken et al. (2001) were one of the first studies on such a large scale, which showed that after completion of introductory programming courses students had an insufficient level of both knowledge and skills. The novice programmers were not so successful in problem solving as the teachers would expect. Although they could answer questions asked about the specific single element of the program, they could not use that knowledge for solving new problems, they also understood insufficiently a current status of the program, including what is a course of performance of a ready and complete application (R. Lister et al., 2004).

According to Anabela Gomes and A.J. Mendes (2007), first of all, the teaching methods used should be changed because it seems they do not meet the needs of contemporary students. The main objections to programming teaching made by them are following:

- insufficiently personalized teaching;
- use of strategies by teachers which do not support different preferences and styles of learning of students;
- use of means by teachers having a static and presentation character, while programming is a dynamic process in essence;
- teachers focus more on teaching of a programming language and its sentence structure than on the problem solving skill, being the key skill in this case.

An important element of a didactic character is a selection of a proper programming environment, which use can be a source of additional difficulties that the novice programmers will have to deal with (A. Pears et al., 2007). In general,

those applications meet the needs of the professional programmers to a greater extent – they have an advanced interface and incoherently sounding messages about errors of the compilation (most frequently only in the English language) and that is why their use can be difficult for novice programmers.

Methods

The aim and a scope of the study

The paper presents the results of the investigations of which the aim was to know opinions of the students of the computer science (CS1) on difficulties that they experience while learning to program at the introductory programming courses and to examine if that opinion depends on programming experience which students already have when they start studies. The investigations were performed by use of an electronic survey questionnaire. The questions in the survey which allowed performing the aim of the studies, were divided into two separate blocks – first one included an assessment of the difficulty level of the matters taught (knowledge), second one concerned selected aspects of creating programs that are connected with having programming competences (skills). The respondents expressed their opinions on basis of the five-point Likert scale with appropriately assigned ranks (the difficulty level: 1 – very easy, 2 – easy, 3 – medium difficult, 4 – difficult, 5 – very difficult).

Participants

The group of the respondents consisted of 80 students of the first year of engineering computer science studies (CS1). Among them there were 66 men (82.5%) and 14 women (17.5%), the average age of the respondents was nearly 21 years (mean M=20.8, standard deviation SD=1.33). The students completed introductory programming course in C language (completed with an examination) in the semester preceding the date of the survey. The half of the respondents (50%) began learning to program at the studies (group G_NDO), and the others (group G_DO) at earlier stages of their education, including 41% at high schools, 6% at the junior high-school, and 3% at the primary school. About 72% respondents did not program earlier in C language.

Results

Programming concepts

According to 55% students, the course in Introduction to programming (mean M=3.5, median MD=4) was more difficult, and 15% found it easier than courses in other subjects. The list of the analyzed programming matters was as follows:

T1: Flowchart of the algorithm.
T2: Using data types, variables.
T3: Operators and expressions.
T4: Formatted input/output (e.g. scanf, printf).
T5: Control statements – loops and if statements.
T6: Functions – prototyping, defining, calling, formal parameters and arguments.
T7: Pointers and operations on the pointers.
T8: Functions – using pointer parameters.
T9: One-dimensional arrays and two-dimensional arrays.
T10: Arrays as function arguments.
T11: Character strings.
T12: Structures – pointers to structures, arrays of structures.
T13: Passing structures as function arguments.
T14: Dynamic memory allocation.
T15: Recursion.

The obtained percentage distributions of the answers and basic numerical descriptive statistics are presented in Table 1. The results are also shown in Figure 1 in which there is the information on the median values (MD) and a range of the lower (Q1) and upper quartile (Q3) for all categories in question, considering the division into groups G_NDO i G_DO.

On basis of the data in Table 1, it should be stated that none of the issues presented was assessed as very difficult by the students. The classification of the subjects according to the difficulty levels is not unequivocal, but considering the values of the means, the medians and the inter-quartile range the following division was made:

1. Very easy issues: T4 (median MD=1, mean M=1.6) and T2, T3, T5 (median MD=2 and the negative skew distribution, mean M<=2.1).
2. Easy issues: T1, T6, T9 (median MD=2 and the positive skew distribution, mean M>=2.1).
3. Moderately difficult issues: T10, T11 (median MD=3, the negative skew distribution, mean M=2.7) and T7, T8, T14 T15 (median MD=3 or MD=3.5, the positive skew or symmetrical distribution, mean M>=3.0).
4. Difficult issues: T12, T13 (median MD=4, mean M>=3.6).

Table 1. Programming concepts – a percentage distribution of the opinions of the respondents and the basic descriptive characteristics

Variable	Level of difficulty (%)					M	MO	MD	Q1	Q3
	1	2	3	4	5					
T1	22.5	52.5	21.3	1.3	2.5	2.1	2.0	2.0	2.0	2.5
T2	28.8	57.5	12.5	0.0	1.3	1.9	2.0	2.0	1.0	2.0
T3	22.5	56.3	16.3	3.8	1.3	2.1	2.0	2.0	2.0	2.0
T4	56.3	36.3	5.0	1.3	1.3	1.6	1.0	1.0	1.0	2.0
T5	31.3	51.3	15.0	0.0	2.5	1.9	2.0	2.0	1.0	2.0
T6	21.3	33.8	36.3	7.5	1.3	2.3	3.0	2.0	2.0	3.0
T7	5.0	17.5	41.3	27.5	8.8	3.2	3.0	3.0	3.0	4.0
T8	7.5	10.0	32.5	38.8	11.3	3.4	4.0	3.5	3.0	4.0
T9	25.0	40.0	27.5	5.0	2.5	2.2	2.0	2.0	1.5	3.0
T10	17.5	26.3	37.5	10.0	8.8	2.7	3.0	3.0	2.0	3.0
T11	15.0	25.0	41.3	13.8	5.0	2.7	3.0	3.0	2.0	3.0
T12	3.8	10.0	27.5	38.8	20.0	3.6	4.0	4.0	3.0	4.0
T13	3.8	11.3	23.8	37.5	23.8	3.7	4.0	4.0	3.0	4.0
T14	11.3	22.5	33.8	21.3	11.3	3.0	3.0	3.0	2.0	4.0
T15	5.0	20.0	37.5	18.8	18.8	3.3	3.0	3.0	2.5	4.0

Level of difficulty: 1 – very easy, 2 – easy, 3 – medium difficult, 4 – difficult, 5 – very difficult
MD – median, MO – mode, M – mean, Q1 – lower quartile, Q3 – upper quartile

Source: prepared by the author.

Since the study group was not homogenous regarding the programming skills possessed, it was considered whether this fact had an impact on the opinions of the respondents. By taking the mean values in groups G_NDO and G_DO into account and analyzing Figure 1, it can be stated that the greatest divergences in the opinions were in category T10 (G_NDO M=3.0; G_DO M=2.4) and T2 (G_NDO M=2.1; G_DO M=1.7) and T9 (G_NDO M=2.4; G_DO M=2.0). Issues T6 (G_NDO M=2.5, MD=3; G_DO M=2.2, MD=2) and T8 (G_NDO M=3.5, MD=4; G_DO M=3.3, MD=3) can be also recognized as more difficult according to the students who began to learn to program at the studies – their results are characterized by the higher values of the means and medians. The non-parametric U Mann-Whitney test was made for each category and only in case T10 the statistically significant result was obtained (G_NDO MD=3, G_DO MD=2, U=567,5, Z=-2,24, p=0,025).

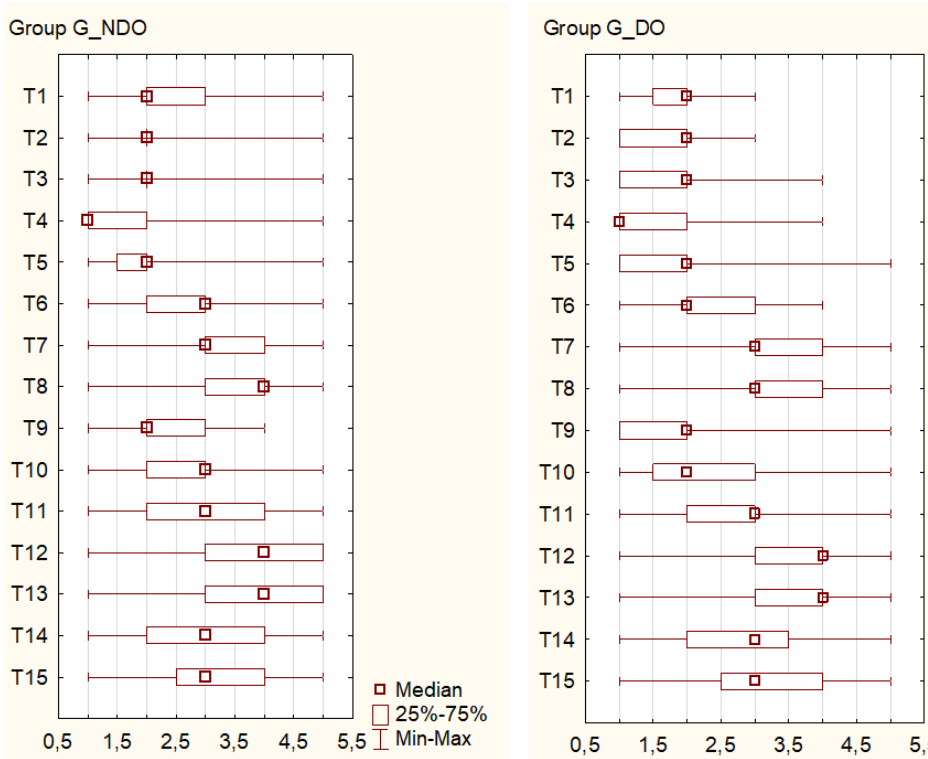

Figure 1. Programming concepts – the box and whisker plot for two groups of the respondents

Source: prepared by the author.

Programming skills

The list of the analyzed categories of the competence acquired was as follows:

C1: Designing a solution (an algorithm) for the specific problem.

C2: Appropriate use of the principles of the syntax of programming language.

C3: A selection of proper data structures and language concepts (e.g. loops, types of variables) to solve the problem.

C4: Designing a structure of the whole program (e.g. a division of the program into functions).

C5: Use of the programming environment.

C6: Understanding of messages about errors while compiling and their correcting.

C7: Finding errors of performance of own program.

C8: Understanding of a code of the ready program (e.g. the exemplary algorithm written in the code).

The obtained results are presented in Table 2. On the basis of the analysis of both the percentage distribution of the opinions of the examined and the basic descriptive characteristics, such as the mean and the median, it can be stated that according to the overwhelming majority of the students, the process of acquiring the programming competences is moderately difficult or easy. Moreover, from Table 2 it can be read that the respondents assessed most frequently (mode MO=3) all differentiated categories of competences as moderately difficult, except three ones – C3, C5 and C6, which were indicated most frequently as easy (MO=2). Furthermore, competences C5 and C6 obtained the lowest values of the means and the medians (C5 M=2.3, MD=2; C6 M=2.4, MD=2). C1 and C8 (C1 M=3.0, MD=3; C8 M=2.8, MD=3) were indicated as the most difficult competences.

Table 2. Programming skills – the percentage distribution of the opinions of the respondents and the basic descriptive characteristics

Variable	Level of difficulty (%)					M	MO	MD	Q1	Q3
	1	2	3	4	5					
C1	7.5	20.0	48.8	16.3	7.5	3.0	3.0	3.0	2.0	3.0
C2	12.5	31.3	46.3	7.5	2.5	2.6	3.0	3.0	2.0	3.0
C3	10.0	38.8	37.5	12.5	1.3	2.6	2.0	3.0	2.0	3.0
C4	13.8	31.3	32.5	13.8	8.8	2.7	3.0	3.0	2.0	3.0
C5	23.8	35.0	30.0	8.8	2.5	2.3	2.0	2.0	2.0	3.0
C6	13.8	45.0	28.8	11.3	1.3	2.4	2.0	2.0	2.0	3.0
C7	10.0	32.5	38.8	16.3	2.5	2.7	3.0	3.0	2.0	3.0
C8	7.5	33.8	38.8	12.5	7.5	2.8	3.0	3.0	2.0	3.0
Level of difficulty: 1 – very easy, 2 – easy, 3 – medium difficult, 4 – difficult, 5 – very difficult MD – median, MO – mode, M – mean, Q1 – lower quartile, Q3 – upper quartile										

Source: prepared by the author.

In the case of all categories in question, the opinions of the respondents were not differentiated what is confirmed by the small inter-quartile range (IQR), which determines the same value of the lower and upper quartile (Q1=2; Q3=3) for each category.

By taking the mean values in the groups into account and analyzing Figure 2, it can be also stated that the greatest discrepancies in the opinions between the groups were in category C1 (group G_NDO M=3.1, Q1=3.0, Q3=4.0; group G_DO M=2.8, Q1=2.0, Q3=3.0) and C4 (group G_NDO M=2.9, Q1=2.0, Q3=4.0; group G_DO M=2.6, Q1=2.0, Q3=3.0), which were assessed as more difficult by the students beginning to learn to program. However, the U Mann-Whitney test for each category in question did not show statistically significant differences be-

tween the group of the students who began programming learning at the studies (group G_NDO), and those who programmed already at the earlier stages of their education (group G_DO).

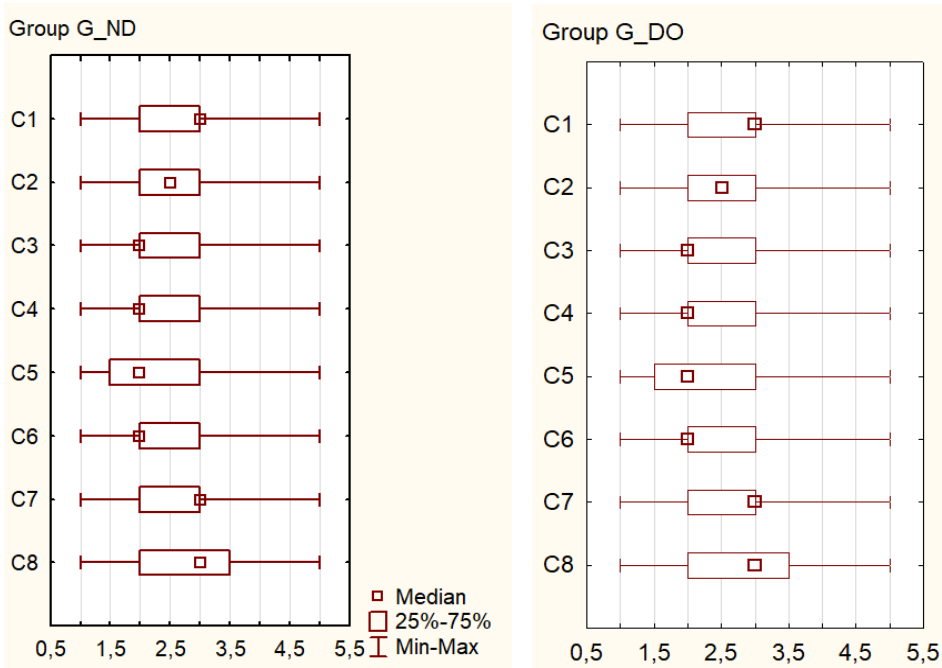

Figure 2. Programming skills – the box and whisker plot for two groups of the respondents
Source: prepared by the author.

Discussion

The results of the survey in question are consistent with the basic findings made by other researchers. The results of the difficulty level assessment of particular programming issues indicate that the problems which require understanding abstract or complex elements of the program are the most difficult ones for the students. For all the respondents such issues were: T12: Structures – pointers to structures, arrays of structures and T13: Passing structures as function arguments. Among the difficult subjects the following should be also mentioned: T7: Pointers and operations on the pointers, T8: Functions – using pointer parameters, T14: Dynamic memory allocation and T15: Recursion. The similar results were obtained, for example, in the studies of Iain Milne and Glenn Rowe (2002), in which the respondents assessed such issues as pointers and memory allocation as difficult to learn.

The greatest differences between the established groups of the students (group G_NDO and group G_DO) concerned the following issues: T2: Using data types, variables, T9: One-dimensional arrays and two-dimensional arrays and T10: Arrays as function arguments. In the opinion of the persons beginning to learn to program (group G_NDO), these issues were more difficult, and in the case of category T10 the difference between the groups was statistically significant. The investigations of Noor Azizah Mat Isa and Siti Rosminah D Derus (2017) brought the convergent results, according to their participants the data structure of the array type was the most difficult issue.

In the case of the process of acquiring the programming competences none of the categories proved difficult or very difficult. However, it should be borne in mind that it is a view of the students who perhaps overestimate their understanding of concepts and their skill levels. In the studies of Milne and Rowe (2002) and Essi Lahtinen et al. (2005), in which teachers also participated at the same time, they had a different opinion on these issues. The students may not be aware of all difficulties which they face, and the teachers have a broader spectrum – for example in connection with grading of examinations. Moreover, knowledge of teachers is deeper and they are able to see problems that students do not fully understand, although they consider them themselves as fully understandable. According to Lahtinen et al. (2005), these different views can be a potential source of problems with motivation on the part of students.

Even though according to majority of the students, acquiring all categories of competences was a moderately difficult process, such skills as C1: Designing a solution (an algorithm) of a specific problem and C4: Designing a structure of the entire program (e.g. a division of the program into functions), were assessed as more difficult by the group of the students who began to learn to program at the studies (G_NDO).

The obtained result is not surprising. It is widely believed that developing an algorithm is a very important and difficult programming activity, in particular for novice programmers. It is simultaneously an important activity which has an impact on the development of so-called algorithmic thinking, being mental basis in the process of learning to program (K. Ala-Mutka, 2004).

The issues connected with understanding of a program structure were also indicated as the most difficult ones by the participants of the studies performed by Isa and Derus (2017) and Busra Ozmen and Arif Altun (2014), in which the students, in spite of having the required programming knowledge had difficulties while making a complete program. It seems that understanding of the basic concepts is not the greatest problem of the novice programmers, but rather an ability to use them. This aspect of learning is also indicated by Anthony Robins et al. (2003) who suggest that teachers should concentrate, first of all, on the issues connected with designing of a program. A theory is a very important element of

programming learning, but in order to understand abstract concepts the students need, first of all, practical examples, and the more pragmatic didactic materials are, the more effective learning is (E. Lahtinen et al., 2005).

Conclusions

The aim of the paper was to find out opinions of the students about problems that they encountered while programming learning at its initial stage. The survey results provided information on the difficulties perceived by the respondents connected with both understanding basic programming concepts and acquiring competence of creating a program. The obtained results indicate that the issues which require understanding abstract or complex elements of a program are the most difficult ones for the students. Among the skills designing a solution (an algorithm) of a specific problem is the most difficult one. The persons who began to learn to program at the studies indicated designing a structure of the entire program as difficult.

Thus, the obtained results are consistent with findings of other researchers made over the last years, and even decades. Therefore, a call to direct both methods and didactic materials at the introductory stage of programming to the development of problem-solving skills, like the competence of algorithms creating, is still current. While designing an algorithm, flowcharts that describe precisely the strategies to be applied and determine the steps to be followed in order to solve the problem, are usually created. The second important issue is that the didactic process should be supported by practical examples involving students in the process of creation, modification and debugging of programs by themselves. It is worth referring here to guidelines which were proposed by Mario Konecki (2014) in order to improve effectiveness of acquiring programming skills by novices:

1. Introduce additional programming course prior to introductory programming course that would promote algorithmic way of thinking.
2. Increase motivation of students for learning to program.
3. Explain to students that programming is a skill, not merely knowledge.
4. Introduce elements of constructivism into teaching process.
5. Introduce learning by example.
6. Introduce animation and other visualization techniques combined with interaction.
7. Introduce interactive visual simulations.
8. Include support for multiple learning styles.

Didactic aspects of programming teaching are undoubtedly the key to overcome lots of difficulties. Owing to properly designed materials and methods teachers can help students acquire and consolidate knowledge and form programming skills.

Bibliography

Ala-Mutka K. (2004), *Problem in Learning and Teaching Programming – a literature study for developing visualizations in the Codewitz-Minerva project*, http://www.cs.tut.fi/~edge/literature_study.pdf [15.09.2018].

Gomes A., Mendes A. J. (2007), *Learning to program – difficulties and solutions* [in:] Proceedings of the ICEE 2007 – International Conference on Engineering Education, http://icee2007.dei.uc.pt/proceedings/papers/411.pdf [15.09.2018].

Isa N.A.M., MD Derus S.R. (2017), *Students experience in learning Fundamental Programming: An analysis by gender perception*, "Advanced Journal of Technical and Vocational Education", No. 1(1), pp. 240-248.

Konecki M. (2014), *Problems in programming education and means of their improvement* [in:] B. Katalinic (ed.), DAAAM International Scientific Book, DAAAM International, Vienna, pp. 459-470.

Lahtinen E., Ala-Mutka K., Jarvinen H. M. (2005), *A study of the difficulties of novice programmers* [in:] Proceedings of the 10th Annual SIGSCE Conference on Innovation and Technology in Computer Science Education (ITiCSE 2005), pp. 14-18.

Lister R., Adams S., Fitzgerald S., Fone W., Hamer J., Lindholm M., McCartney R., Moström J.E., Sanders K., Seppälä O., Simon B., Thomas L. (2004), *A Multi-National Study of Reading and Tracing Skills in Novice Programmers*, "ACM SIGCSE Bulletin" No. 36(4), pp. 119-150.

McCracken M., Almstrum V., Diaz D., Guzdial M., Hagan D., Kolikant, Y. B.-D, Laxer C., Thomas L., Utting I., Wilusz T. (2001), *A multi-national, multi-institutional study of assessment of programming skills of first-year CS students*, "ACM SIGCSE Bulletin", No. 33(4), pp. 125-140.

Mendes A.J., Paquete L., Cardoso A., Gomes A. (2012), *Increasing student commitment in introductory programming learning* [in:] Proceedings of the 42th ASEE/IEEE Frontiers in Education Conference, Seattle, USA.

Milne I., Rowe G. (2002), *Difficulties in learning and teaching programming – views of students and tutors*, "Education and Information Technologies", No. 7(1), pp. 55-66.

Ozmen B., Altun A.(2014), *Undergraduate Students' Experiences in Programming: Difficulties and Obstacles*, "Turkish Online Journal of Qualitative Inquiry", No. 5(3), pp. 9-27.

Pears A., Seidman S., Malmi L., Mannila L., Adams E., Bennedsen J., Devlin M., Paterson J. (2007), *A survey of literature on the teaching of introductory programming*, "ACM SIGCSE Bulletin", No. 39(4), pp. 204-223.

Robins A., Rountree J., Rountree N. (2003), *Learning and teaching programming: A review and discussion*, "Computer Science Education", No. 13, pp. 137-172.

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THE SCOPE OF IMPLEMENTATION OF NEW ICT TRENDS IN THE OPINION OF CHILDREN AND ADOLESCENTS

Abstract

The article presents a fragment of diagnostic environmental research that determines the scope of knowledge, understanding, actions and attitudes of children and adolescents towards new trends in ICT related to cloud computing. The paper attempts to define how much ICT tools are used by students and to determine the scope of 1) their knowledge on cloud computing; 2) their usage of cloud computing in everyday activities; 3) their interest in new ICT trends and the practical usage of the trends. It emphasizes the subjective conditions that construct the circumstances in which contemporary students undertake (or do not undertake) activities for the implementation of modern ICT tools in school and after-school activities.

Keywords: students' information competencies, implementation of new ICT trends, cloud computing, environmental research of children and adolescents.

Introduction

The world of the ICT (Information and Communication Technology) sector, telecommunications and new media is constantly announcing breakthrough changes, surprising premieres, new trends. The leaders of large companies shaping the market for new technologies present visions of its development and future. Experts and representatives of ICT giants talk about the modernity, innovation and development of new computer technologies. They emphasize that it is not only the world of entertainment and gadgets, but also the world of the most modern technologies that help people and enrich our reality. Visionaries build an image of the future of new technologies and associate it especially with the dynamic development of products in the area of the Internet of Things, sophisticated mobile devices and the ground-breaking tools and solutions of cloud computing (A. Jadczak, 2018) – which offer its users completely new forms of work, ground-breaking changes in the use of information and telecommunications technologies.

Today, children and adolescents are also facing these technical and technological challenges, and IT education is expected to "prepare students to take on the responsibilities and challenges of the 21st century" (*Podstawa programowa*, 2017, p. 27). According to standard guidelines, a modern student should know the basic trends in the development of information and communication technology and implement them for everyday (school and after school) projects (*Podstawa programowa*, 2017, p. 177). Will children and adolescents meet these requirements?

Research assumptions

The adopted theoretical assumptions emphasize one of the possible proposals for shaping and developing information competencies which see the foundations of modern teaching and learning in the cognitive and constructivist theory (with special emphasis on the socio-cultural perspective), pointing to one way of thinking about forming knowledge – learning about ICT methods and ICT tools with the help of ICT (B. Siemieniecki, 2007, 2013). The theoretical standpoint is set by: 1) concepts of critical pedagogy (T. Szkudlarek, B. Śliwerski, 2009; T. Szkudlarek, 2004, pp. 363-377); 2) postmodern approach (Z. Bauman, 1995, 2011); 3) indications for self-education, self-realization, self-determination and open education (Z. Melosik, T. Szkudlarek, 2010; Z. Melosik, 2004, pp. 452-464).

In order to research pedagogical practice, attempts were made to show educational reality in confrontation with contemporary dominant scientific theories which draw the image of a "new student" that exists and is realized in the internet cyberspace, in the world of new new media (P. Levinson, 2010) that enables multi-sensory information transfer and multisensory learning – an "offline" student who has unlimited opportunities to use modern ICT tools and new spaces in e-education. The study attempted to answer the following question: what are the information competencies of students in the use of ICT methods and tools in the context of new technological trends and accompanying civilization changes?

As far as the methodology of pedagogical research was concerned, it was assumed at the conceptual stage of the project that it would take the form of diagnostic-correlation studies (G.A. Ferguson, Y. Takane, 2003, p. 33; S. Juszczyk, 2004, p. 166; K. Rubacha, 2008, p. 29; T. Pilch, 2010, p. 66) of quantitative and qualitative type (W. Dróżka, 2010, p. 125), embedded mainly in media pedagogy. The main research problem was composed of four specific problems (three diagnostic and one of dependency type). The first question-problem was related to establishing the scope of students' knowledge, understanding and application of new trends in ICT and the reflection of children and adolescents on ICT activities they took (or did not take); the second problem was related to the identification of the areas of ICT usage by children and adolescents that were outlined by the opinions of students and teachers; the third problem was related to the identification of the

effects of ICT use by children and adolescents based on the opinions of students and teachers; the fourth problem referred to an indication of the relation between the students' opinions and the teachers' views on the areas and effects of ICT use by children and adolescents and the identification of factors differentiating the variables and relations studied. Focusing on factors that motivate students to take action, the problems guided the description, explanation and interpretation of students' reflections on: ICT infrastructure (access to computers and the internet); the extent of the usage of ICT instruments; sources of gaining knowledge and skills related to new technologies; the extent of the implementation of new ICT trends (cloud computing); reasons and arguments for which they used (or did not use) ICT tools in their everyday practice. This refers to the presented concept – a structural model of information competencies in relation to ICT use – which includes "new trends in ICT development" (E. Baron-Polańczyk, 2011, pp. 84-92).

The research into students' information competencies in relation to the ICT use was based on the diagnostic procedure (D. Skulicz, 2010, pp. 221-225), and the method of a diagnostic survey was applied (E. Babbie, 2004, p. 268; S. Nowak, 2007, p. 47) along with two techniques: 1) targeted questionnaire (T. Pilch, T. Bauman, 2001, p. 96); 2) an open interview directed by dispositions for an individual interview (T. Pilch, T. Bauman, 2001, pp. 91, 92; M. Łobocki, 2009, p. 3; Ch. Frankfort-Nachmias, D. Nachmias, 2001, pp. 249, 612).

The study was conducted in the school year 2014/2015 in schools in Zielona Góra and selected schools located in Lubuskie Voivodeship and other neighboring voivodships. It included teachers who taught various school subjects and students attending four stages of education. 40 students who attended schools in Zielona Góra and nearby towns were interviewed. The research group (the entire sample) constituted 2510 students and 1110 teachers.

The results presented in this article refer to the first detailed research problem, and they are to give an answer to the question: to what extent students: 1) know cloud computing technology, 2) apply cloud computing in everyday practice, 3) show interest in new ICT trends and put them into practice (detailed analyses and comprehensive results can be found in: E. Baron-Polańczyk, 2018).

Study findings

Bearing in mind the requirements of the ICT world and standard guidelines for general education which say: "the student uses a computer network (school network, the Internet) to work in a virtual environment (on the platform, in the cloud), applying the methods and principles of working in this environment" (*Podstawa programowa*, 2017, p. 177) – the students were asked if they knew the tools and methods of cloud computing and whether they used this technology in practice. The children and adolescents were also asked to indicate specific examples

of applications in order to establish their areas of interest in new ICT trends and attempts to put them into practice. They were asked about this technology because at the time the study was being conducted, cloud computing became very popular not only among corporate users[1], but also individuals. Moreover, by its very nature, this technology could have very wide educational applications (see: *Przemiany w ICT – praca grupowa, dane i programy w Internecie*, in: E. Baron-Polańczyk, 2011, pp. 106-110).

The question regarding modern digital technology was answered by 2497 (99.5%) respondents. Among them, only 266 (10.7%) students declared their knowledge about new ICT trends. This very small group of children and adolescents by saying yes to the question "do you know the tools and methods of cloud computing?" claimed that they had knowledge on technological novelties and current development trends of digital technologies. However, it is worrying that the vast majority – 2231 (89.3%) of the respondents – answered no to the question, thus said that they: "do not know the tools and methods of cloud computing". Therefore, it could be concluded that the respondents did not meet the guidelines for educational preparation in information technology and computer science, according to which the student should know and understand the concepts underlying ICT and know the basic trends in ICT development – to the extent that the student could learn and work in a virtual environment.

This picture of the students' knowledge becomes even more disturbing in the light of the results related to their abilities to apply this knowledge in practice. Those who declared that they knew cloud computing were further asked whether they used it or not. Only 118 (4.7%) students said yes, and the credibility of these declarations was doubtful because in the group of the students using cloud computing only 32 (1.3%) respondents gave specific examples of tools and technological solutions used by them.

The examples of practical application of cloud computing given by the students mainly (16 examples) referred to using "various programs", free network applications for IT support of (as the students listed) "computers", "printers", "smartphones" and "the internet". Only some of the students referred to Microsoft, Google, Onet, WP.

"Various games" are examples of the application of new ICT trends for six respondents. One student justified that he "plays games which are like teaching

[1] According to the study called "Cloud in Polish companies" conducted in 2016 by Ipsos at the request of Intel, 35% of the surveyed companies in Poland used cloud computing. Although the respondents were large enterprises, cloud computing is not exclusively reserved for this group. Cloud computing is especially beneficial for the entities of the SME sector. According to the Cisco report on adaptation of cloud solutions, thanks to this technology companies can reduce IT spending by as much as 77%, and at the same time they can implement new applications and services quicker by 99%. Achievable profits reach 10.4% (see: *Oszczędności w firmie…*, 2018).

aids". They listed arcade games (so-called shooters), logic games and simulators, such as: 1) "Rapid" (*Rapid Gun – Strzelanki – Darmowe Gry Online*[2]); 2) "Życie Nolife'a" (*Dzień z życia NoLife'a/Gracza*[3]); 3) "DarkOrbit" (*DarkOrbit*[4]); 4) "Saper" (*Saper – graj online!*[5]); 5) "WWW.trainz.pl" (*Trainz*[6]).

Some (five students) perceived cloud computing only as the use of popular, common programs and services available on the internet. They listed the following examples: "email and searching information on Google", "e-mail", "mail, the internet", "social networking, and conversations on FB", "electronic school register".

Intentional and determined actions in using new ICT trends, as evidenced by the specific examples of practical application of cloud computing provided by five students, were illustrated in the following statements:

1) "I use the trial version of Adobe After Effects" (video and visual effects program, professional tools for creating animations and special effects[7]) and Adobe Photoshop (a raster graphics editor, professional program that is very popular among beginners and advanced users. Its main applications include editing and manipulating digital photography, creating internet graphics, creating graphics for printing and publishing. The program enables the user to create professional and impressive projects, consisting of an almost unlimited number of layers, masks, high resolution graphics neatly combined together with a wide range of filters and effects[8]);
2) "I work in a dropbox" (DropBox – a file hosting multiplatform application and service). The tool facilitates the process of archiving data on the computer, their subsequent synchronization and online sharing with friends[9]);

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[2] See: *Rapid Gun…*, 2018.

[3] See: *Life or Nolife…*, 2018; *Dzień z życia NoLife'a...*, 2018.

[4] DarkOrbit – free MMO game (by Bigpoint) in which the player becomes a pilot of the space fighter. The player takes part in hundreds of missions and great battles for world domination (see: *DarkOrbit…*, 2018).

[5] Saper (*Minesweeper*) – logic single player game created by R. Donner in 1981. Since then it has been available for each Windows version. There is also a Java Script version that makes the game available to players who have other operating systems such as Mac OS, Linux, Unix, etc. (see: *Saper – graj online!...*, 2018).

[6] Trainz – virtual simulator of railway models to collect and expand one's collection. Perfectly reproduced models of trains move on railway tracks that are ready-made or created with a three-dimensional railway track editor. The basic version of the game, the starter pack, is free to download. The pack includes several modules, locomotives, wagons and railway accessories. All additional models are available for a small fee. Models created by the players themselves are also available free of charge (see: *Trainz [PC]…*, 2018).

[7] See: *Adobe After Effects…*, 2018.

[8] Photoshop also offers a set of useful tools to improve work with graphics and application – including Adobe Bridge file browser, Adobe Extension Manager, Adobe Drive service, etc. (see: *Adobe Photoshop…*, 2018).

[9] For online sharing with friends one only needs to activate the Share option and provide email addresses to which file links are sent. An important aspect of DropBox application is simple

3) "I use Paint" (Paint.NET – raster image editing program[10]);
4) "I use free MySQL servers" (MySQL – a dynamically developed database server that together with the Apache and PHP servers creates the so-called "LAMP" [*Linux – Apache – MySQL – PHP*] – a popular server architecture for small and medium websites[11]);
5) "I use http FTP servers" (WWW and FTP servers[12]) and "disk space on my RPS" (virtual RPS servers where the user gets a fully isolated set of resources to install virtually any operating system, as well as full freedom in the configuration of the operating system and the database layer[13]).

When giving an example of using new ICT trends, one respondent (a boy in a junior secondary school) also emphasized that cloud computing gave a chance to "use free programs on the internet". He further explained that "at home I eliminate the need to purchase a license or the need to install and administer the software". In this case the respondent proved his knowledge, understanding and applying new ICT trends, as well as the awareness of the advantages and appreciation of these technologies in optimizing practical tasks.

In other cases, the examples of practical implementation of new ICT trends given by the students were either not relevant and showed their lack of understanding (e.g. "at home", "I know it from my brother"), or they were direct declarations of lack of knowledge and justification for not responding to the question (for example: "I do not know what CC is", "O! Error occurred", "Eeee, yes, I do not know"[14], "Sorry. I do not know this concept and unfortunately I cannot give

operation (just add a folder for synchronization with the server), data synchronization with multiple systems at the same time, access to files through a web browser and secure file sending via SSL protocol and AES-256 encryption (see: *DropBox…*, 2018).

[10] Paint.NET – a program created by a group of students from Washington State University. The creators' ambition is to add as many features as possible from professional graphics packages and to distribute the program for free. The program can be a successful replacement for Microsoft Paint program, but it also works well for more demanding users. Paint.NET has many features typical of expensive commercial programs, such as unlimited history of performed operations, special effects, modern user interface or layer usage (see: *Paint.NET…*, 2018).

[11] MySQL was created mainly for performance, and not for compliance with applicable standards. Many specialists accuse it of lacking basic functions, available at the competition for years. The authors tried to achieve greater compatibility with ANSI SQL 99 and ensured that the most significant flaws were removed: lack of stored procedures, views and replication (see: *MySQL…*, 2018).

[12] WWW and FTP servers – Apache, BulletProof FTP Server, Cerberus FTP Server, CrushFTP Server, FileZilla Server, Home FTP Server, Home Web Server, Tomcat, WampServer, Xlight FTP Server. For instance, Apache – a free HTTP server with shared source code, which is very popular (according to various sources, about 50% of all servers used) among ordinary users and companies of all sizes (see: *Serwery WWW i FTP…*, 2018; *Apache…*, 2018).

[13] RPS servers are also used in building solutions that for various reasons require resource guarantees and as a package of administrative and archiving services (see: *Cloud Computing. RPS…*, 2018).

[14] 'Eeee – an exclamation expressing various emotional states depending on the situation and context, it often means reflection, consideration, consent (in Polish "yyyy") (see: *Słownik…*, 2018).

examples"). Therefore, these responses were not classified (taken into account) in the discussed category.

Conclusions

On the basis of the collected data (for 2510 respondents) and the analyses, it can be stated that among the respondents only a tenth (10.7%) of the children and adolescents declared that they knew the tools and methods of cloud computing, and only 118 (4.7%) respondents used this technology in everyday practice. What is worse, among those who used cloud computing only 32 (1.3%) respondents were able to give specific examples of tools and technological solutions they used, so it is doubtful whether their declarations were credible. In addition, many statements indicated that the students had a simplified understanding of the concept of cloud computing and they limited this technology only to the usage of the most popular internet applications available via the browser (e-mail, electronic school register and above all social networks). There were also answers given in the form of short slogans that made it doubtful whether the respondent undertook conscious real practical actions. However, there were also some statements which led to the conclusion that many students used cloud computing tools despite their (declared) lack of knowledge and understanding.

Thus, it is much easier to look at the results from a different perspective and generally conclude that almost all of the surveyed population (95.3% of students) did not show interest in new ICT trends and did not implement the modern forms of activity offered by cloud computing. Even if they did, they were unaware of the scope of activities supported by cloud computing tools. This may indicate that modern technology is increasingly "transparent" to the end user. In other words, the end user does not need to know how the functions he/she uses are technically realized. Virtualization and cloud computing are areas that are not unknown to entrepreneurs. These technologies have been successfully used by Polish and foreign companies (D. Wolak, 2010, p. B11). The Polish public cloud market is growing every year[15]. It is a pity that new technological solutions are far less (or not at all) popular in education, even among children and adolescents.

This may raise some concern, because today it is widely reported that the era of open education has begun – where access to knowledge is democratizing, and the availability of knowledge is becoming easier and easier. New media, especially the internet, which are not limited by space or time, create a virtual world of knowl-

[15] According to IDC preliminary estimates, in 2016 the Polish public cloud market increased by over 25% compared to 2015. It is estimated that by 2019 it will have been growing on average 5 times faster than the market for traditional IT services, which means that we are close to the world average in terms of investments in cloud computing. The average investment rate in the cloud will have globally reached 21.5% by 2019, while in Poland it will have reached 18.6% (see: A. Jadczak, 2018).

edge in an almost costless, interactive way. In this world everyone can co-exist and compete in science and technology. The development of ICT provides technical and practical opportunities for every participant in the global world to participate actively in the process of permanent education in clouds (E. Baron-Polańczyk, 2014, pp. 111-122).

Bibliography

Babbie E. (2004), *Badania społeczne w praktyce*, trans. W. Betkiewicz et al., Warszawa.

Baron-Polańczyk E. (2011), *Chmura czy silos? Nauczyciele wobec nowych trendów ICT*, Oficyna Wyd. UZ, Zielona Góra.

Baron-Polańczyk E. (2014), *Nauczyciele wobec technologii cloud computing (komunikat z badań środowiskowych)*, "Kognitywistyka i Media w Edukacji" 2014, No. 1.

Baron-Polańczyk E. (2018), *My i Oni. Uczniowie wobec nowych trendów ICT*, Oficyna Wyd. UZ, Zielona Góra [w druku].

Bauman Z. (1995), *Wieloznaczność nowoczesna, nowoczesność wieloznaczna*, trans. J. Bauman, PWN, Warszawa.

Bauman Z. (2011), *Kultura w płynnej nowoczesności*, Wyd. Agora, Warszawa.

Dróżka W. (2010), *Trangulacja badań. Badania empiryczne ilościowo-jakościowe* [in:] S. Palka (ed.), *Podstawy metodologii badań w pedagogice*, GWP, Gdańsk.

Ferguson G.A., Takane Y. (2003), *Analiza statystyczna w psychologii i pedagogice*, trans. M. Zagrodzki, PWN, Warszawa.

Frankfort-Nachmias Ch., Nachmias D. (2001), *Metody badawcze w naukach społecznych*, trans. E. Hornowska, Wyd. Zysk i S-ka, Poznań.

Juszczyk S. (2004), *Statystyka dla pedagogów*, Wyd. A. Marszałek, Toruń.

Levinson P. (2010), *Nowe nowe media*, trans. M. Zawadzka, Wyd. WAM, Kraków.

Łobocki M. (2009), *Metody i techniki badań pedagogicznych*, Wyd. "Impuls", Kraków.

Melosik Z. (2004), *Pedagogika postmodernizmu* [in:] Z. Kwieciński, B. Śliwerski (ed.), *Pedagogika*, Vol. 1, PWN, Warszawa.

Melosik Z., Szkudlarek T. (2010), *Kultura, tożsamość i edukacja. Migotanie znaczeń*, Wyd. "Impuls", Kraków.

Nowak S. (2007), *Metodologia badań społecznych*, PWN, Warszawa.

Pilch T. (2010), *Strategia badań ilościowych* [in:] S. Palka (ed.), *Podstawy metodologii badań w pedagogice*, GWP, Gdańsk.

Pilch T., Bauman T. (2001), *Zasady badań pedagogicznych. Strategie ilościowe i jakościowe*, Wyd. "*Żak", Warszawa*.

Rubacha K. (2008), *Metodologia badań nad edukacją*, Wyd. Akademickie i Profesjonalne, Warszawa.

Siemieniecki B. (2007), *Konstruktywizm w edukacji wspieranej mediami* [in:] B. Siemieniecki (ed.), *Pedagogika medialna*, Vol. 1, PWN, Warszawa.

Siemieniecki B. (2013), *Pedagogika kognitywistyczna. Studium teoretyczne*, Wyd. "Impuls", Kraków.

Skulicz D. (2010), *Badania opisowe i badania diagnostyczne* [in:] S. Palka (ed.), *Podstawy metodologii badań w pedagogice*, GWP, Gdańsk.

Szkudlarek T. (2004), *Pedagogika krytyczna* [in:] Z. Kwieciński, B. Śliwerski (eds), *Pedagogika*, Vol. 1, PWN, Warszawa.
Szkudlarek T., Śliwerski B. (2009), *Wyzwania pedagogiki krytycznej i antypedagogiki*, Wyd. "Impuls", Kraków.
Wolak D. (2010), *Jeden komputer, wiele serwerów*, "Rzeczypospolita", No. 123, p. B11.

Electronic publications

Adobe After Effects, http://www.dobreprogramy.pl/Adobe-After-Effects,Program,Windows,12434.html [06.01.2018].
Adobe Photoshop, http://www.dobreprogramy.pl/Adobe-Photoshop,Program, Windows,12430.html [06.01.2018].
Cloud Computing. RPS, http://www.tempus.net.pl/hosting.html [06.01.2018].
DarkOrbit – darmowa gra MMO w pilota myśliwca, "Komputer Świat", http://www.komputerswiat.pl/gry/gry-online-w-przegladarce/dark-orbit.aspx [06.01.2018].
DropBox, http://www.dobreprogramy.pl/Dropbox,Program,Windows,13165.html [06.01.2018].
Dzień z życia NoLife'a/Gracza, https://www.youtube.com/watch?v=mALESsn2gY4 [06.01.2018].
Jadczak A., *CES 2016: zbliża się najważniejsze wydarzenie w świecie nowych technologii*, ITWIZ, http://itwiz.pl/ces-2016-zbliza-sie-najwazniejsze-wydarzenie-swiecie-nowych-technologii/ [20.09.2018].
Jadczak A., *Wielkość rynku cloud computing w Polsce w roku 2016*, ITWIZ, http://itwiz.pl/wielkosc-rynku-cloud-computing-polsce-roku-2016/ [29.05.2017].
Life or Nolife czyli moje życie jest lepsze od twojego, http://zpopk.pl/life-or-nolife-czyli-moje-zycie-jest-lepsze-od-twojego.html#axzz42u0OkpNl [06.01.2018]
MySQL, http://www.dobreprogramy.pl/MySQL,Program,Windows,13187.html [06.01.2018].
Oszczędności w firmie: gdzie ich szukać?, Magazyn "Sukces", http://www.sukcesmagazyn.pl/artykul/1305309.html?p=1 [13.09.2018].
Paint.NET, http://www.dobreprogramy.pl/Paint.NET,Program,Windows,12332.html [06.01.2018].
Podstawa programowa…, Załączniki do Rozporządzenia Ministra Edukacji, Narodowej z dnia 14 lutego 2017 r. (poz. 356), DzU z 2017 r., poz. 356.
Rapid Gun – Strzelanki – Darmowe Gry Online, http://www.krainagier.pl/gra/rapid-gun-6543.html [06.01.2018].
Saper – graj online!, http://gra-saper.pl/ [06.01.2018].
Serwery WWW i FTP, http://www.dobreprogramy.pl/Serwery-WWW-i-FTP-dla-specjalistow-IT,Programy,Windows,244.html; *Apache*, http://www.dobreprogramy.pl/Apache,Program,Windows,19564.html [06.01.2018].

Słownik Języka Polskiego SJP, http://sjp.pl/yyy [03.08.2018].
Trainz [PC], http://www.gry-online.pl/S016.asp?ID=779 [06.01.2018].

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TECHNOLOGY AND EDUCATION: WHY DO STUDENTS STILL NEED ACCESS TO SPECIALIZED KNOWLEDGE?

Abstract

The current neoliberal school reforms stress the development of skills and competences, so that students can function well in the labor market. These school reforms tone down the role of knowledge in education and correspond to new educational principles applied in schools. In the new ICT-school, students themselves shall construct knowledge, assisted by various pedagogical methods, supposedly leading to in-dept learning. This article raises a number of objections against the knowledge claims promoted by the learning sciences. With a starting point in the Legitimation Code Theory (K. Maton, 2014), as well as studies of Norwegian teacher education, this article argues for that students still need access to specialized knowledge in their education.

Keywords: ICT, digitalization of the school, Legitimation Code Theory, sematic gravity, knowledge building, knowledge practices, subject areas, specialized knowledge.

Introduction

The central focus of ICT-research in education is learning, not knowledge. It is assumed that an increased access to technology in school has changed the premises for learning and teaching (S. Østerud, 2004; R.J. Krumsvik, 2007). This development, including the toning down of knowledge in school, is supported by contemporary neoliberal school reforms (L. Wheelahan, 2010). The school of today and of the future, according to the latest Norwegian curricular reform (LK20), shall have a contemporary focus on a knowledge-based labor market, where having the competences currently in demand is the decisive factor (Meld. St. 28, 2015-16). These competences are often called "21st century skills", where digital competence

together with the ability to work in a team, creativity, and productivity are central elements (J. Voogt, N.P. Robin, 2012). For teachers in the new ICT-school it is consequential to create learning situations that allow access to rich and varied information, which students can use to become producers, not just consumers of knowledge (A. Lund, T.E. Hauge, 2011).

Today's ICT-research has a strong focus on learning and new learning theories. These theories are based on a program for changing teaching, moving from traditional classroom teaching where the teacher presents theories, facts, and procedures for solving tasks to a school where the students themselves develop understanding and knowledge (R.K. Sawyer, 2006). It is assumed that students who work in this way will experience processes of in-depth learning, which means to learn "integrated and usable knowledge, rather than the sets of compartmentalized and decontextualized fact emphasized by instructionism" (R.K. Sawyer, 2006, p. 2). While teaching earlier was aimed at providing students with insights into the theories and established knowledge of a subject, now the primary concern is that students themselves construct knowledge, using methods such as problem-based learning, exploration, project work, etc. In other words, in-depth knowledge means that students themselves create knowledge through authentic studies and practices, which is assumed to provide students with new insights and understanding in the form of in-depth knowledge.

The new learning sciences, with newly postulated principles for learning in school are the foundation for ICT-research. Learning is the central focus, and research is based on a "subjective doxa" (K. Maton, 2014, p. 3), the assumption that knowledge is linked to the initiation of mental processes that lead to new insights and even to in-depth learning. These premises of the learning sciences imply that knowledge is identical to knowing, and that the development of learning and knowledge in education can be studied based on cognitive, social, and emotional processes. The problem with this approach is that it ignores the subject-specific forms of knowledge, as well as the teacher's knowledge practices, which determine how technology is used in the subjects (S. Howard, K. Maton, 2011). In addition, if we wish to give students a deeper understanding, this requires that we leave behind the subjective doxa by initiating forms of learning and knowledge building of a context-transcending character. In this article, I will illuminate these arguments in several steps, first by examining the background for the subjective turn in education. Next, I will provide examples from my own research and conclude that overcoming the problem of segmentalism in school requires that students maintain access to specialized knowledge.

The subjective turn: The revitalization of constructivism

The neoliberal educational reforms, carried out in the last decades in Norway and in other countries, have changed the concept of knowledge in schools and in higher education. While traditional education saw the transmission of knowledge, established in different disciplines, as being important, knowledge in the reformed school acquired a new character. The new reforms assume that students shall be prepared for the labor market in what is often called a knowledge society (L. Wheelahan, 2010). In school, these ideas have helped to create a new type of hybrid curricula that focus less on theoretical knowledge and more on applied knowledge, competences, and skills (M.F.D. Young, 2008). Where school earlier insisted on a strong relation to established scientific knowledge, this has been gradually replaced by the idea of learning as experience, where knowledge is a product of practices in a situated context (R.K. Sawyer, 2006). Based on this train of thought, empirical knowledge, as it arises through practice and experience, is the source of knowledge in school, not the knowledge that has been systematically structured, tested, and being established in the different disciplines.

The turn towards subjectivity and contextuality in the neoliberal school reforms is as such not established in the principles of the new learning sciences but is based on the idea that school is a tool to develop society, in particular a knowledge-based economy (R. Moore, 2004; M.F.D. Young, 2008; L. Wheelahan, 2010). Instrumentalism is a trend fueling the neoliberal school reforms, and it stresses practice, as well as learning in a real-world setting, with authentic forms of practice, in line with how modern workplaces function. This program contains an implicit critique of the old school and stresses the role of generic skills and forms of competence, at the expense of theoretical knowledge.

Even though instrumentalism is not *per se* based on pedagogical learning theories, there is a strong affinity between its program, to link school tightly to the needs of the workplace on the one hand, and the assumptions of constructivism about knowledge and learning on the other. Both these currents tone down theoretical knowledge and stress the importance of "knowers" instead, who live and work in societies where knowledge has been relativized and where individuals in education and at the workplace experience the constant need for learning and being updated. This alliance leads to a revitalization of constructivism, which with reinforced strength argues for an adapted and contextualized concept of knowledge in education (J. Cullen et al., 2002; S. Østerud, 2004). This contextualized concept of knowledge implies the concept of learning as a particularly social activity with

construction of meaning or knowledge being enacted in a "real world" setting. Inside education, problem-based learning and methods of exploration represent a concentrated expression for the new pedagogy, where knowledge is contextualized and adapted and is a product of students' social practices, linked to the problem or project the students work on.

The epistemology of constructivism stresses the role of social practices as a source of knowledge in education (L. Wheelahan, 2010). In this approach, the distinction between theoretical knowledge and everyday knowledge is abandoned. Specialists' research at universities and other institutions is reduced to just another type of practice. With this background constructivism can ally itself with a program where specialized theoretical knowledge forms part of a wider concept of competence (E. Bratland et al., 2016), stressing the contextualization of a knowledge that is used to study reality rather than established forms of knowledge. The implication of this epistemology is that specialized and theoretical knowledge are squeezed out of education, and that the practices and experiences of students are elevated to being important sources of knowledge in education. This turn claims to be a "democratization" of knowledge production: Knowledge production is no longer reserved for the members of a research community, but is an activity conducted by everyone in a learning society and in education. When the distinction between theoretical knowledge and everyday knowledge is abandoned, all knowledge is relativized. Further consequence is that concepts such as truth and objectivity appear to be obsolete (L. Weelahan, 2010). For constructivism, all knowledge is local and contextual, and all knowledge is equally relevant. There is no knowledge that is better or more reliable than other knowledge. The inevitable consequence is a school marked by segmentalism (B. Bernstein, 2000; K. Maton, 2014), where students gain access to a contextual form of knowledge that cannot be transferred to new contexts.

Segmentalism has been a persistent problem in the system of education (P. Haug, 2003), but this problem becomes acute with the increased accessibility of technology in education (T. Brabazon, 2002, 2007; R.J. Krumsvik et al, 2013; M. Blikstad-Balås, 2016). When the ICT-school emphasizes that students themselves should construct knowledge through exploration and other pedagogical methods, there is an imminent danger that this process will lead to segmental forms of learning, producing knowledge that is valid only in a local setting. A Google search can provide students with information relevant for the project they work with, but such internet searches do not necessarily provide access to the theories that are established in the disciplines. The disciplines' theories and concepts represent the best attempt of science to grasp the social and natural world. These theories provide students with an epistemic access, enabling them to transgress the local context and to participate in processes with cumulative knowledge building in education. In the following sections, I will use the LCT-theory and the concept of semantic

gravity to illuminate how studies of knowledge practices in selected subjects can demonstrate different forms of knowledge building in education.

LCT-theory and semantic gravity

Legitimation Code Theory (LCT) is a framework for research and practices (K. Maton, 2014), forming a part of a broader social and realist current (K. Maton, R. Moore, 2010), consisting of a set of approaches with the aim to characterize the social and realist aspects of research, which can be studied with the LCT-theory. LCT-theory expands and integrates ideas from several other theories, most importantly those of Pierre Bourdieu and Basil Bernstein. LCT-theory has been developed by Karl Maton (2014, 2016) and encompasses several dimensions and a set of concepts that can be used to analyze organizational principles or the legitimate codes underlying knowledge practices in education.

In this section, I focus on the concept of semantic gravity, which refers to meanings or context-dependency of concepts. Maton (2014, p. 129) defines this term as follows:

- Semantic gravity (SG) refers to the degree to which meaning relates to its context. Semantic gravity may be relatively stronger (+) or weaker (-) along a continuum of strength.
- The stronger the semantic gravity (SG+), the more the meaning depends on its context.
- The weaker the semantic gravity (SG-), the less dependent meaning is on its context.
- All meanings relate to a context of some kind; semantic gravity conceptualizes how much they depend on that context to make sense.

The concept of semantic gravity shows how meaning is related to its context, and the term is well suited to investigate knowledge practices, differentiating the forms of knowledge that are involved in the practices. The concept of semantic gravity avoids over-simplifying dichotomies such as student-centeredness vs. teacher-centeredness and instead allows to see that all forms of practice encompass meanings with varying degrees of semantic strength. The concept semantic gravity allows to uncover variations of context dependence in meanings and practices by showing that all forms of practice have a different semantic strength. Semantic gravity, therefore, can trace a continuum of strength, with fine gradation. The realization of semantic gravity will depend on the object of study. This means, for example, that specific views about concrete historical events have a strong semantic gravity (SG+), while general explanations of the same phenomena by using theories and concepts will have a weak semantic gravity (SG-). Studying changes over time allows detecting characteristic patterns that are expressed as semantic waves (K. Maton, 2014; K. Maton et al., 2016). These gradual changes can also

be described as movements that cause a weakening of semantic gravity, expressed as movements ranging from views regarding a specific case to generalizations and abstractions where meaning depends less on context and vice versa. Thus semantic waves, when connected to specific knowledge practices, have the potential to show how different types of knowledge interact and allow insight into the different forms of knowledge building in education.

Semantic waves, as they are expressed in connection with knowledge practices in education, can precipitate into different forms of knowledge building. A distinction can be made between segmental and cumulative forms of knowledge building (K. Maton, 2014, p. 108):

- Cumulative knowledge building provides students with access to conceptual or theoretical knowledge, based on earlier acquired knowledge and allows the integration and expansion of that knowledge across contexts and time.
- Segmental knowledge building is achieved when knowledge is strongly bound to a context and only meaningful in this context.

Semantic gravity allows studying different forms of knowledge building. Knowledge practices that lead to cumulative knowledge building encompass semantic waves caused by the use of concepts and theories, here understood as relatively context-independent meanings with weak semantic gravity (SG-). Accordingly, knowledge practices that exclusively focus on information on the internet or reflections and experiences in a particular context will be characterized by stronger semantic gravity (SG+), with more context-dependent views, which will lead to segmental forms of knowledge in education.

Semantic gravity and knowledge building: Examples from research

As mentioned above, semantic gravity allows investigating knowledge practices in education. Knowledge practices depend to a varying degree on the context. Semantic gravity analyzes how knowledge practices produce semantic waves. These waves create semantic profiles that can shed light on the forms of knowledge building in a given subject or program. In this section, I provide some examples for such connections and present my own research on Norwegian teacher education (E. Bratland et al., 2018). The project was conducted between 2015 and 2016. Different forms of data collection were used, and here I will focus on student papers that were handed in in three subjects: history (23 students), geography (31 students), and pedagogy (21 students). To answer the questions of the task, students of geography and history used internet-based sources to a large degree, while this Figure was lower among students of pedagogy (see below).

In order to analyze the student papers and to determine their relative semantic strength a degree of context dependence, an external language was developed, a set of operalizations that allows the coding of data (see Figure 1).

Semantic Gravity	Code categories	Description of coded content
Weaker (SG-)	Red (R)	Students describes a theory, concept or principle in a general manner, without reference to experiences, social conditions or own assessments.
	Green (G)	Students describes the object, by reference to various sources, but without explicit reference to relevant academic theories or explanations. This intermediate level can "create links" to the red and yellow level.
Stronger (SG+)	Yellow (Y)	Students describes the object, by referring to their own experiences, views or perceptions of social conditions.

Figure 1. An external language of description for semantic gravity
Source: E. Bratland et al., 2018.

The student papers were coded in terms of the strength of their semantic gravity; three levels were defined: red, green, and yellow. The result of the coding demonstrated considerable differences of the semantic profiles of the student papers in history, geography, and pedagogy (E. Bratland et al., 2018). Here I outline the most notable differences.

The topic for the history papers was sustainable development, and in the task created by the teacher students were instructed to discuss the following aspects: the historical background for the state of the planet, ecological sustainability, and solutions for a sustainable society. An analysis showed that most of the papers (75%) covered all three levels. All those student tasks contained a definition of the term sustainable development (SG-). The description of the state of the planet, focusing on global warming, was found on pages with UN-reports and related information.

The papers furthermore contained further discussions of solutions for a sustainable society, inviting to write from one's own point of view (SG-).

The topic in geography was the persecution of ethnic minorities between 1945 and 1980. The instructions of the teacher in particular mentioned Sami, Gypsies, and Kvens. The majority of student papers in geography (56%) have a green semantic profile, marked by fact-based presentations, in many cases with references to Wikipedia or similar internet sites about the persecution of these minorities. These papers seldom refer to established theories and concepts, and there are no individual assessments beyond the adaptation of the source material to the task.

The papers in pedagogy were so-called reflection tasks. After a common trip into nature together with lower secondary school students, the teacher instructed students to write about their experiences with the outdoor "classroom", with a focus on the professional role of the teacher. Most of the papers in pedagogy (73%) cover two levels, green and yellow. These papers seldom refer to pedagogical theories and concepts, and the reflections of the students are based on observations and experiences from the mentioned trip. Therefore, those papers have a strongly context-dependent character (SG+).

An analysis of student papers in the subjects of history, geography, and pedagogy shows that these papers have considerably different semantic profiles, with different semantic strength, and with knowledge practices producing different semantic movements. Figure 2 is a heuristic illustration of three different semantic profiles, showing movements over time, of the majority of student papers in this study.

Figure 2 shows the differences between the semantic profiles; the students' knowledge practices produce semantic waves with varying scope and with different degrees of context dependence.

The semantic waves in the history papers cover all levels, with texts moving in waves from weaker to stronger semantic gravity and vice versa. The history papers create a distinct profile, with long semantic waves moving from theories and concepts, to descriptions of the object, and finally to one's own assessment. In contrast, the papers in geography produce a semantic flat line, consisting of adapted descriptions of the object (ethnic minorities). Knowledge practices in pedagogy create gravity waves with limited scope.

An analysis of the student papers, with their varying semantic strength and context dependence, can be translated back into the different forms of knowledge building in education. Semantic gravity illuminates how the meanings in student papers rely on context, ranging from strong to weak context dependence. This approach allows translating data into the two fundamentally different forms of knowledge building, which here are categorized as segmental and cumulative knowledge building (see Figure 3).

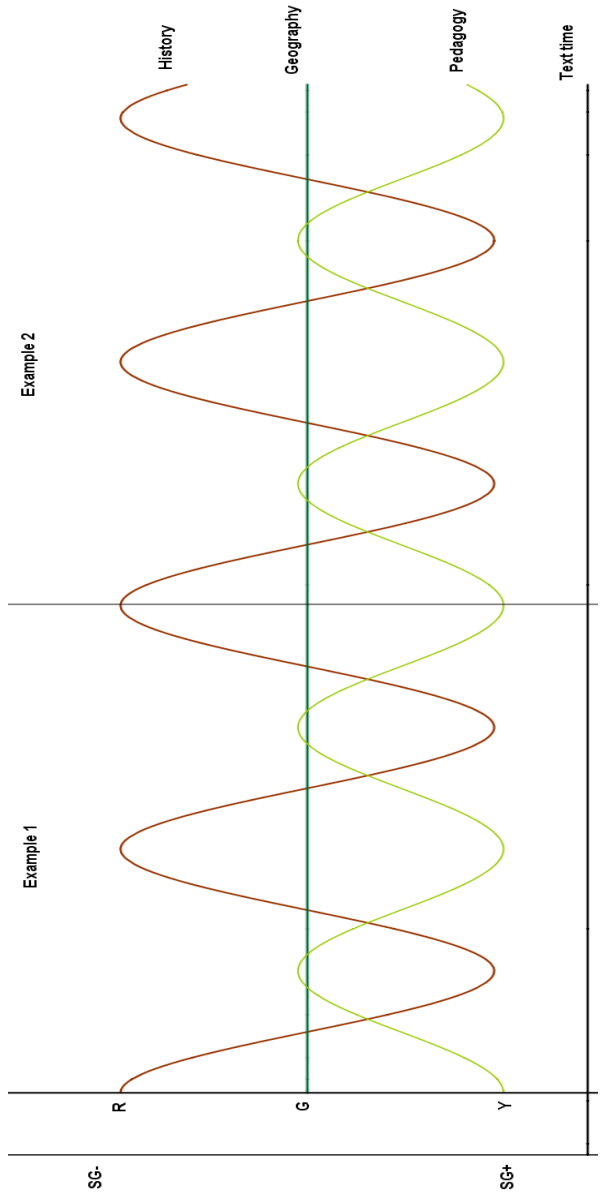

Figure 2. Profiles of semantic gravity in student papers in three subjects
Source: prepared by the author.

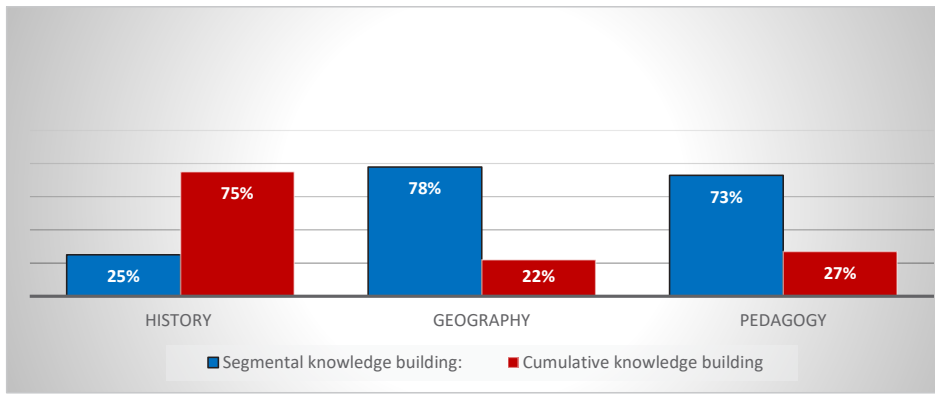

Figure 3. Employment of knowledge building in subjects
Source: prepared by the author.

An analysis of student papers in the subjects of history, geography, and pedagogy demonstrates their different semantic profiles. Figure 3 shows that students' knowledge practices, as expressed in their papers, lead to different forms of learning and knowledge building in education. Only in history, where papers were characterized by long semantic waves, do the students' knowledge practices lead to cumulative knowledge building. These papers have several levels, which allows a recontextualization and decontextualization of knowledge. Decontextualization, using theory and concepts, allows history students to transgress the local context. In this way, students acquire a knowledge that can be built on and that allows later expansion. The papers in geography and pedagogy have different semantic profiles, but their common denominator is that both lead to segmental forms of knowledge building. Facts are important, but facts about ethnic minorities represent a type of knowledge that is difficult to integrate and expand in order to provide students with a deeper knowledge of geography. The knowledge practices of students of pedagogy, as they are expressed in their papers, are based on the idea that experiences are the most important source of knowledge in education. These practices allow a recontextualization of knowledge, but they do not lead to the development of principles and concepts that can be applied to new contexts. The practice of students of pedagogy, with their interpretation of their own experiences and observations, lock students into a local context without the option to transfer knowledge to new contexts. In education, these practices lead to segmental forms of knowledge building.

Conclusions

This article set out with a presentation of neoliberal school reforms in Norway and several other countries (L. Wheelahan, 2010). These reforms are driven by a form of instrumentalism, aiming at orienting school towards present needs and enabling students to function in a new labor market. The new Norwegian curricula (LK 20) strongly emphasize learning in a real-world setting, with authentic forms of practice, in line with the reality of the labor market (Meld. St. 28, 2015-16).

The neoliberal school reforms have an affinity to the program of the new so-called learning sciences and have boosted constructivist ideas about knowledge and learning in education. A core element of this turn towards the "subjective doxa" is the idea that students themselves can create knowledge through student-active practices and explorations, which are assumed to provide students with new insights and understanding, also called in-depth learning (R.K. Sawyer, 2006). These principles of learning sciences form implicitly or explicitly central elements in both research on and use of ICT in education.

This article problematizes the claims of learning sciences and its assumption that student-active practices, where students themselves create their own knowledge, will automatically lead to a deeper insight or to in-depth learning. With the help of LCT-theory and the concepts of semantic gravity and segmental and cumulative knowledge building, this article argues that the doxa of learning sciences are highly problematic. The study in this article suggests that the dichotomy between a student-centered and a teacher-centered pedagogy, with the assumption that student-active forms of learning will lead to in-depth learning, is an untenable simplification. The study discussed in this article rather suggests that the questions of learning progress and knowledge building are much more complex than the learning sciences assumes.

Segmentalism is a widespread problem in education, and my study demonstrates the problem in student papers in the subjects of geography and pedagogy. The students' knowledge practices in these subjects, where students themselves create knowledge, correspond in many ways to the core ideal of practice in the learning sciences. Nevertheless, these practices lead to segmental knowledge building in two of three cases, as shown in the study. In other words, student-active learning, in the form of information retrieval from the internet or in the form of reflections about experiences do not lead to in-depth learning, but primarily to local and context-bound forms of knowledge that cannot be transferred to new contexts. It appears that the medicine prescribed by learning sciences to cure segmentalism is ineffective.

Cumulative knowledge building with student-active methods, with or without the use of ICT, where students are enabled to transgress the local context, is a constant challenge in education. However, the case of the students of history shows that it is possible, under certain circumstances. Specialized knowledge, in the form of a subject's concepts and theories, appear to be a key factor. Despite all present proclamations, for adapting education to the modern workplace or for the subjective doxa of learning sciences, students still need access to specialized knowledge in education to be able to transgress local and context-dependent forms of knowledge. Cumulative knowledge building requires epistemic access to established theories and concepts in the subjects. Without that access, learning processes in education will inevitably lead to segmentalism.

Bibliography

Andreas L., Trond Eiliv H. (2011), *Designs for Teaching and Learning in Technology-Rich Learning Environments*, "Nordic Journal of Digital Literacy", No. 6(04), pp. 258-271.

Bernstein B. (2000), *Pedagogy, symbolic control and identity: theory, research, critique*, Rowman & Littlefield, Lanham.

Blikstad-Balås M. (2016), *Faglig og ikke-faglig bruk av teknologi i klasserommet* [in:] R.J. Krumsvik (ed.), *Digital læring i skole og lærerutdanning* (2. utg. ed., pp. 136-150), Universitetsforlaget, Oslo.

Brabazon T. (2002), *Digital hemlock: internet education and the poisoning of teaching*, University of New South Wales Press, Sydney.

Brabazon T. (2007), *The university of Google: education in the (post) information age*, Ashgate, Aldershot.

Bratland E., Sieminiecka D., Baron-Polańczyk E., Perzycka E. (eds) (2018), *Knowledge building in education (fortcoming)*, Adam Marszałek, Toruń.

Bratland E., Sieminiecka D., Siemienicki B. (eds) (2016), *Knowledge, ICT and education – a variety of perspectives*, Adam Marszałek, Toruń.

Cullen J., Hadjivassiliou K., Hamilton E., Kelleher J., Sommerlad E., Stern E. (2002), *Review of current pedagogic Research and practice in the fields of post-compulsory education and lifelong learning*, The Tavistock Institute, London.

Haug P. (2003), *Evaluering av Reform 97: sluttrapport frå styret for Program for evaluering av Reform 97*, Norges forskningsråd, Oslo.

Howard S., Maton K. (2011), *Theorising Knowledge Practices: A Missing Piece of the Educational Technology Puzzle*, "Research in Learning Technology" 19(3), 191-206, doi: 10.1080/21567069.2011.624170.

Retningslinjer for utforming av nasjonale og samiske læreplaner for fag i LK20 og LK20S (2018), Kunnskapsdepartementet, Oslo.

Krumsvik R.J. (2007), *Skulen og den digitale læringsrevolusjonen*, Universitetsforl, Oslo.

Krumsvik R.J. (2013), *Sammenhengen mellom IKT-bruk og læringsutbytte (SMIL) i videregående opplæring: hvilken sammenheng er det mellom IKT-bruk og (intendert, subjektivt, og objektivt) læringsutbytte i videregående opplæring: sluttrapport*, Universitetet i Bergen, Institutt for pedagogikk, Bergen.

Lund A., Hauge T.E. (2011), *Designs for teaching and learning in technology rich learning environments*, "Nordic Jounal of Digital Literacy", No. 6(4), pp. 258-271.
Maton K. (2014), *Knowledge and knowers: towards a realist sociology of education*, Routledge, New York.
Maton K., Hood S., Shay S. (2016), *Knowledge-building: educational studies in legitimation code theory*, Taylor & Francis Group, Routledge.
Maton K., Moore R. (2010), *Social realism, knowledge and the sociology of education: coalitions of the mind*, Continuum, London.
Meld. St. 28. *Fag – fordypning – forståelse: en fornyelse av Kunnskapsløftet* (2015-2016), Kunnskapsdepartementet, Oslo.
Moore R. (2004), *Education and society: issues and explanations in the sociology of education*, Polity, Cambridge.
Sawyer R.K. (2006), *The Cambridge handbook of the learning sciences*, Cambridge University Press, Cambridge.
Voogt J., Roblin N.P. (2012), *A comparative analysis of international frameworks for 21 st century competences: Implications for national curriculum policies*, "Journal of Curriculum Studies", No. 44(3), pp. 299-321, doi: 10.1080/00220272.2012.668938.
Wheelahan L. (2010), *Why knowledge matters in curriculum: a social realist argument*, Routledge, London.
Young M.F.D. (2008), *Bringing knowledge back in: from social constructivism to social realism in the sociology of education*, Routledge, London.
Østerud S. (2004), *Utdanning for informasjonssamfunnet: den tredje vei*, Universitetsforl, Oslo.

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APPLICATION OF DIGITAL COMPETENCE OF THE TEACHER IN INNOVATIVE APPROACH OF STUDENTS' ASSESSMENT BY MEANS OF INTERACTIVE ELECTRONIC EXERCISES

Abstract

Recent reform changes that affected the education system in the Slovak Republic within the last period are related not only to further education of teachers; they also relate to new content of the State educational program focused on elementary school, whereas one of the key reform aims is the improvement in quality of education. Task of development and perfecting of professional competences of teacher is gaining an important meaning. The aim of these changes is that the teacher applies gained professional competences within the educational process in a way enabling to develop key skills of students of the elementary school in the technical subject. Based on the European Framework of Reference, we focus our attention to the digital competence which, in regard to usage of modern technologies within educational process, belongs to essential competences of the modern, third millennium teacher. Teacher, who acquired the digital competence by use of information and communication technologies (ICT), applies his innovative approach, for example, in assessment or self-evaluation of student in the educational process, which forms an important element of learning. In such case, we may speak about electronic assessment (e-assessment). The research in this field confirms highly positive impact on improvement of student's performance in self-evaluation applying by means of ICT (e.g.. B.M. Klecker, 2007; T. Wang, 2008). The modern information and communication technologies are more frequently applied also in new forms of learning materials and tools; they contain learning exercises or they are used in solving of exercises. The submitted study presents the results of pre-research of how do teachers apply acquired digital competence in student's assessment. Next part of the study presents selection of proposed interactive electronic exercises focused to formative assessment of students within the subject Technique in elementary school in the Slovak Republic.

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Keywords: elementary school, education, teacher's competences, electronic assessment, interactive electronic exercises.

Introduction

Nowadays, the word competence refers to the system of professional conditions that is open and able to further develop. Competences cover the whole scale of teacher's profession performance including components such as knowledge, skills, experience and personality requirements that are mutually linked and understood in complex. Teacher's profession, further education of teachers, change of school from traditional to modern are priorities of the school reform conduced in elementary and high schools in the Slovak Republic since 2008. Changes that took place were based on Law no. 317/2009 from the Collection of Law, focused on lifelong education of teachers within their professional growth. The law is precisely defining professional growth of teacher as the process of enhancing, improving and broadening qualification of professional competences in line with the most updated scientific findings, social needs and requirements regarding pedagogical profession and performance. Requirements for the quality of teachers' education have changed; teachers are demanded to heighten their qualification, as well as to update and innovate their teaching process.

Some of the major changes that appeared as a result of the school reform include focusing on new educational goals based on a new content of School Educational Programme. Great attention is paid to the development and improvement of key competences of teachers by means of their lifelong educating. The focus is put not only to acquiring of competences, but also to their utilizing and applying within the teaching process. Regarding to teachers' education in the field of information and communication technologies (ICT), which is reasoned by the strategy of society informatization in the Slovak Republic from 2009 to 2013, it is stated that the recent educational process requires high level of teachers' and students' abilities to use digital technologies in both, teaching and learning. According to this document, the human potential forms one of the main pillars of building the information society since only those teachers who are qualified and who acquired their professional competences are able to utilize potential of the information society and are able to implement them within subjects they teach. One part of the school reform in the Slovak Republic is formed by the support of further education of teachers. It is currently being performed by means of continual education which includes innovative education as well. The aim of innovative education is

to improve teachers' professional competences that are essential for their standard pedagogical performance, which is in line with the valid school legislation. Only those teachers who have acquired the digital competence and built it as a part of their personality are able to strategically affect students and help them develop their digital competence.

Effective acquiring of professional competences by technical subject teachers presuppose bold change within their way of teaching, utilizing various educational methods, applying new strategies and processes in technically focused subjects.

Digital competence – on of key competences of teacher within the teaching process

Broad spectrum of utilizing digital technologies supports the idea to enhance digital literacy within all social fields, i.e. within the field of educative-teaching process as well. The digital competence has its irredeemable place in the system of key competences and it covers information, computer and digital literacy. According to European Framework of Reference for key competencies (2006), the digital competence includes assured and critical usage of information society technologies (IST) in professional scope, spare time and in communication. It is ground on essential ICT skills, for example, computer use for gaining, assessing, saving, creating, presenting and exchanging information, as well as for communication and participation in cooperative internet networks.

Starting point of these competences is that they should include pedagogical capabilities, which enable teacher, for example, to integrate digital competence within his educative and teaching activities and methods. It is obvious that the development of digital literacy of students directly depends from the level of development of digital literacy of their teacher (equally in the case of informational literacy). The teacher sustains to use various modern material and information-communication instruments not only to pass new information to students, but by means of interactive electronic exercises teacher sustains to assess students (e-assessment). At the same time, students get immediate feedback of their knowledge and results. Within his/her profession the teacher uses and appropriately implements various forms of working with information, for example, multi-media tools, digital sources, educational materials and tools for students, available software, digital educational material, internet and others. All these, along with reasonably selected practical and demonstrational tools help teacher to fulfil the educative-teaching aim, i.e. specific goal, and to develop positive approach to modern information technologies in students.

Acquiring and implementing of ICT in teaching process by the teacher of technical subjects should form the foremost competences since technique and digital content of the subject are not enough to achieve expected, required and

inevitable change from traditional to modern school. Modern information and communication technologies are only offering teachers possibility to change their approach in teaching. ICT usage in creation of educational tools offers us new multimedia dimension. In modern school, assessment should lead to motivation, as well as acquiring skills for self-assessment, creative and meaningful learning in students. Unfortunately these approaches appear rather rarely in our school and only in work of innovative teachers. It is really acute and necessary to change the ways and various types of assessment in modern school if we really want to "reveal" students' talent and if we want to help students to develop their innovation, creativity and self-action. ICT may therefore become high-grade tool not only for summative, but mainly for formative assessment of students' performance. Implementing of ICT into the teaching process puts higher demands to teachers. Although the preparation for lessons and teaching itself with use of ICT may be more time consuming for teachers, it will lead to greater interest to learn and focus to given profession by students. ICT may transform teaching process to more effective, demonstrative, updated. All these steps require teacher to have acquired information, computer and digital literacy.

Implementation of digital competence by teacher – selected results of the survey

In connection with observation of digital competence, we have conducted pedagogical survey focused on acquiring and utilizing of given competence by teacher within the teaching process of subject Technique in selected elementary schools in the Slovak Republic. The survey was performed during October and November 2016 with help of non-standardized questionnaire consisting of 17 entries related to information, computer and digital literacy. The survey sample was made of 86 respondents (teachers) who expertly teach the subject Technique in elementary schools. We achieved 90% return of questionnaires. In the initial entries (No. 1, 2 and 4) the attention was paid to respondents from the view of their sex, length of pedagogic practice and from the view of their participation in continual education focused on observed digital competence. Based on assessment of above mentioned entries, it emerges from the questionnaire that out of 86 respondents (100%) there were 67 women (78%) and 19 men (22%) teaching the subject Technique.

Out of total number of 86 respondents (100%) there were 90% of them with pedagogic practice longer than 10 years and 10% of teachers with their pedagogic practice shorter than 10 years. It also emerges from this analyses that in our survey more experience teachers prevailed (majority group was formed by teachers with pedagogic practice over 10 years). Therefore, we may suppose that their answers should reflect their long-term experience and that we should gain candid informa-

tion related to implementing of digital competence within pedagogic practice in technically focused subject in elementary school.

Educating by means of continual education during the pedagogical practice was performed by 90 respondents (93%). Educating was focused on utilizing information and communication technologies in teaching process. We suppose that the respondents enhanced, improved and broadened their knowledge within continual education and that it further helped them in their teaching process, for example, in becoming familiar with current trends in education with use of ICT; in using modern material and information-technological means, in their selection and usage of multimedia tools and digital sources, in creation of their own tools with support of ICT which help students in getting accurate ideas and concepts within demonstration lessons, help them develop creative thinking and influence them in getting positive approach to modern learning tool based on ICT. Out of the whole sample there were 6 respondents (7%) who did not participate in continual education and noted in the questionnaire that they have decided for different education form that helped them to enhance their digital competence.

Table 1. Basic information on questionnaire respondents

Basic information on respondents	**Length of pedagogic practice**								**Participation in continual education of teachers**	
	Less than 5 years		From 6 to 10 years		From 11 to 20 years		21 years and more		Education in the field of ICT	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Women	3	4	3	4	26	39	35	52	65	97
Men	1	5	2	10	5	26	11	5	15	79
Total 86	**4**	5	**5**	6	**31**	36	**46**	53	80	93

Source: prepared by the authors.

With entry No. 6 of the questionnaire we were finding whether respondents use the internet at their work. Browsing information for the purpose of subject they teach was confirmed by all 86 respondents (100%). It is consolatory that teachers with pedagogic practice exceeding 21 years also acquired digital competence and thanks to that they are able to use internet for searching new information on taught topic for their students. We expected this activity in younger respondents with pedagogic practice up to 10 years since internet is nowadays considered a major source of information. To get information on the internet is easily available, generally cost free and nearly unlimited. Respondents pointed out mainly fast

results when searching information and free access to information. Searching for newest and most updated information related to subject is effective way of how respondents (teachers) add new information to topics they teach. As it emerges from above mentioned survey results, teachers have acquired digital competence and are able to use internet for searching new information effectively. Connected to implementing of digital competence by teachers within the subject Technique in lower secondary education, we were verifying the use of information and communication technologies in activities related to assessment of students' performance during lessons.

In entries 7 and 8 of the questionnaire we were finding which ICT teachers use within subject Technique when they examine and assess students' performance. In this part of their work, teachers use these technologies quite often (76.92%), as it emerges from Figure 1. Research confirms that ICT are used by teachers not only within exposure part of teaching process, but also as a tool for testing within the diagnostic phase (J. Zounek, K. Šeďová, 2009, p. 99). This result may be reasoned easily by the fact that teachers of elementary schools have at their disposal software tools for performing examination and assessment of students.

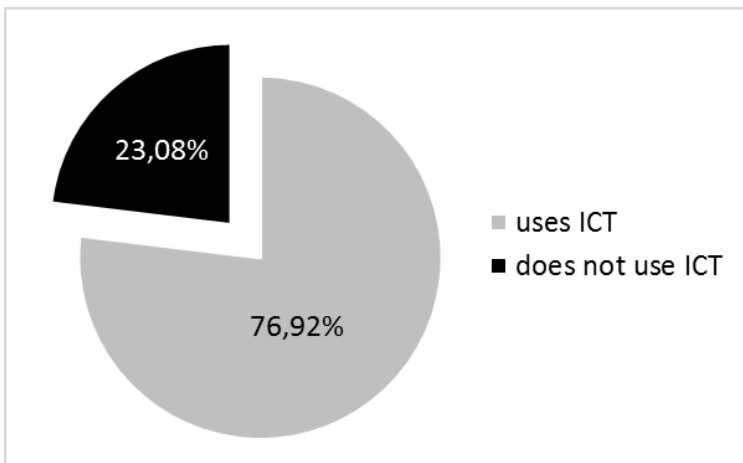

Figure 1. Use of ICT in examination and assessment of students' performance within the subject Technique
Source: prepared by the authors.

Figure 2 illustrates which types of information and communication technologies are used by teachers within the process of examination of students' knowledge

and assessment of their performance. At most the respondents stated, their use of PC, notebook, tablet (44.07%), further the use of interactive board (30.51%), use of internet (15.25%) and data projector (10.17%). In other responses the respondents noted that they use topic CD, visualisation, software for technical drawing and MS Excel. Based on above mentioned results, we may stat that elementary schools are currently quite well equipped with information and communication technologies (mostly computers and interactive boards) and that elementary school teachers use them within the subject Technique not only in exposure phase of the teaching process, but also in the diagnostic phase.

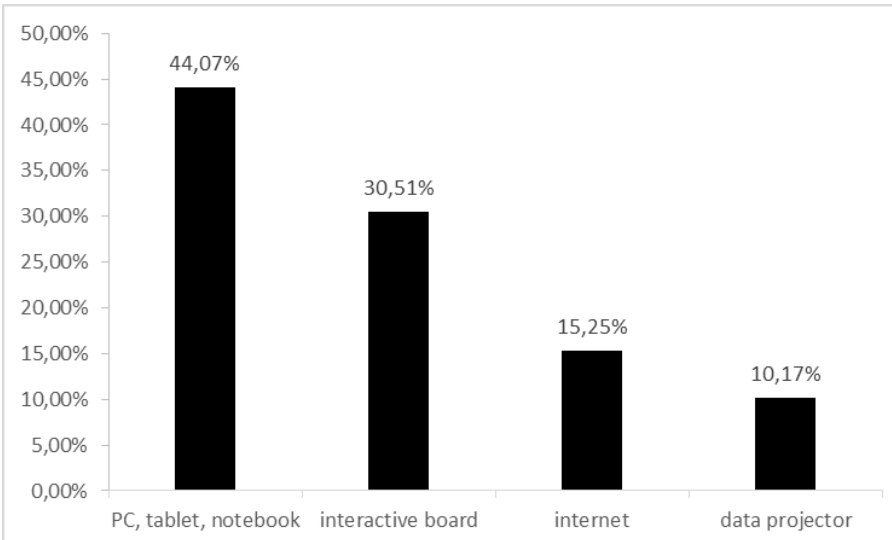

Figure 2. Types of ICT used in examination of knowledge and assessment of students' performance within the subject Technique
Source: prepared by the auhtors.

In the entries 9 and 10 of the questionnaire we were finding whether the respondents use ICT for the purpose of self-assessment of students within their teaching process. Although teachers quite often (65% of respondents) use self-assessment of students within the subject Technique (Figure 3), they implement ICT to this process rather rarely.

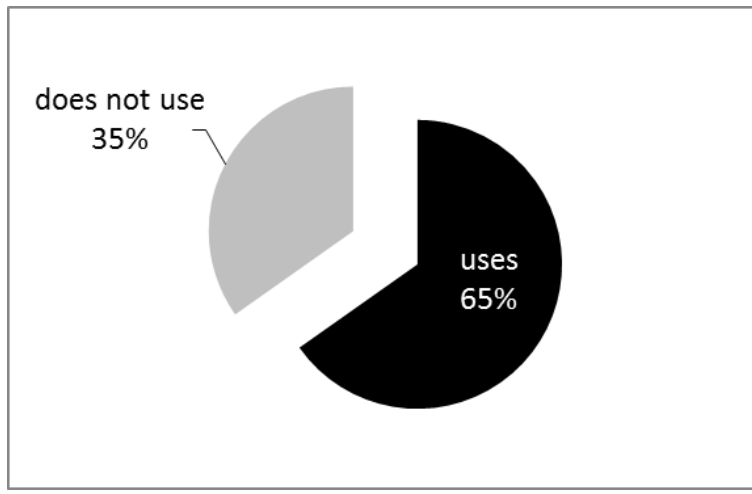

Figure 3. Use of students' self-assessment within the teaching process
Source: prepared by the authors.

As it is illustrated in Figure 4, information and communication technologies are not used in this phase of teaching process as much as by 79.63% of teachers. According to us, the reason for this is absence of such software tools at individual schools, that would enable them to implement this type of assessment, as well as teachers' low awareness of possibilities of existing software or their inability to use software available which contains the functionality of immediate feedback, as well and which is necessary for the formative assessment of students within the teaching process.

In the entry 17 we were searching what kind of software is used by teachers of Technique when testing students with help of PC. As it emerges from Figure 5, the major part of respondents does not use any software (55.56%). According to respondents statements, the mostly available, as well as the most frequently used by them, is the software product MS Office – MS Word, MS Excel and MS PowerPoint (14.81%), followed by application Hot Potatoes (3.70%), various educative CDs that contain testing exercises (3.70%) and website www.zborovna.sk (3.70%). Several respondents noted different types of software, out of which each is used just by one respondent: website EduTech, Socrative, software for interactive board (Flow! Works, Activestudio Professional, ActivInspire, Workspace), Alf, digital booklet of Physics and website www.oskole.sk. Respondents in their responses also noted such software applications which are not primarily determined for examina-

tion of students with use of PC – such as MS Office the product is determined for enhancing the office and business activities. Based on inspection of classes performed within our educative practice, we deduce that they use these applications for creation of non-standardized didactic tests, or learning exercises for students (MS Word), which they print out and students work with them during lessons. By means of application MS PowerPoint, teachers are able to instruct students various learning exercises within diagnostic phase as well. As a part of examination and assessment of students teachers also use internet websites, for example, www.zborovna.sk, www.oskole.sk and EduTech (these websites provide teachers with source of non-standardized didactic tests, learning exercises and electronic tests) and learning CDs (we suppose that they also contain testing exercises, however without possibility to adapt or amend them by teacher). Functionality of creation and administration of testing exercises is provided also by software products (application is primarily focused on testing of students), Socrative, software application for interactive board and application Alf. Based on given responses, we may state that teachers probably are not aware of what they may consider as software, therefore their responses are frequently misrepresenting. For this reason, we may consider teachers' responses for guidance, subjective, missing required validity.

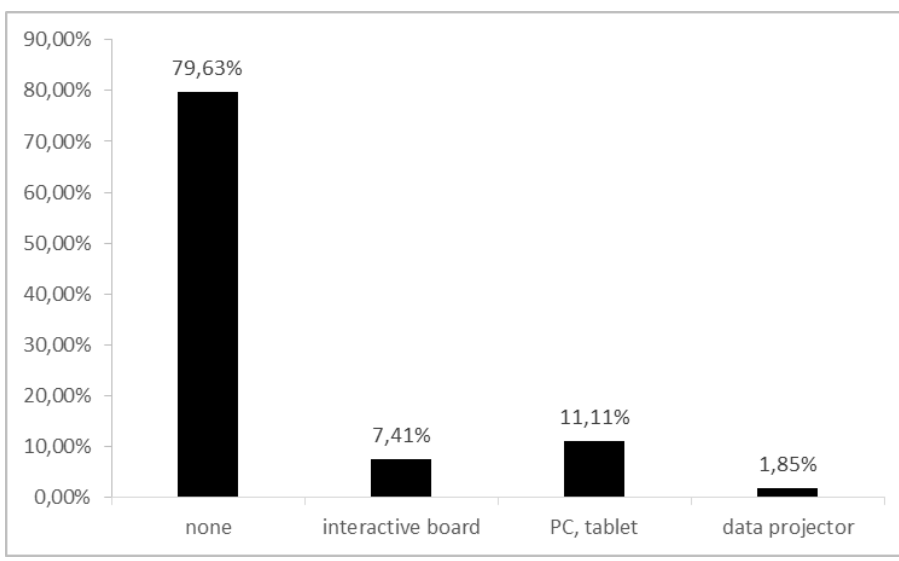

Figure 4. Use of ICT in self-assessment of students during teaching process
Source: prepared by the authors.

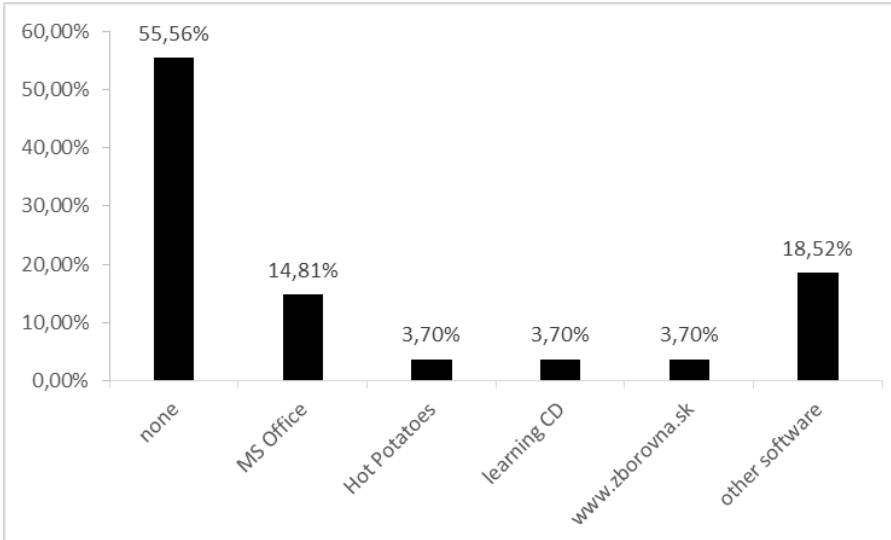

Figure 5. Use of software for students' testing
Source: prepared by the authors.

Assessment of students' performance with use of ICT

In our pedagogic practice, we most often interfere with summative assessment as the one that prevails than with formative assessment. The outcome of summative assessment is the grade, percentage of successful answers in test and so on, i.e. quantitative result. Frequent use of summative assessment leads students to detach from the actual learning process; they focus on result which is in most cases the grade. The students do not care for what they are doing and what that means for their growth, they only concentrate on reward.

Within formative assessment students are assessed from the point of view of quality, i.e. development of their personality. Formative assessment is focused on assessment of students' activities in progress (how they are learning, how they are solving learning exercises, how they proceed when creating product, how they cooperate in groups, etc.) When formative assessment is implemented, student does not compare himself/herself to other students, he/she only relates the result of himself/herself (J. Kratochvílová, 2012, pp. 162-163).

The call for increase in share of formative assessment usage within the teaching process as one of appliances that may improve students' learning and their results also emerges from the conclusion and recommendations in OECD announcement (C. Shewbridge et al., 2014, p. 143). This announcement informs on analysis performed in the field of students' assessment at schools in the Slovak Republic that took place in 2014 and it points out prevailing traditional summa-

tive assessment of students and non-systematic, misunderstood and rarely used formative assessment of students during lessons.

Assessment of students' performance within the teaching process constitutes important part of learning process, particularly if we focus on providing us with immediate feedback. Research in this field confirm positive impact on improvement of students' performance connected to immediate feedback with use of ICT (for example, B.M. Klecker, 2007; T. Wang, 2008). Use of ICT for whatever activity that includes assessment of knowledge, skills, competences and capability may be coved up by term electronic assessment (e-assessment). It is implemented in formal education as a support of assessment within the teaching process, in gaining and evidence of credits, in diagnostics of learning, etc.

In our research project we are focusing on implementation of formative assessment of students in fixation phase of the teaching process, since testing exercises may not only serve us as a tool for summative assessment of students (in the strict sense of the word for measurement of results of students' learning activities), but they may be fully asserted to gain greater quality and to anchor knowledge and skills of students who may further apply them in practical tasks and life situations. In the broad sense of word the purpose of formative assessment of students is to achieve determined goals by means of modern and canvassing teaching methods (T. Prextová, B. Czeczotková, 2014, p. 38).

It may be assumed that electronic assessment of students with use of ICT focused on formative assessment includes technologies that are becoming an important support in innovation of education and development of students' skills in the twenty-first century – problem solving, communication, team work, creativity.

The teacher who acquired the digital competence should be able to conduct electronic assessment of students within the teaching process of the technical subject. Such innovative approach of teacher with focus on formative assessment is reasonable since it is proven by electronic assessment of students, as well as research in this field (de E. Bruyn et al., 2011; S. Knight et al., 2014; therefore it is suitable for all levels of revised Bloom's taxonomy on educational objectives in technical education).

Electronic interactive exercises

Electronic assessment focused on formative assessment of students may be performed by means of electronic interactive exercises as well. They constitute electronic learning tasks serving for individual work of student or team work and their purpose is to discover level of successfulness in achieving specific objective within the teaching process of given topic. Learning exercises serve for development of knowledge and skills of students; as part of their solution advancing process is of the same importance as a result.

Electronic learning materials, part of which is constituted by learning exercises, dispose characteristics that influence way of proceeding for teacher, as well as student, within the teaching process and which cannot be found within traditional learning texts. The most important of these characteristics are:

1. Interactivity – way of communication between user and computer; computer immediately reacts to impulses of user (teacher, student).
2. Multimedia processing of information to be learnt – multimedia enable creation of integrated presentation of information by means of PC based on text, sound graphics, display image, video, illustration, scheme, graph, animation, simulation, virtual reality, etc.
3. Hypertext processing of information to be learnt – multilevel approach enabling to proceed in several directions within one text based on a bridge between independent information units.

Learning exercises that we propose contain graphic and multimedia elements, as well as simulations. By implementation of these elements in the individual exercises, we develop imagination and observation abilities of students; based on these students are active when solving given electronic exercise. By this students may verify not only their theoretical, but also practical skills which are important in real life. Some exercises are constructed in a way which uses inter-subject relations, mainly knowledge and skills from physics. From the point of view of taxonomy in cognitive field according to Niemerk, these exercises are focused on understanding of information, and applying the knowledge in problem situations.

By creating and implementing the collection of electronic exercises for the subject Technique in lower secondary education in the elementary school, we did not create educational software with explanatory part, but rather didactic training and diagnostic software tool in form of electronic exercise collection. With this step we are enhancing implementation of activating teaching methods in the particular part of teaching lesson; these methods may complement, for example, traditional explanatory part of the teacher. Collection of electronic exercises is primarily determined for repeating and anchoring of studied information and their applying in practical life; and at the same time it should serve as a tool for formative assessment of students within the teaching process.

Software application *QuizCreator* that we used is suitable from the point of creating the testing exercises also for average PC-skilled teacher who will be able to handle basic functions of the application really fast, even without prior study of user's guide. From the didactic point of view this application enables to settle the fast feedback for student, i.e. immediately after his/her performance it provides him/her with information on the correctness/incorrectness of the solution. In the case of incorrect answer, the student may be provided with certain form of help from the application, or from the teacher, until getting correct solution of the

exercise. Software application offers possibility of random choice of exercise from the collection arranged with various order of alternatives for the choice of answer. The collection of electronic exercises may be placed on the internet website of the school and may serve as a support of students during home preparation when they repeat and anchor the topic they need to learn.

In Figure 6, we present electronic exercise with simulation of electronic building blocks that contains basic constituent parts of simple electric circuit. When solving this exercise the student actively works with simulation; correct arranging of electric circuit helps student to answer given question. This electronic exercise is focused on solving the problem situation (non-specific transfer), and at the same time it helps to develop the observation skills of students. It is a typical exercise focused on use of formative assessment with constructive elements; it keeps student active in learning process and assessment phase as well. For this reason we adopted formulations of individual alternatives for the choice of the correct answer as well.

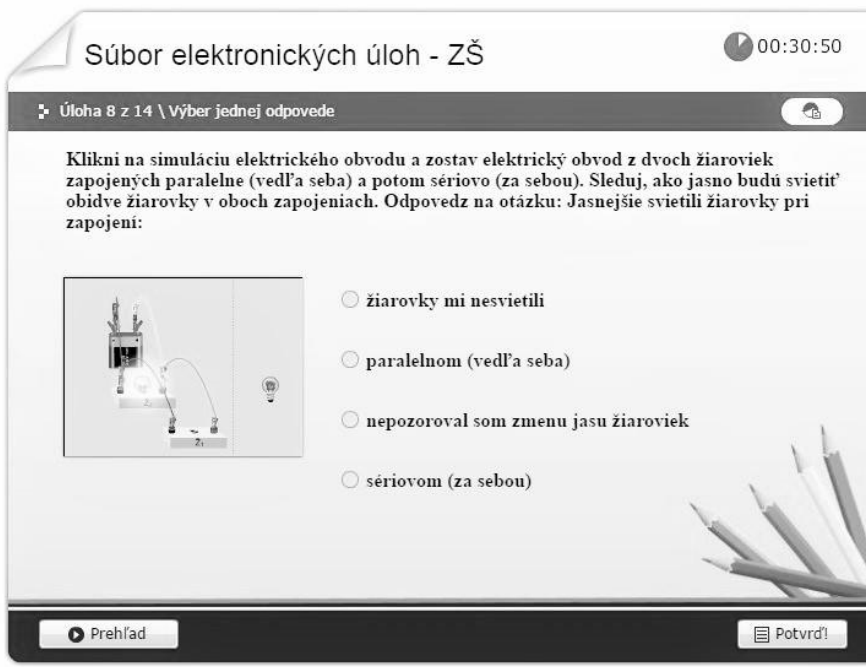

Figure 6. Demonstration of electronic exercise with simulation
Source: prepared by the authors.

In Figure 7, we present demonstration of electronic exercise with the short video sequence. In this video sequence students observed practical connection of numerous bulbs in electric circuit, their gradual unscrewing and screwing by

teacher, while observing their luminous or non-luminous power, as well as intensity of luminance. Based on this observation students were supposed to determine the type of bulb connection. The exercise was focused on solution of problem situation and practical usage of knowledge, as well as on development of observation skills of students.

Figure 7. Demonstration of electronic exercise with video sequence
Source: prepared by the authors.

Conclusions

The school reform in elementary schools in the Slovak Republic had determined in 2008 the main objective in the educational field, which is continuously being fulfilled until now. The main objective of the school reform is focused on education in relation to competences. From the aspect of students, it refers to development of key competences and essential skills within each subject of the elementary school and preparation of students for their further education in the high schools. From the aspect of teachers, it refers to two mutually interlocked requirements. One of them demands for lifelong education of teachers; the second one demands for acquiring and applying of key professional competences by teachers. European Framework of Reference determines key competences for lifelong education of teachers. One of them is constituted by digital competence. The teacher who acquired the digi-

tal competence and applies it in the subject Technique is able to implement such strategies and models within the teaching process, which support visual learning, interactivity, and adventure learning of students; this at the same time makes learning process more attractive for students as well. The teacher may apply acquired digital competence also in creation of electronic learning tools, electronic exercises, which may be also used in formative assessment of students' performance.

Formative assessment of students is applied only up to small degree in elementary schools in the Slovak Republic, although majority of foreign scientific results prove positive impact of formative assessment on the learning outcomes of students and their approach to learning. However, teachers do not often realize that they use formative assessment (for example in verbal form when examining students or in self-assessment of students); this activity is rather random, not performed on purpose. Information and communication technologies are currently significantly enhancing development of formative assessment of students at schools, and at most within the international context. Implementation of the collection of electronic exercises within the teaching process of technical education constitutes important innovation in applying the formative assessment and self-assessment of students from the point of the current pedagogic practice in elementary schools. When solving individual electronic exercises the student applies and anchors his/her knowledge and skills in actual and practical, as well as problem situations, which becomes more and more often required from the elementary school graduates. Apart from this, the student receives immediate feedback of his successful/non-successful result of learning.

From the technological point of view our collection of electronic exercises integrates software application for testing and multimedia compositions; from the didactic point of view, it integrates examination and assessment of students with learning, which is not provided by majority of software applications available in the market.

Prospectively we expect and assume that interactive electronic assessment of students will gradually replace traditional assessment and that its focus will be to assess various key competences of student when solving application and problem exercises. Technical and natural science subjects are particularly suitable for use of modern means for demonstration and simulation of various phenomena, patterns and technologies. Use of information and communication technologies in this relation sets basis for more attractive and more interesting conditions for learning of technical subjects. At the same time, it may constitute one of the most important factors of students' decision making and choosing for the further education in the technically focused high schools.

Bibliography

de Bruyn E., Mostert E., van Schoor A. (2011), *Computer-based testing – the ideal tool to assess on the different levels of Bloom's taxonomy* [in:] "Interactive Collaborative Learning (ICL)", pp. 444-449, NJ, IEEE, USA.

Horst B., Siegrist M. (2001), *Klíčové kompetencie a jejich rozvíjení*, Portál, Praha.

Hrmo R., Turek I. (2003), *Kľúčové kompetencie 1*, STU, Bratislava.

Klecker B.M. (2007), *The Impact of Formative Feedback on Student Learning in an Online Classroom*, "Journal of Instructional Psychology", No. 34(3), https://www.learntechlib.org/p/99806 [15.10.2018].

Kľúčové kompetencie pre celoživotné vzdelávanie Európsky Referenčný Rámec, 2006, http://katchem.truni.sk/prilohy/TPSV/KK_pre_CV.pdf [10.03.2017].

Knight S., Buckingham S., Littleton K. (2014), *Epistemology, Assessment, Pedagogy: Where Learning Meets Analytics in the Middle Space*, "Journal of Learning Analytics", No. 1(2), http://learning-analytics.info/journals/index.php/JLA/article/download/3538/4156 [15.10.2018].

Kratochvílová J. (2012), *Aktivní spoluúčast žáka při hodnocení – zdroj inspirace rozvoje osobnosti žáka a pokládání základů zodpovědnosti za kvalitu svého života* [in:] *Proměny pojetí vzdělávání a školního hodnocení: filozofická východiska a pedagogické souvislosti*, pp. 151-180, Asociace waldorfských škol ČR, Praha.

Prextová T., Czeczotková B. (2014), *Adaptívne testovanie ako nástroj hodnotenia vedomostí*, "Media4u Magazine", No. 11(2), http://www.media4u.cz/mm022014.pdf [15.10.2018].

Shewbridge C., van Bruggen J., Nusche D., Wright P. (2014), *OECD Reviews of Evaluation and Assessment in Education: Slovak Republic 2014*, doi: 10.1787/9789264117044-en.

Wang T. (2008), *Web-based quiz-game-like formative assessment: Development and evaluation*, "Computers & Education", No. 51(3), http://www.sciencedirect.com/science/article/pii/S0360131507001467 [15.10.2018].

Zounek J., Šeďová K. (2009), *Učitelé a technologie: Mezi tradičním a moderním pojetím*, Paido, Brno.

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LEARNING AUGMENTED BY MOBILE TECHNOLOGY: THE CASE OF MILAGE LEARN+ MOBILE APP

Abstract

This paper presents a mobile learning project MILAGE "Interactive Mathematics by implementing a Blended-Learning model with Augmented Reality and Game books" (Nº2015-1-PT01-KA201-012921). The project was realized between September 1, 2015 and August 31, 2018, within the framework of Erasmus+ program, in cooperation between universities and upper-secondary schools from Portugal, Norway, Spain and Turkey. The focus in the presented study is on pedagogical aspects of mobile learning, the design and application of a mobile app developed as one of the project outputs, and students' perceptions of learning with mobile technology.

Keywords: mobile learning, blended learning, Erasmus+ project.

Introduction

Numerous pedagogical questions arise in relation to the new digital technologies. It is contended that new technologies represent "a paradigm shift with specific and multiple impacts on the nature of knowledge in society, and therefore on the nature of learning" (H. Beetham, R. Sharpe, 2013, p. 4). Mobile and wireless counterparts of the networked digital computer brought about new considerations about how technology can be at the service of effective learning experiences. It is argued that "mobile devices create new forms of knowledge and new ways of accessing it. Furthermore, mobile learning is not about 'mobile' as previously understood, or about 'learning' as previously understood, but part of a new mobile conception of society". This remains in contrast with technology enhanced or technology supported learning (J. Traxler, 2007, p. 5). Without doubt mobile technology can offer new opportunities for learning that extend beyond the traditional teacher-led classroom (M. Sharples et al., 2009, p. 233). It is emphasized that "educational

institutions must now appropriate personal technologies – the mobile phone, as well as social networks – partly due to the student demand for mobile access and partly because these tools facilitate interactions that can support educational ends" (A. Kukulska-Hulme, J. Traxler, 2013, p. 245).

Mobile learning: History and pedagogical perspectives

The era of mobile learning devices may be traced back to the 1970s when a team of researchers at the Xerox Palo Alto Research Center, California, proposed a low-cost wireless handheld device that would support active involvement and allow learners to share their creative ideas (M. Sharples, R. Pea, 2014, p. 501). The history of mobile learning in Europe dates to the 1980s when early handheld devices were tested in a few schools. A broader perspective on mobile learning arose in the mid-1990s with research projects to exploit a new generation of pen tablet and Personal Digital Assistant (PDA) devices for learning (A. Kukulska-Hulme et al., 2009, p. 14). The earliest major mobile learning project was Mobillearn, involving 24 partners from academia and industry across 10 countries. The focus of the project was to develop and support learning outside classrooms. Researchers involved in the project concluded that mobile learning should be reconceived around learner mobility rather than technology, i.e. learning interleaving with other everyday activities (M. Sharples, R. Pea, 2014, pp. 501-502).

Mobile learning is defined as "the process of coming to know through conversations across multiple contexts amongst people and personal interactive technologies" (M. Sharples et al., 2007, p. 225). This definition emphasizes social aspects of learning process, however, multiple meanings of mobile learning have become prominent, some underlining the physical mobility of learners, some focusing on the affordances of mobile technology, some emphasizing connections between contexts or settings, and some noting the primacy of access to digital resources (A. Kukulska-Hulme, J. Traxler, 2013, p. 244).

Mobile technologies introduced unprecedented opportunities for developing blended learning models. Blended learning is defined as "the range of possibilities presented by combining Internet and digital media with established classroom forms that require the physical co-presence of teacher and students" (N. Friesen, 2012). The combination of face-to-face classroom activities with outside of the classroom digitally mediated activities is a key defining element of blended learning process. The attributes of mobile devices allow learning to be ubiquitous, situated, and collaborative. With mobile access to learning content, learning can happen in everyday and unconventional contexts. This quality contributes to promoting the culture of life-wide learning, i.e. learning in informal setting, which are not traditionally associated with educational activities (A. Kukulska-Hulme, 2010, p. 5).

Mobile Learning Project MILAGE

MILAGE "Interactive Mathematics by implementing a Blended-Learning model with Augmented Reality and Game books" (Nº2015-1-PT01-KA201-012921) is an Erasmus+ project aiming at developing digital resources for learning through a connected and participative process, and with appropriation of personal technologies. Higher education institutions involved in the project were the University of Algarve, Portugal (the coordinator); Nord University, Norway; University of Extremadura, Spain; and Çağ University, Turkey. Each of the participating universities worked in close cooperation with an upper-secondary school in their respective countries, i.e. Escola Secundária Pinheiro e Rosa in Portugal; Verdal videregående skole in Norway; IES Norba Caesarina, in Spain; and upper-secondary school operating within Çağ University, Turkey. The developmental work within the MILAGE project focused on creating digital resources supporting the realization of three-year curriculum for mathematics in upper-secondary schools, i.e. an eBook and a mobile application MILAGE Learn+ for Teachers and MILAGE Learn+ for Students. From didactic perspective, the project aimed at determining the potential of blended learning through exploring educational use of mobile devices in upper-secondary schools. The goal of the project was to create an environment that supports active learning through activities that are peer-supported, production-centered, personalized and networked.

MILAGE Learn+Application: The design and implementation

This section describes the mobile application for learning mathematics designed and developed by the University of Algarve in Portugal.

The application is powered by a web server and a relational database management system to store and query the data about users, worksheets of problems and relations between them (Figure 1). Each worksheet includes a set of questions related to a selected theme, chapter and grade (year) of the mathematics curriculum. Information about users' activities is also stored in the database such as the date and time of the login, selected worksheets and submitted answers.

Teachers used MILAGE Learn+ Launcher for Teachers, a desktop application that runs on Windows and OSX operating systems. An intuitive interface of the Launcher app allows to create worksheets of mathematical problems. These worksheets were uploaded to the server and made available to students via their mobile devices. Teachers personalized activities for students by differentiating the level of problems' difficulty and the complexity of the solutions. Solutions to mathematical problems were recorded in the form of videos.

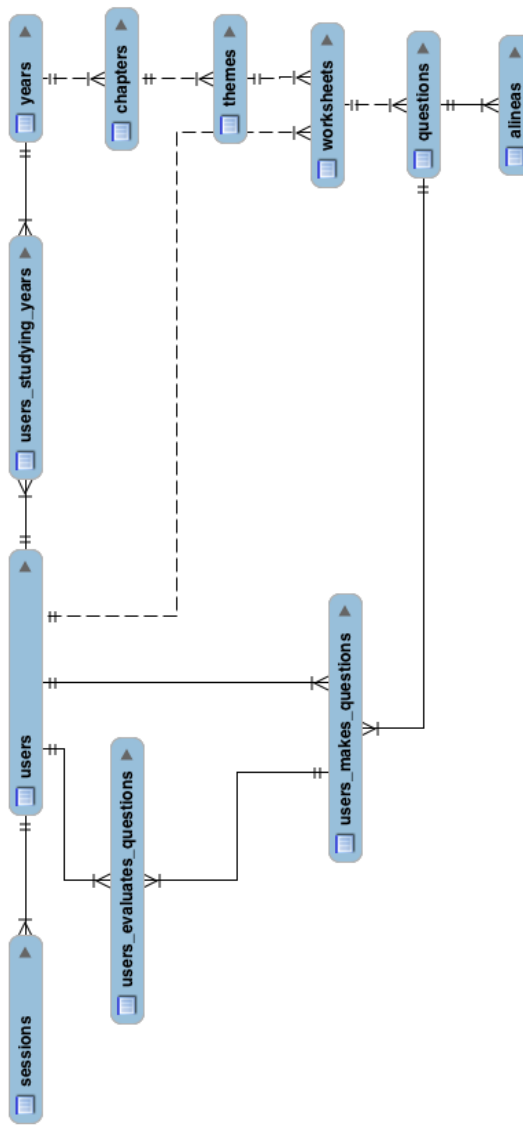

Figure 1. Relational database structure to support the mobile application
Source: M. Figueiredo et al., 2016, p. 8867.

Students used MILAGE Learn+ app on their smartphones or tablets. They logged in to the app using their e-mail addresses and passwords (Figure 2). Then they were choosing a worksheet of problems they wanted to work with.

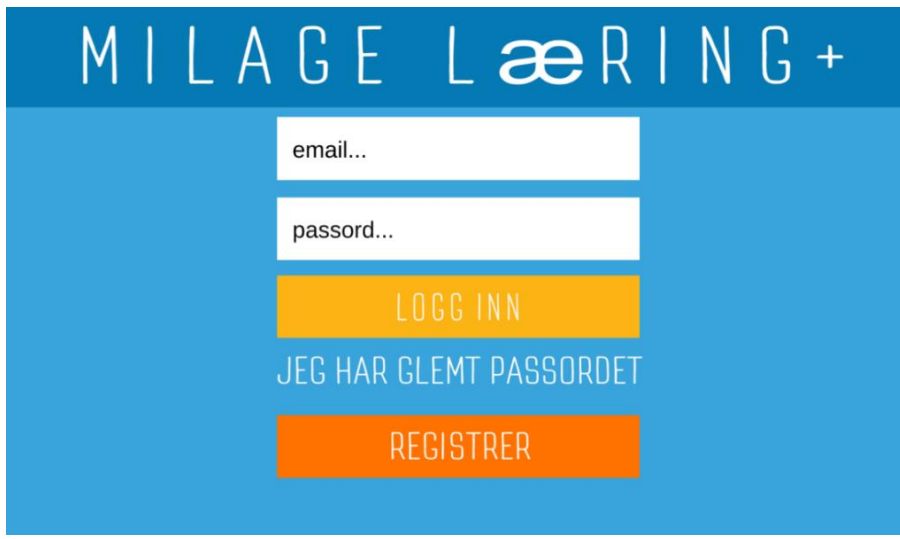

Figure 2. MILAGE Learn+ for students: interface. Students log in using their e-mail addresses and passwords
Source: MILAGE Learn+ for students, Norwegian version.

Each worksheet was related to the grade (a year of study) and a theme in the curriculum. The problems came either in the form of multiple-choice questions or open questions (Figure 3). In case of multiple-choice questions, the app automatically identified if the chosen answer was correct.

In case of open questions, students were solving the problem with 'pen and paper' and taking a picture of the solution with the mobile device. Picture taking function is embedded in the app. After the picture has been taken students could choose to view a video with a possible solution to the problem (Figure 4). This sequence provided a possibility for self-evaluation which introduced a metacognitive element to the learning process.

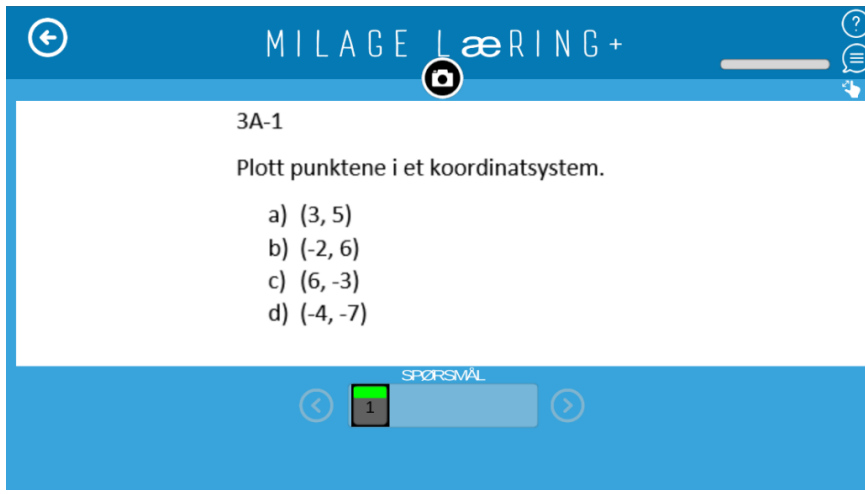

Figure 3. MILAGE Learn+ for students: an example of an open question task
Source: MILAGE Learn+ for students, Norwegian version.

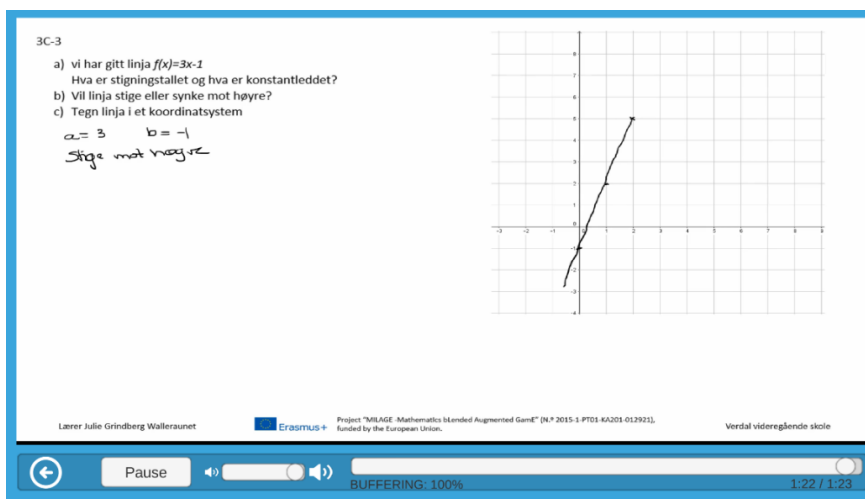

Figure 4. MILAGE Learn+ for students: an example of a solution to a task
Source: MILAGE Learn+ for students, Norwegian version.

Results of project evaluation in Norway

This section presents evaluation of the project in the first two years of its realization. The data from the third year is still being analyzed.

Qualitative analysis conducted after the first year of project realization focused on students' perceptions of being involved in producing and sharing videos

showing solutions to mathematical problems. These videos were integrated into two digital learning resources created as the outputs of MILAGE project, i.e. an e-book and an educational application for mobile use, both covering the three-year curriculum for mathematics in upper-secondary schools. The aim of the research was to develop an insight into students' attitudes and opinions on learning experience resulting from using digital media to produce digital learning content. Digital media used were personal computers, video screen capturing software, and computer input devices that enable users to hand-draw mathematical formulas. To obtain perceptions on the defined area of interest, the involved researchers conducted focus groups with selected students and interpreted collected data with the aid of computer-supported qualitative content analysis techniques. The sample size from Norway amounted to sixteen students (students in the first grade of upper secondary school in Verdal). The researchers transcribed the interviews verbatim and applied descriptive codes for attributing interpreted meaning to the data. Data analysis was conducted inductively, i.e. without pre-existing model. We tried to understand participants' views from their perspective and thus followed grounded theory mandate of studying the emerging data. However, the data were collected selectively as the interviews were guided by a fixed set of open-ended questions. This approach was chosen to introduce a certain degree of comparability across the cases in the participating countries. The coding process was aided by computer-assisted qualitative data analysis software (CAQDAS) NVivo 11. Constructed codes were eventually synthetized into three major themes. The frequency of coded items is visualized in Figure 5.

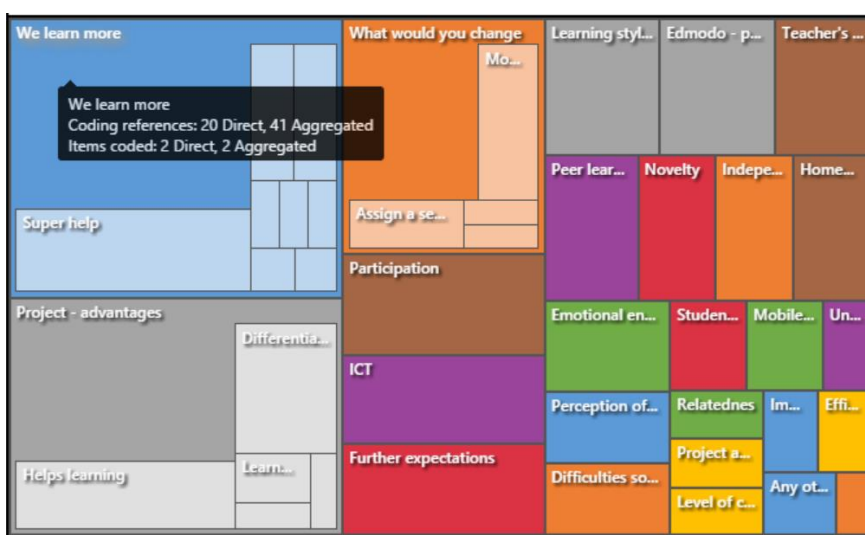

Figure 5. Hierarchical chart generated by CAQDAS. The size of the fields' areas reflects the number of items coded in Norway
Source: B. Godejord et al., 2016, p. 4147.

In the presented study, the themes emerged from repeatedly referred ideas (topics that occurred and reoccurred) and shifts in topics. We assumed that the more the same concept occurred in the data corpus, the more likely it was a theme. Based on the space within data items and across the data sets, most salient themes identified in Norway were following: "Project helps us learning" (the most notable theme); "We benefit from the project" (here students emphasized the benefit of "learning by doing" and collaborative aspect of working with the app). Table 1 contains representative quotes from the interviews. The results of this study were presented in more detail in a conference paper "Breaking free of the classroom: Implementing digital media to enhance students' involvement in learning mathematics" (B. Godejord et al., 2016, pp. 4146-4147).

Table 1. Identified themes and representative quotes from the interviews

Identified themes	Quotes from the interviews
"Project helps us learning"	*Sitting at home and doing the math yourselves and not quite knowing how we should do it, so yeah I thought I can try to watch these videos to see if I learn something and it was tremendous help.*
"We benefit from the project"	*We learn in a different way and we learn by doing concrete things, which we can share with others and we can help others in this way"*

Source: prepared by the author.

The evaluation of the project after the second year of project realization was guided by the *Quality Criteria for Digital Learning Resources* developed by the Norwegian Centre for ICT in Education as an aid for teachers and others who want to evaluate the sustainability of digital learning resources in educational context (Norwegian Centre for ICT in Education, 2012). The evaluation criteria focused on three broad categories: user dimensions, distinctiveness of the digital resource, and subject and education dimensions. The category of 'User dimensions' focuses on the interface between the user and resource. The category 'Distinctiveness of the digital resource' focuses on the possibilities and limitations of the digital resource. The category 'Subject and education dimensions' refers to the educational and evaluation potential. The objective of the research was to obtain an insight into students' opinions on a mobile app as a learning resource and thus contribute to the discussion on the potentialities of mobile learning and the design of mobile learning applications. Data were collected through online survey created and analyzed by Google forms. The survey consisted of two general demographic questions, seven

Likert scale questions, seven open-ended questions and two multiple-choice questions. Each Likert scale question was followed by an open-ended question. Likert scale questions measured respondents' attitudes to MILAGE App as a learning resource. We used unipolar scale with five degrees of attitude. Open-ended questions enriched the survey with a qualitative element by providing insight into respondents' opinions and reflections. Answering the open-ended questions was optional. Answering of the other type of questions was obligatory. The responses to multiple-choice questions gave us information on students' involvement in producing learning content, as well as the opinions on educational impact of the app components and functionalities. The formulation of the survey questions was guided by a set of key questions defining each category of evaluation criteria. Key questions defining each category of evaluation criteria are shown in Table 2. The survey was answered by thirty-four respondents, students in the second grade of upper secondary school in Verdal, of whom 58.8% were 17-year-old and 41.2% – 16-year-old. Majority of the respondents were women (70.6%).

Table 2. Specification of key questions defining categories of evaluation criteria

Categories of evaluation criteria	Set of key questions defining categories of evaluation criteria
User dimensions	Does the digital resource create interest? Is the digital resource inclusive and accessible?
Distinctiveness of the digital resource	How does the digital learning resource enable new possibilities that are lacking in traditional learning?
Subject and education dimensions	Does the digital resource enable an evaluation that is adapted to the education setting? In which educational setting is the digital resource suitable?

Source: B. Godejord et al., 2017, p. 4901.

The results of the survey (Likert scale questions) are shown in Table 3. The largest amount of "Yes" responses was received by the question "Do you think using MILAGE app is an innovative way of learning?" Also, the open-question that followed this question received the highest degree of feedback. In their responses, students emphasized that the app is appealing to young people as they are involved with technology in their everyday lives. They did not use an educational mobile app in any other course and this made them perceive the app as an innovative way of learning. Neither of the Likert scale question received "Strong no" response and the degree of "No" responses did not exceed 1%.

Table 3. Results of the survey (Likert scale questions)

Question	Yes Degree	Degree of neutrality
Is the app an interesting learning resource?	62%	24%
Is the app easy to use?	50%	29%
Does using the app contribute to utilizing and developing your digital skills?	44%	44%
Do you think using MILAGE app is an innovative way of learning?	71%	0.9%
Does the app help you reflect on your work with mathematical tasks?	47%	32%
Does the app support your individual work?	53%	38%
Does the app support collaborative work?	62%	26%

Source: B. Godejord et al., 2017, pp. 4901-4902.

According to students' opinions, the elements of the app that support learning most are the videos showing the solution to a mathematical problem. Majority of students made videos themselves. 61.8% of respondents were actively involved in producing learning content, 2.9% of the respondents were determined to make videos for the app in the future, while 8.8% respondents thought they would not do that. An interesting part was made by the remaining 26.5% respondents who chose the response "No" without specifying their attitude to the possible involvement in producing learning content for the app (Figure 6).

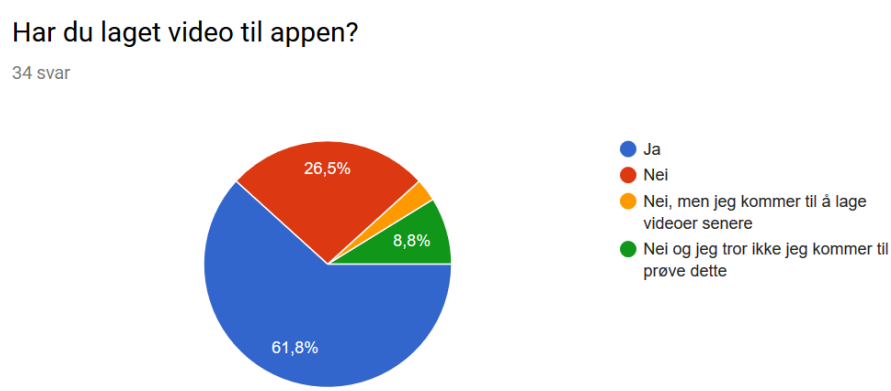

Figure 6. Responses to the question "Have you made a video for the app yourself?"
Source: B. Godejord et al., 2017, p. 4903.

Students involvement in producing the learning content is a positive result. In assumption, this role was supposed to be teachers' responsibility. However, we hoped that students would share it to a certain degree. Students' involvement in the creative work exceeded our expectations. The results of this study were presented in more detail in a conference paper "Ubiquitous technology in education context: An evaluation of a mobile learning application" (B. Godejord et al., 2017, pp. 4894-4904).

Conclusions

It has been proven that active learning increases student performance in science, engineering, and mathematics (S. Freeman et al., 2014, pp. 8412-8413). By producing the learning content students participating in the project actively engaged in the learning process by doing the activity itself (i.e. creating the digital resources) and thinking about what they were doing (i.e. planning, designing, rehearsing, evaluating). Digital content creation is an important competence area in digital literacy frameworks (UNESCO, 2018, p. 7), as well as an area of digital skills defined by the Norwegian Directorate for Education as one of the five key competences (Utdanningsdirektoratet, 2016). Given that a mobile app is a networked resource, student activity was enriched with sharing and collective elements. Social aspects such as communication and collaborating through digital technologies have corresponding status in both documents mentioned above.

Mobile learning has been described as 'disruptive' and 'paradigm-shifting'. It changes classroom dynamics and departs from traditional pedagogical practices. However, advantages of mobile technologies for learning seem to balance the skepticism. Improved access to education (use of relatively inexpensive everyday technologies) and support for vital communication (opportunities for learners to give immediate feedback) make arguments that deserve consideration (A. Kukulska-Hulme, 2010, p. 4). The so far results of the presented project show the potential of involving mobile technology in providing opportunities for active and social learning. Students in Norway quickly assumed an active role of media producers and the performance of this role was largely motivated by the wish of helping others to learn. The innovative approach to the learning process and connectivity enabled by the mobile devices encouraged student participation and interest in the project. Further analysis is needed regarding teachers' perception of mobile learning. Such analysis will be conducted in the further stages of the research.

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Bibliography

Beetham H., Sharpe R. (2013), *An Introduction to Rethinking Pedagogy* [in:] H. Beetham, R. Sharpe (eds), *Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning*, Routledge, New York and London.

Figueiredo M., Godejord B., Rodrigues J. (2016), *The development of an Interactive Mathematics App for Mobile learning* [in:] I.A. Sanchez, P. Isaias (eds), *Proceedings of the 12th International Conference on Mobile Learning*, International Association for Development of the Information Society, Vilamoura, Portugal.

Frieman S, Eddy S.L., McDonough M., Smith M.K., Okoroafor N., Jordt H., Wenderoth M.P. (2014), *Active learning increases student performance in science, engineering, and mathematics*, PNAS, 111(23), http://www.pnas.org/content/pnas/111/23/8410.full.pdf [12.10.2018].

Friesen N. (2012), *Report: Defining Blended Learning*, http://learningspaces.org/papers/Defining_Blended_Learning_NF.pdf [10.10.2018].

Godejord B., Godejord P.A., Bostad R. (2017), *Ubiquitous technology in education context: An evaluation of a mobile learning application* [in:] *Proceeding of the 10th Annual International Conference on Education, Research and Innovation*, International Academy of Technology, Education and Development, Seville, Spain.

Godejord B., González-Pérez A., Figueiredo M., Solmaz A., (2016), *Breaking free of the classroom: Implementing digital media to enhance students' involvement in learning mathematics* [in:] *Proceeding of the 9th Annual International Conference on Education, Research and Innovation*, International Academy of Technology, Education and Development, Seville, Spain.

Kukulska-Hulme A. (2010), *Mobile Learning for Quality Education and Social Inclusion*, UNESCO Institute for Information Technologies in Education, http://iite.unesco.org/policy_briefs/ [10.10.2018].

Kukulska-Hulme A., Sharples M., Milrad M., Arnedillo-Sanchez I., Vavoula G. (2009), *Innovation in Mobile Learning: A European Perspective*, "International Journal of Mobile and Blended Learning", No. 1(1), pp. 13-35.

Kukulska-Hulme A., Traxler J. (2013), *Design Principles for Mobile Learning* [in:] H. Beetham, R. Sharpe (eds), *Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning*, Routledge, New York and London.

Norwegian Centre for ICT in Education (2012), *Quality Criteria for Digital Learning Resources*, https://web.archive.org/web/20160513230934/https://iktsenteret.no/sites/iktsenteret.no/files/attachments/quality_criteria_dlr.pdf [10.10.2018].

Sharples M., Arnedillo-Sanchez I., Milrad M., Vavoula G. (2009), *Mobile Learning: Small Devices, Big Issues* [in:] N. Balacheff, S. Ludvigsen, T. de Jong, A. Lazonder, S. Barnes (eds), *Technology-Enhanced Learning*, Springer, Dordrecht.

Sharples M., Pea R. (2014), *Mobile Learning* [in:] K. Sawyer (ed.), *The Cambridge Handbook of the Learning Sciences*, Cambridge University Press, New York.

Sharples M., Taylor J., Vavuola G. (2007), *A Theory of Mobile Learning for the Mobile Age* [in:] R. Andrews, C. Haythornthwaite (eds), *The SAGE Handbook of E-learning Research*, Sage Publications, London.

Traxler J. (2007), *Defining, Discussing, and Evaluating Mobile Learning: The moving finger writes and having writ...*, "International Review of Research in Open and Distance Learning", No. 8(2), http://www.irrodl.org/index.php/irrodl/article/view/346/875 [10.10.2018].

UNESCO (2018), *A Global Framework of Reference on Digital Literacy. Skills for Indicator 4.4.2*, UNESCO Institute for Statistics, Montreal, Canada, http://uis.unesco.org/sites/default/files/documents/ip51-global-framework-reference-digital-literacy-skills-2018-en.pdf [12.10.2018].

Utdanningsdirektoratet (2016), *Digitale ferdigheter som grunnleggende ferdighet*, https://www.udir.no/laring-og-trivsel/lareplanverket/grunnleggende-ferdigheter/digitale-ferdigheter-rammeverk/ [12.10.2018].

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MASSIVE OPEN ONLINE COURSES AS A CHANCE FOR ACADEMIC EDUCATION

Abstract

The phenomenon of massive open online courses (MOOCs) has made it possible for every student to broaden their knowledge using the resources of the most renowned universities around the world. By paying a fee, one can be educated online even for Master's degree. Jobseekers in professions requiring specialist skills can quickly acquire them without the need to graduate. Therefore, the threat that young people in Poland will not decide to go to university has become real. In this situation, it is extremely important to intensify the activities aimed at creating Polish MOOCs. The first international educational platforms were launched almost seven years ago. This means that catching up in this area can be extremely difficult. On the other hand, it gives a chance to analyze the solutions adopted in the world. The review of this type of offers presented in this article has been compiled with a description of activities undertaken in Poland. To date, a number of open online courses have been made available, both in academic centres and as private initiatives. The integration of these solutions may lead to the launch of a large MOOC platform in our country.

Keywords: massive open online course, MOOC, e-learning, teaching and learning methods, academic teaching.

Introduction

Massive open online courses (MOOC), which are gaining increasing popularity, are carried out with the participation of renowned universities around the world and market-leading companies. They offer tens of thousands of free courses to all interested. Their paid versions allow the participants to obtain certificates that are more and more often accepted by employers. Certified open online courses in many cases allow the student to complete individual subjects during the course of study.

Increasingly, by paying fees, one can educate online for a Master's degree. There are courses whose organizers guarantee employment to the graduates.

An easy access to contents developed by the most prominent specialists is an excellent opportunity to use them during classes (unless it is forbidden by the relevant clause). Even in the case of legal restrictions, this material can be recommended for independent study. In the case of complicated scientific discussions presented in the form of video, usually in English, understanding them does not pose a major problem. The creators offer transcriptions or subtitles, which Google Translator can easily handle. Massive open online courses in Poland are particularly valued by students of science. The most popular are courses in computer science and mathematics.

An unrestricted access to academic and specialist courses in the long term may pose a threat to universities that use only a closed education model. If a young person needs to master a narrow section of knowledge to get a job, it is probable that he/she will resign from studying. Thus, on the initiative of the Ministry of Science and Higher Education, steps were taken to develop the Polish MOOC platform. Although nearly seven years have passed since the launch of the largest international educational platforms, there is still a chance to catch up. The analysis of the offers and ways of functioning of individual platforms can be helpful in this respect. It is not true that Poland has not been interested in this type of education. Numerous Polish research centres have their own e-learning platforms and large databases of teaching materials. Many professionals also provide online courses on their own. Only lack of appropriate sources and forms of financing and integrating a number of separate initiatives stops the implementation of the joint MOOC platform.

Mass media in distance learning

The idea of universal and free access to higher education content appeared in Poland when the radio and television became popular. In 1974 the Teachers' University of Radio and Television (NURT) established by the Teacher Training Institute started to be broadcast. Its goal was to improve professional competencies of teachers who did part-time or evening studies.

In its radio and television programmes (shown on Polish television TVP) and materials printed in the weekly magazine "Oświata i Wychowanie", NURT offered courses in three thematic blocks: general cultural block, pedagogical and psychological block, subject and methodical block. In each of them appropriate program cycles were available. The students had at their disposal textbooks, scripts and lists of literature (F. Lipowicz, M. Rataj, 1988, p. 293). Due to political changes and low profitability public television ceased broadcasting NURT in 1990. The initiative in this respect was taken over by private television.

Between November 9, 2002 and February 7, 2016, the Educational Satellite TV Edusat operated. Its creator, author and first president was professor doctor habilitated Wojciech Pomykało. The television was established on the initiative of the Innovation Foundation, originally for the Higher Social School of Economics (WSSE) in Warsaw. It was a free-to-air, unencrypted TV channel broadcasting lectures from WSSE to local branches throughout Poland. Gradually, the program offer was expanded, and it took into account the interests of viewers wishing to broaden their knowledge in the field of broadly understood culture and science. Edusat offered lectures on economics, pedagogy, psychology, management, parenting, foreign language learning, environmental protection, tourism, travel, and social and political issues, including EU issues.

Television used in distance education allowed the viewers to obtain a Bachelor's degree in Poland and abroad. It facilitated mastering the knowledge covered by the Bachelor's curriculum for students studying economics and pedagogy. It supported the education of students who attended extramural, evening and full-time university courses.

Along with the wider access to the broadband internet, many universities launched extramural and postgraduate studies in the distance learning system. The centres providing this form of education include: the University of Warsaw, the University of Łódź, the Gdańsk University of Technology and the Warsaw University of Technology. Since 2002, the Academy of Humanities and Economics in Łódź has been running the Polish Virtual University (www.puw.pl). It offers a wide range of first and second cycle studies, online postgraduate courses, and online courses and trainings. To date, over 20000 graduates have completed this type of studies.

In October 2007, the then Department of Media and Information Technologies of the University of Zielona Góra launched a series of massive online courses for teachers. They were an important part of postgraduate studies carried out under the project of the Ministry of National Education and co-financed by the European Social Fund and the state budget. The funds were enough to develop a package of necessary educational media and to conduct e-learning classes. Nearly 600 students participated in the courses. Based on the results of the pilot studies, the multimedia components of the courses were developed: films, animations and interactions. Solutions for individualizing the level of difficulty, time and pace of work were adopted. It was possible to adjust the educational content to the student's individual cognitive abilities and preferences. The most important educational content was accompanied by solutions that were to focus and maintain the student's attention (J. Jędryczkowski, 2007, pp. 597-602). The courses were made available on the Moodle educational platform (open source software according to the GNU GPL license). Although access to the platform's resources was limited only to the

students enrolled in the courses, part of the multimedia materials was linked to the public pages of the teachers conducting particular courses.

Even after the project had been completed, the educational material database was still expanded. Over four thousand students have taken part in distance learning classes (e-learning and blended learning). Up to now, the author of this article has been preparing own educational materials for the classes. Until 2015, most of the films and presentations were made in Flash technology. This solution provided excellent graphic quality and enabled adding interactive elements to the films (e.g. quizzes, hypertext within the film or simple educational games). As mobile devices no longer support this technology, currently educational films are posted on YouTube channel (www.youtube.co/c/JJKursy). This solution has a number of advantages. It saves the limited resources of the existing server, offers access to extensive YouTube Analytics reports and allows easy publication on any website or social media. From the point of view of recipients, the most important is mobile access and the possibility of subscribing and giving likes, which makes it easier to return to interesting content.

Massive closed online courses as the dominant form of distance education

From the perspective of the current situation on the online education market, online courses available exclusively to students of a specific university can be described as massive closed online courses. Their commercial counterpart is the offer of the Udemy educational platform created in 2010 (www.udemy.com). It provides over eighty thousand paid courses in 50 languages. Classes are taught by 35000 instructors for 24 million users. Each user can view a fragment of any course to know what the course is on and what it is like. Udemy encourages all professionals to publish their own courses on the platform. It offers access to appropriate tools and training. Each creator can receive real incomes if his/her course is successful. This solution results in a wide choice of courses on various subjects and their number is constantly growing. When entering the Udemy site for the first time or in incognito mode each time, the potential user is offered large discounts. After paying for the course, one gets lifelong access to the materials it offers. The website interface in Polish and access to content in Polish makes this platform a valuable offer for those interested in self-education. Udemy certificates are issued in an electronic version and have a symbolic value. They are not accepted by universities and may not be accepted by employers. In some cases, however, the instructors offer certificates of the institutions they represent.

Massive open online courses in distance learning

The closed online education model is addressed only to recruited students, which provides adequate funds. This solution narrows the circle of potential recipients. By defending access to the materials, universities lose an opportunity to promote themselves through professionally prepared, interesting and useful content. This situation is understandable and results from the need to protect the effects of own work. Subsidies or planned subsidies must be sufficient to pay for online courses and for extremely time-consuming preparation of multimedia materials. However, American universities with the support of wealthy investors, suggested a different model. All content prepared for online courses is generally available. This does not apply to checking the papers by lecturers and online consulting. Anyone interested can therefore be educated for free. However, one will not be awarded a diploma or certificate. The possibility of getting to know and often mastering the educational content is a clear incentive to participate in a paid educational path. The new education model is described as the massive open online course (MOOC). As the experience of centres offering MOOCs has shown, this solution attracts tens of millions of students and is a major source of income.

The concept of MOOCs appeared as a result of an educational experiment conducted at Stanford University. Anyone interested was offered a free course on "Introduction to artificial intelligence". 160000 students from 190 countries took part in online classes. On the basis of gained experience, in 2011 the Udacity educational platform was launched. Encouraged by its success, the largest academic centres in the world launched their own platforms in the next years or joined partner programmes.

Udacity (www.udacity.com)

Udacity is now a commercial company that, apart from university courses, also offers courses for professionals. Its main advantage is involvement in the process of finding jobs for graduates. Access to all courses is free. Almost all educational materials are made available under the free Creative Commons license (without the right to create derivative works).

Udacity has over ten million registered users, who are offered 230 online courses. Most of the materials are intended for people interested in practical computer science. The courses have been developed in cooperation with leading companies such as Google, AT&T, Facebook, IBM, NVIDIA, GitHub and Amazon. Thanks to the cooperation with the Georgia Institute of Technology, courses in artificial intelligence, operating system architecture, computer networks and super-

computer design were made available. The cooperation with partners guarantees that the content of the courses corresponds to the current needs of the labor market.

In 2015, Udacity and AT&T launched Nanodegree – a paid programme aimed at certifying competencies. The programme participants use specialist, personalized and timely project reviews, coaching and assistance at every stage of job seeking. The more expensive version of the programme called Nanodegree Plus guarantees that the participant will find a job. If the student does not find it, the course fee is refunded. Udacity also offers scholarships, which have already been granted to 24 thousand people.

All materials are available only in English. Each course consists of several parts that include video lectures (with subtitles) accompanied by quizzes and homework, usually in the form of problems requiring a programming solution. Most of the homework is corrected automatically. However, in the case of certified courses, the student has to deliver projects and codes on time, which are checked by experienced reviewers. All participants can use the mobile application that enables them to download films that are later available offline.

Coursera (www.coursera.org)

The largest global provider of MOOCs is Coursera with over thirty million registered users. In addition to courses with a narrow thematic scope, it allows students to complete their Master's studies at well-known universities completely online.

Coursera was founded in 2012 on the initiative of the employees of the Faculty of Computer Science at Stanford University. It offers over 3000 courses developed by 173 partners from 28 countries, including top universities, eg Stanford University, California Institute of Technology (Caltech), Imperial College London, University of Chicago, Nanyang Technological University of Singapore, École Polytechnique Fédérale de Lausanne, Princeton University, National University of Singapore, Yale University, etc.

The courses have been developed in several dozen languages, mainly in English (2393), Spanish (287), Russian (213) and Chinese (121). Most of the courses contain video materials. In this case, one can choose subtitles in a preferred language version (there are 9 courses with Polish subtitles). A very useful solution is transcription included with each film. This makes the materials available also to those with poor language skills (one can run a translator in the browser).

The courses cover most areas of scientific knowledge. All content is available for free. In order to receive additional teaching materials, to have homework checked individually and to receive certificates the student has to sign up for a paid version of the course. It is possible to pay only for the selected course or to subscribe. An important advantage of Coursera is a mobile application that allows one to learn at any time and place. The option of using selected materials offline is particularly useful in this respect.

edX (www.edx.org)

edX was founded in 2012 on the initiative of Harvard University and the Massachusetts Institute of Technology (MIT) as a non-profit organization. It offers courses for professionals and cycle courses included into Master's studies. It has over 14 million users who have participated in open online courses 52 million times. It currently provides over 1900 courses prepared by 130 partners, including top universities, such as Stanford University, California Institute of Technology, Imperial College London, University of Chicago, ETH Zurich, École Polytechnique Fédérale de Lausanne, Princeton University, etc. Most educational materials offered by the universities are available under an open license and they are shared with open source software (Open edX).

edX offers courses mainly in computer science, science, business and management, humanities and foreign language teaching. The vast majority of courses is available in English, but recently more and more materials have been appearing in Spanish, Mandarin and French.

The education process mainly involves a series of video lectures (with subtitles). They are accompanied by interactive exercises in virtual laboratories. The student actively cooperates and discusses the content of the class. For this reason, earlier subscriptions to groups are required.

In addition to single course certificates, edX offers wider qualifications in the form of XSeries certificates, which are awarded after completing a certain number of courses in a given field. The certificates offered within the MicroMasters program are the most valued by employers. These are series of courses offering a deeper scope of education in a selected field. Courses completed with a MicroMasters certificate can be included into Master's studies. All students can use the free edX mobile application.

FutureLearn (www.futurelearn.com)

FutureLearn is the largest European educational MOOC platform, offering mainly specialized courses for professionals. FutureLearn, founded in December 2012, is owned by The Open University, which established the platform with eleven university partners: University of Birmingham, University of Bristol, Cardiff University, University of East Anglia, University of Exeter, King's College London, Lancaster University, University of Leeds, University of Southampton, University of St Andrews and University of Warwick. Currently, it cooperates with 145 partners. Apart from leading universities around the world, the content providers include some institutions such as the British Council, the British Library, the British Museum and the National Film and Television School. Moreover, the platform cooperates with many renowned international organizations, such as the Association of Chartered Accountants (ACCA) and The Institution of Engineering and

Technology (IET), companies, including BBC and Marks & Spencer, as well as government organizations.

Over eight million students are offered 928 courses, of which 913 are in English. They are in computer science, ICT, science, engineering and art, as well as craft such as paper techniques, joinery, tailoring, etc.

The basic forms of educational communication are video materials. Each film is available with the transcription. When playing a film, subtitles can be turned on. If a Polish translation is activated in Google Chrome, it translates the web content, as well as subtitles in the video. The quality of this translation allows the student to understand the content completely.

The free version of the courses offers access to all articles, videos, reviews and quizzes. The paid option includes additional tasks and tests and allows one to obtain a certificate. Each free course has a strictly defined time limit to be completed. However, at any time one can switch on a certified version. Then the time limit is removed, which allows the student to take additional tests and practical tasks. The certificate is issued as a printed document and a website with a unique address. This solution enables the graduates to add it to their electronic portfolio or LinkedIn profile.

XuetangX (www.xuetangx.com)

XuetangX was launched in 2013 as the first Chinese MOOC platform. It was created on the initiative of Tsinghua University and the Research Center for Online Education MOE for research and online education. It offers courses that are included in university studies and further trainings for a number of professional groups. The platform offers over 1500 courses developed by Tsinghua University, Peking University, Stanford University, Massachusetts Institute of Technology (MIT), Berkeley University and other universities. A number of organisations and institutions are its partners including Microsoft, Huawei, OPPO, VIVO and TC.

XuetangX is an important link in the structures of mass entrepreneurship and national innovation. It is also an online educational platform for UNESCO International Engineering Education Center (ICEE). Some courses are licensed from edX and its university partners. The Chinese platform also uses the modified Open edX software.

XuetangX is an important element of institutionalized university education also in blended learning. It collaborates with universities throughout China, offering certified courses covering a specific range of material. This is done through detailed data reports that enable the supervision of the results of online students.

All lectures, tasks and discussions are in Chinese. Video materials have Chinese subtitles (simplified characters). For ease of use, full transcription is included in the films. For edX courses, videos are in English with Chinese subtitles.

However, for non-Chinese students, the use of courses can be problematic. The translator, available in a web browser, provides good translation of the videos, however, a large number of boards, labels and charts include texts in their graphics that are not translated.

XuetangX offers various forms of education not only for students. Bearing in mind the need for lifelong education in a dynamically developing country, there are courses available for various professional groups (including the army). To this end, the educational platform cooperates with many industry experts, establishing teams of teachers representing market-leading companies and organizations. Online courses can be used with a dedicated mobile application available for both smartphones and smart TVs.

Massive open online courses in Poland

The Copernicus Center Foundation, operating under the auspices of the Copernicus Center for Interdisciplinary Research, a joint unit of the Jagiellonian University and the Pontifical University of John Paul II in Krakow, finances the Copernicus College project. It is a Polish educational platform created in 2014, which provides massive open online courses. At present, it offers 30 courses in general academic areas. Participation in courses requires prior, free registration. Classes are run in cycles, but registered users can view most materials at any time. The main element of the courses are videos from the YouTube channel existing since 2009 – Copernicus Center for Interdisciplinary Studies. It provides nearly two thousand videos that have had nearly 4.5 million views. A significant part of foreign-language films have Polish subtitles. In addition to the courses, the platform provides five course books in an electronic version. Students completing the course may take the exam, and if they pass a certificate can be generated. After paying a fee, one can order the certificate as a printed document.

In 2017, the Ministry of Science and Higher Education announced a competition for the implementation of the project called "Polish MOOC". The grant was awarded to the Young Science Foundation, and it is to create a Polish educational platform by 2020. Its goal is to provide a wide range of courses in various areas. Scientific, business and non-governmental organizations are to be involved in the project.

Individual initiatives in the implementation of MOOC

Two educators Mirosław Zelent and Damian Stelmach offer open massive online courses on their website (http://pasja-informatyki.pl). It contains primarily courses in computer science. Their main elements are the videos posted on the YouTube channel. It has 209 thousand subscribers and over 23 million views. It contains

over 140 films, the length of which varies from 30 to over 90 minutes. Each film is complemented with pieces of code that can be downloaded and modified. The contents of the courses are complemented by the podcast. Its files cover the issues of effective learning and motivation. They offer a substantial amount of knowledge of humanities, which are often neglected by IT specialists. Interactions with the course participants is possible on the discussion forum and fan page.

The scale of the venture is in no way inferior to the scope of IT courses offered by the institutional MOOC providers discussed above. In the Department of Media and Information Technologies of the University of Zielona Góra classes conducted by the author of this study are carried out using teaching materials made available online. Using Google's tools, he developed an educational platform that gives free access to all courses. The materials provided there are public, only the use of tests and file exchange mechanisms requires logging in by students attending classes. Original teaching videos are of key importance for the course. They are available on YouTube (JJ Kursy channel).

At present, the platform contains materials for over a dozen academic subjects for students of the Faculty of Pedagogy, Psychology and Sociology and the Faculty of Computer Science, Electrotechnics and Automation. They are supplemented with 145 films published on YouTube and hundreds of PDF documents and multimedia presentations. The educational platform was integrated with YouTube in June 2015. Initially, data from YouTube Analytics showed only the activity of students during classes and doing homework. After a few months, it turned out that the teaching materials were used primarily by individuals who were not the students of the University of Zielona Góra (J. Jędryczkowski, 2016, pp. 108-109). On October 1, 2018 out of 260,000 views (7946 viewing hours) entries from the official course website accounted for only 3% (7203 views, 347 viewing hours). This means that teaching videos grouped into playlists on the YouTube channel have become an open online course.

After the publication of the films, the author gets access to big data tools, mainly YouTube Analytics, which gathers detailed information on the use of the films. It is an advanced reporting system that provides information on any interactions of the viewers with the published video materials. All these activities are registered and can be presented in reports offering the comparison of different data in defined time intervals. Of particular importance are the reports of maintaining attention, which allow one to determine what and at what point in the video the viewers are interested in. These data help to conclude on the interests and preferences of the viewers, as well as the effectiveness of the educational methods used. They are a valuable source of knowledge which enables the modification and improvement of the educational media and the content promoting the educational platform and the academic centre.

Conclusions

The development of MOOCs, particularly the American ones, is already a real threat to academic centres in Poland. This problem was noticed relatively late. However, the first steps have been taken to implement similar solutions. Following Udemy model, it is possible to offer paid teaching materials (of guaranteed high quality in terms of their content) and online classes to researchers and specialists representing particular branches of the economy. As in the case of Chinese XuetangX, some of these courses should be offered as part of full time studies, or as full Master's degree online studies, similarly to Coursera offer. It will also be a good idea to create courses for those who want to get certain professional competencies without having to attend university. This solution can be a form of university promotion and guarantee real income.

The electronic form of courses in connection with the big data tools such as YouTube Analytics provide the creators with extremely complex reports. The information obtained in this way allows for a precise definition of the target group, its interests, needs or even cognitive preferences. This makes it possible to introduce strictly defined modifications and create further courses that take into account the expectations of viewers and employers.

The knowledge of the offer of MOOC providers, as well as facilities and experience of individual academic centres in connection with initiatives undertaken by the Ministry of Science and Higher Education, should lead to wide involvement in work on the creation of a nationwide educational platform. In several years this may be one of the most important solutions to prevent students from attending courses offered by foreign centres.

Bibliography

Jędryczkowski J. (2007), *Przekaz pozawerbalny w systemie kształcenia zdalnego* [in:] E. Perzycka, A. Stachura (eds), *Pedagogika informacyjna. Media w kształceniu ustawicznym*, Wyd. ZAPOL, Szczecin.

Jędryczkowski J. (2016), *Cognitive preferences displayed by the recipients of short, educational multimedia messages* [in:] E. Baron-Polańczyk (ed.), *ICT in educational Design – Processes, Materials, Resources*, Vol. 10, Oficyna Wydawnicza Uniwersytetu Zielonogórskiego, Zielona Góra.

Lipowicz F., Rataj M. (1988), *Vademecum młodego nauczyciela*, WSiP, Warszawa.

Websites

Copernicus Center – YouTube channel, www.youtube.com/user/CopernicusCenter

Copernicus College, www.copernicuscollege.pl

Coursera, www.coursera.org
Edusat, http://www.hdtv-sat.eu/kanaly_tv,edusat.html
edX, www.edx.org
Fundacja Młodej Nauki, http://fmn.org.pl/aktualnosci/uruchamiamy-polski-mooc
FutureLearn, www.futurelearn.com
JJ Kursy – YouTube channel, www.youtube.com/c/JJKursy
JJ Kursy, https://staff.uz.zgora.pl/jjedrycz
Pasja Informatyki – YouTube channel, www.youtube.com/user/MiroslawZelent
Pasja Informatyki, http://pasja-informatyki.pl
Polski Uniwersytet Wirtualny, www.puw.pl
Udacity, www.udacity.com
Udemy, www.udemy.com
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STUDENTS IN THE ROLE OF CREATORS OF E-LEARNING COURSES

Abstract

The article is a report from the workshop conducted by the author entitled: The use of an e-learning platform to create a reservoir of knowledge for the needs of Faculty of Pedagogical Sciences students at the UKSW in Warsaw, implemented under the project "Modern educator". Presented is summary of the course and analysis of knowledge growth of students' knowledge in the field of independent creation of an e-learning course.

Keywords: e-learning, information technology, lifelong learning, Moodle platform, competences, competences in online education, teaching remote.

Introduction

Bureaucracy and the speed of technology in our world make every act, process or product subject to standardization. The competency, which a person promoting certain tasks should have, is determined. There are pros and cons of that. In the information society, information and knowledge based on it, as well as education by which the ability to gain, select and judge information is acquired are the basic values, goods or commodities. Education functions both in the primary (commercial) and the secondary (public, non-commercial) information sector of the society as well. Remote education is a service (often commercial) that results in a product in the form of a university graduate, training course or a learning course (J. Kandzia, 2012, p. 159).

Distance learning through the internet constitutes a very attractive alternative for the traditional teaching. It enables learning at the very high level which can be available at any place and any time (S. Juszczyk, 2002, p. 39, 40). It gives a chance to people with disabilities, working people and all those looking for knowledge 'accessible everywhere and all the time'. In the corporate and public

administration such learning reduces costs and gives access to 'the real knowledge at the right place and the right time' (so called just-in-time learning). The complex information systems are no longer able to determine the level of knowledge of each trainee and as a result to adapt the process of learning to individual needs (so called learning the differences).

In Poland, e-learning appears under different names: e-courses, e-learning, remote control. Thus, it fits into the idea of lifelong learning very well[1]. The terms and models related to e-learning include:

1. Online learning – learning with the use of the internet (lack both the physically existing teaching materials and the direct contact with the teacher).
2. Mixed-mode/resource-based/blended learning – a method linking direct teaching (through face to face contact with the teacher) with distant learning.
3. Learning object – a program, page, file that is used many times during the e-learning.
4. LMS (Learning System Management) – a set of e-learning tools available through the common interface. This system often takes the form of educational platforms. Database – searching for information in the indexed databases.
5. Online Support – similar to the database, however, the source of information embraces forums, newsletters and electronic mail.
6. Asynchronous training – involves learning at the learner's own pace; contact with the teacher through discussion groups, e-mails and forums; all materials are available in the electronic form.
7. Synchronous training – listeners communicate with the instructor at a certain time; in the form of virtual class or a video conference.

The use of digital media, e-learning platform in education create new, additional opportunities to communicate and to support creative development of the learner. The basic function is primarily a teaching aid and a component of the given field of science. The device, which in combination with information methods, enriches and extends its scope and the methods.

The opinions of scientists, teachers, practitioners and students concerning the advantages of e-learning are divided. Just as in every teaching method, you can point out the good and bad sides, therefore the remote teaching has supporters and opponents. There are many advantages: individual pace of work, broadening and complementing knowledge, self- sufficiency, systematicity and responsibility.

[1] Lifelong learning (Brit. Lifelong Learning Program – LLP) (2013) – educational program put into operation by the European Commission in 2007 as a continuation of the Socrates Program II. LLP came into being in the years 2007-2013. It aims at strengthening cooperation between the European Union and supporting the exchange of students and teachers within the member countries. The National Agency of LLP program in Poland is the Found for Development of Educational System.

An unquestionable drawback is the lack of contact with the living human being – a man – with a lecturer and with other students as well. Such a situation often leads to low commitment of the participants and affects the need for strong motivation together with the willingness to learn. Difficulties in motivating students belong to one of the major problems. It is more difficult to achieve a sense of rivalry and to make participants exchange their opinions.

Regardless of the views, the twenty-first century and the 'e-reality' that surrounds us, gives us no choice. Either we are 'e' or we will be dealing with various inconveniences. This applies to the entire generation from the youngest to the oldest. The information technology devices are something our children were born with and live with. It is important, therefore, that their teachers/pedagogues were competent and able to provide information out of which a single individual will build knowledge with the use of such methods and forms that bring the intended results, which are friendly and desirable.

Remote teaching competences of the participants

At this point it is necessary to mention what the notion *competence* (Latin *competentia*) means and why it is very popular. This phrase used for politics is identified with the concept of power, medical staff, lawyers – giving advice, bringing professional help; policemen, teachers or students – in particular to the activities or assignments to be performed. It is certain ability to perform tasks or making decisions. The word also involves qualifications to judge and assess.

Good substantive preparation, professionalism and academic skills of teachers, as well as innovative multimedia resources, are not enough to make the education routine work properly. It would be advisable to carry out a preliminary diagnosis of predisposition to this form of education. Such a move will reduce the disappointment of learners and diminish financial losses caused by resignation. Awareness of the rigors and requirements associated with teaching will be greater if its elements are commonly distributed at lower levels of education. For the time being it happens sporadically in some upper secondary schools, as an attempt to experiment, based on the open source Moodle platform. That is why, it is difficult to talk about successes or failures.

The teacher plays a leading role in e-learning. The teacher's competences and involvement have a direct impact on the effectiveness and quality of the didactic process, improvement of classes and reaction to various on-going teaching situations. The areas of competence are: technical and linguistic; psychological and pedagogical – master, guide, friend, creator, good organizer and manager; diagnostic – learning about students and their environment; in the scope of planning and designing – creates programs, scenarios, tests – diagnostic, evaluating; didactic

and methodological – pedagogue, methodologist, didactics developing research and scientific activity; communication and media – skilfully (clearly, precisely, unambiguously) communicates with the virtual community; in the field of control students results and quality evaluation of the school achievements – assessment of students, evaluation of teacher's own achievements; in the scope of designing and assessment of programs – designing of authors' programs and their evaluation; auto-education-care for teacher's professional development – observance of moral and ethical norms both in reality and in the virtual world. This is not the only division as in the case of each competency[2].

E-learning requires specific qualifications and predispositions not only from the teacher side, but also from students (listeners). It can be said that certain qualities are equally important in such dimensions as: the education and technical – knowledge of information technology and preparation for self – study, social conflict – free area, consciousness, perseverance, tolerance, precision in formulating opinions and judgements, psychological – strong will and motivation, predisposition for network communication, organization of time, consequence, civilization and culture – knowledge of the participants' culture determinants in the education process (J. Kandzia, 2016, p. 131). Whatever definition of competence we accept, the most important elements are: knowledge, ability and responsibility.

Description of workshops

The workshops began in March 2017 and lasted until May 2017 (March 9, 2017 – May 29, 2017) in two groups. The design assumptions envisaged groups of eight people. The first one had six and the second nine students. Each group had thirty didactic hours. The speech on the forum entitled "My experience with e- learning", placed on the Moodle platform, revealed that the participants probably had no experience with e-learning. The prerequisites for the participants were: computer skills, knowledge of the word programs, support for the web browser and the basic ability to navigate the internet and knowledge of issues related to publishing online. The aim of the planned classes was to gain knowledge and practical skills needed to the use of the Moodle e-learning platform and to learn about issues related to planning, creating and managing e-learning courses. The essential part was preceded by a pre-test and ended with a post-test (K. Rubacha, 2008b; 2008a, p. 162). There were ten questions and nineteen multiple choice questions. Each course started with an introduction to online learning and basic information/messages regarding the platform's operation and rules for creating courses. After proposing topics

[2] The list of the key competences can be found on the webside of the Academic E-learning Association. The following areas of competence were identified: didactic, in the field of remote work, in the scope of educational evaluation process, technological, http://sea.edu/pl/kryteria/pliki/SEA-kompetencje_e-nauczyciela.pdf [04.08.2014].

by the lecturer (unfortunately students did not have any thematic preferences) each participant was assigned two topics to be elaborated in accordance with the leitmotiv of the lecture and the syllabus. The next phase included the presentation of appropriate evaluating tests. The summary involved the thematic multimedia presentations. The materials were placed on the platform in such a way that each group created a fifteen – week cycle of lectures with exercises. To avoid mistakes everything was analyzed and checked together with participants of the group. The instructor also suggested a joint version of the presentation material to be published. The created courses should be consistent in terms of substantive part, editing and graphic. According to the educational assumptions, they should constitute material for students of Faculty of Pedagogical Sciences (W. Zaczyński, 1995).

The selection of groups was arbitrary, however, both during the classes as well as the classes based on pre-test and post-test, it turned out that the groups were definitely different. Therefore, they could not be considered together. The creation of the course required a lot of commitment and personal involvement of participants. They obtained the necessary substantive and practical assistance.

Analysis of results

In the first group of six students, the theme was "Fairy tales in films and literature and their role in raising pre-school children". The scope of the material: areas of child's development – physical, motor, emotional, social, child raising – a child in the family and local environment, kindergarten's educational role; fairy tales in life and child upbringing – characteristics of the genre, fairy tales, films and preschool literature; multimedia presentation – motif of a fairy tale in preschool education. The topic seems to be interesting for students of early school education. The initial stage of the courses was very difficult to organize. The participants were leaving classes and arrived late. They seemed to have difficulty in understanding the specifics of the e-learning course, all more so, to create it. After the first classes the problems were solved and the students were willing to work. The problems should be explained by the fact that the participants basically did not have (it can be said that any) contacts with this form of learning even as listeners. They appeared to be able to download anything from the internet and paste it. They described their experiences in this way: one of them used an electronic journal at school, another one made a short language quiz, just four small notes and occasional texts to read, one student has never encountered e-learning teaching. The individual modules were implemented in the programmed time frames. In spite of the original dilemmas, the workshops resulted in a good didactic material and were conducted in a sound atmosphere.

Table 1. Results of the test and pre-test/post-test for students in group I

Student's number	Pre-test – max. 45 pt. points/percentages		Post-test – max. 45 pt. points / percentages		Increase point rates
1.	7	15.6%	39	86.7%	**71.1**
2.	2	4.4%	29	64.4%	**60.0**
3.	7	15.6%	32	71.1%	**55.5**
4.	5	11.1%	29	64.4%	**53.3**
5.	2	4.4%	34	75.6%	**71.2**
6.	5	11.1%	31	68.9%	**57.8**
Together	**40/270**	**14.2%**	**220/270**	**81.5%**	**67.3**

Source: prepared by the author.

Analyzing the global results of the pre-test and post-test collected in the above table, one can notice a significant increase in knowledge of the Moodle platform and e-learning courses: from 14% of correct answers to 81.5% i.e. an increase by 67.3 percentage points depending on how low the start was. The results of individual people were not too high, nevertheless, a substantial increase in knowledge of the subject can be noticed.

In the second group of nine students, the subject of the course was "A child in an early school age in an electronic network – educational values and threats". The scope of the material: the internet and its meaning in life of a small child – the history of the internet in Poland and in the world; development of a child in an early school age – physical, motor, emotional and social; media education, the internet at school, access to computer network at home – the role of parents, online advertising – child a victim of manipulation, games and network entertainment and their types, threats related to the presence of children in the network – the scale of threats, how to protect a child, paedophilia, suicide, net violence; multimedia presentations – examples of educational games and activities for six- to nine-year-old children.

As before, the topic was suggested by the lecturer. Similarly to the first group from the e-learning forum experience, one person participated in a stationary course with the use of remote learning platform, six people had experience with materials placed on the platform and two never used this form of leaning. The participants showed solidarity and diligence and took up the course with full responsibility. The materials were prepared competently. It was a great pleasure for me to conduct classes with the group.

Table 2. Results of the test and pre-test/post-test for students in group II

Student's number	Pre-test – max. 45 pt. points/percentages		Post-test – max. 45 pt. points/percentages		Increase point rates
1.	11	24.(4)%	41	91.(1)%	**66.7**
2.	7	15.6%	41	91.(1)%	**75.5**
3.	15	33.(3)%	43	95.6%	**62.2**
4.	12	26.7%	41	91.(1)%	**64.4**
5.	7	15.6%	41	91.(1)%	**75.5**
6.	21	46.7%	42	93.(3)%	**46.6**
7.	13	28.9%	41	91.(1)%	**62.2**
8.	16	35.6%	41	91.(1)%	**55.5**
9.	8	17.8%	41	91.(1)%	**73.3**
Together	**110/405**	**27.2%**	**372/405**	**91.9%**	**64.7**

Analyzing globally the results of the pre-test and post-test collected in the above table, one can notice an increase in the knowledge of the Moodle platform and creation of the e- learning course from 27.2% to 91.9% that is an increase by 64.7 percentage points. The initial potential was higher than in the first group, but the final increases in knowledge are comparable. Comparing both groups, the increase in knowledge in the first (67.3 percentage points – the overall result for the pre-test 14.2% for a post-test 81.5%) was slightly higher than in the second (64.7 percentage points – the overall pre-test score 27.2% and post-test 91.9%). Despise slightly lower increase in the second group, after thirty hours of didactic work, all individual student results were definitely better by over 90%.

Conclusions

The working conditions were comfortable due to the fact that the groups were not numerous. That is why, the teacher could reach every participant, each work could be thoroughly analyzed and the mistakes corrected. The most problems were caused by the tests and correct allocation of the points in the test questions. They were solved together to avoid mistakes during assessment the knowledge of potential students. Considering the students' lack of contact with the remote teaching platform in the whole cycle of university education, I believe that setting up the courses was an enormous success. They are a good didactic material.

The workshops aimed mainly at presentation, but also were meant to encourage students as future teachers to use e-learning platform. I think that this goal has been achieved. To sum up, in my opinion not everyone had the necessary competences to be a participant in the online course, or even to be a teacher using this method. They acquired such abilities during the course of workshops giving the hope that in the future these teachers will try to apply in their professional life what they have learned at the course.

To avoid learners' disappointment on one hand, and on the other to reduce financial losses caused by the large percentage of students resigning from this form of education, an in-depth diagnosis of these predispositions together with a test course should be carried out. As the courses have revealed, it also refers to people who plan to take up such form of e-learning. Distance education becomes, though not without difficulties, a permanent segment of higher education, both commercial and public (B. Siemieniecki, 2012, 2013, 2015). E-education has already reached and should further reach lower levels of teaching and such a practical subject as creating e-courses and e-materials ought to appear permanently in the university education system for the future lectures regardless the subject areas.

Questions – Pre-test/Post-test

1. Distance learning to – a) user ID; b) e-learning platform; c) form of education;
2. Does the e-learning platform use the website's interface? – a) yes; b) not; c) I do not know;
3. Requirements/skills for remote teaching participants are – a) computer and internet; support; b) searching for information; c) developing materials; d) discipline; e) the motivation; f) freedom in meeting deadlines; g) independence;
4. User roles/permissions available as part of the course – a) lead; b) leader without editing rights; c) teacher without editing rights; d) student; e) student with editing rights; f) the guest; g) administrator; h) the author of the course; i) manager;
5. In what formats can you create courses (4)? – a) thematic; b) week; c) friendly; d) SCORM; e) a month; f) a few days (e.g. 3 days);
6. The components of the course are – a) survey; b) database; c) chat; d) forum; e) excel; f) vote; g) the lesson; h) quiz; i) dictionary of concepts; j) graphic program; k) the workshop; l) wiki; m) jobs;
7. Resources on the platform can be placed by selecting the option – a) URL address; b) folder; c) the label; d) page; e) resource;
   How do we check the knowledge/knowledge of course participants?;
9. What information can be available to participants of the course when check-

ing the news/knowledge – a) during the test; b) immediately after the test; c) later, when the quiz is still open; d) after closing the quiz;

10. With what tools do we keep the participants involved? – a) forums; b) quizzes; c) they are not needed; d) chats; e) the workshop; f) database; g) the survey; h) vote.

Bibliography

Harel D. (1992), *Algorytmika. Rzecz o istocie informatyki*, WNT, Warszawa.

Juszczyk S. (2002), *Edukacja na odległość*, Wyd. A. Marszałek, Toruń.

Kandzia J. (2012), *Kształcenie online* [in:] J. Kandzia (ed.), *Nowe metody nauczania w matematyce*, WEMA, Warszawa, projekty.matematyka.uksw.edu.pl/node/56.

Kandzia J. (2013), *E-nauczanie w szkole wyższej-przykład dobrej praktyki pedagogicznej* [in:] W. Walat, W. Lib (eds), *Edukacja – Technika – Informatyka. Wybrane Problemy Edukacji Informatycznej i informacyjnej*, Rocznik Naukowy, No. 4-2, Rzeszów.

Kandzia J. (2016), *Edukacja matematyczna a cywilizacja cyfrowa. Podmioty kształcenia wobec wyzwań technologii informacyjnych*, Wyd. UKSW, Warszawa.

McLuhan M. (2001), *Wybór tekstów*, E. McLuhan, F. Zingrone (ed.), Zysk i S-ka, Poznań.

Rubacha K. (2008a), *Metodologiczna struktura przedmiotu badań pedagogiki* [in:] K. Rubacha (ed.), *Konceptualizacje przedmiotu badań pedagogiki*, Impuls, Kraków.

Rubacha K., (2008b), *Metodologia badań nad edukacją*, Wydawnictwo Akademickie i Profesjonalne, Warszawa.

Siemieniecki B. (2012) (ed.), *Edukacja medialna w świecie ponowoczesnym*, Wyd. Naukowe UMK, Toruń.

Siemieniecki B. (2015), *Edukacja a nowe technologie w kulturze, informacji i komunikacji* [article in an unpublished version].

Siemieniecki B. (2013), *Pedagogika kognitywistyczna*, Impuls, Kraków.

Zaczyński W. (1995), *Praca badawcza nauczyciela*, WSiP, Warszawa.

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COMPUTER CHESS PROGRAMS AS EDUCATIONAL TOOLS

Abstract

This article presents the influence of the chess game on human development. It also indicates the differences between the game of chess between people and computers. The article includes a short history of chess and a comparison of existing computer chess engines. The benefits of practical chess skills and the competitive disadvantages among children playing are presented. The possibilities of using computer chess programs as educational tools are assessed.

Keywords: chess, computer chess programs, educational tool, game, human development, rivalry.

Introduction

Chess is a game known for centuries in various societies and a permanent element of our culture. It is an extremely valuable game because it is a specific combination of sport, art elements and scientific thinking. The rules of chess can be learned in a short time. The multiplicity of strategies makes the game very diverse so it is a universal tool, both for entertainment and intellectual activity, as well as for developing the positive qualities and skills of children, youth and adults. Attempts are made to assess the impact of chess not only on mental development, but also on the personality of each player (R. Aciego et al., 2012).

The benefits of teaching chess at various stages of education have been appreciated by the European Parliament which introduced an educational program "Chess at school" to the education systems in the European Union on March 15, 2012. In the document (S. Binev et al., 2012) it was written that "chess is a game accessible to children from every social group, can contribute to achieving social cohesion and realization of political goals such as social integration, combating discrimination, reducing the crime rate or even combating various types of addic-

tions, regardless of the child's age, chess can improve his concentration, increase patience and perseverance, as well as develop a creative sense, intuition, memory and analytical thinking and decision-making skills; whereas playing chess also teaches determination, motivation and sporting behavior". The general goals of this innovative educational program are: supporting the comprehensive development of children, increasing children's mathematical skills (especially in the areas of: logic, spatial orientation, analytical thinking, problem solving), shaping important personality traits (responsibility, concentration, intuition and courage), developing children's self-esteem and confidence in their own abilities (M. Dworecki, A. Jusupow, 2008, pp. 15-34).

Chess is a board game that, as a specific tool to help children development, is introduced even for pre-school children. In a child's early education, it is worth shaping the ability to concentrate, memorize details and reach the correct solution to the problem in a short time. The young adept of the 'Royal game' becomes more patient, persistent and learns to control his emotions (J. Meyers, 2000, pp. 3-5).

In almost 40 countries, including Poland, chess has become part of the educational program (A. Harazińska, 2015). Development of computer science allowed for using chess programs to play chess at home. However, the following questions arise: Is it worth playing chess against computers? Is it more beneficial in education and human development to play chess against another human or to pit a human against a computer? What are the qualities that develop when a human plays against human and when human plays against computer? Does human play against a very good chess program make any sense? Which chess programs are the best and how to assess the value of a chess program? This article is an attempt to answer these questions in relation to a variety of multifaceted research.

History of chess

Chess is a known, two-player strategic game played on a chessboard with 64 squares arranged in an 8×8 grid. The exact origin of the game is unknown, most likely it originated in India. The game *chaturanga* from India (mid-fifth century AD) is considered the earliest form of game similar to chess, which in the sixth century AD in a changed form (as a *chatrang* game) went to Persia and China (H.J.R. Murray, 1913, pp. 25-50, 119-169). The word *checkmate* comes from Arabic *shah mat* meaning "the king is dead". The first book describing the rules of chess was written in Persia. In the seventh century AD, after the conquest of Persia by the Arabs who willingly played this game, chess spread to other countries. In Europe, chess was played initially in Spain, Portugal, France and Italy, then slightly later in England, Germany and Scandinavia (J. Giżycki, 1984, pp. 9-40). The game got into Russia directly from the East in the ninth century AD, and to Poland in the twelfth

century during the reign of Bolesław Krzywousty. In the thirteenth century, the chessboard took on today's appearance (earlier it was one-colored). Later the first chess book entitled *Bonus socius*, developed by Alonzo, the king of Castile, appeared. The guide to chess according to the new rules was developed by Lucena in 1497. A flowering of chess occurred in the sixteenth century, and the rules of the modern game were introduced, which finally took on today's form. In Poland, the first chess book, developed by Kazimierz Krupski, was printed in 1835 (J. Giżycki, 1984, pp. 42-43). In nineteenth century, chess masters appeared in many countries: in England – Howard Staunton, in Russia – Alexander Petrov, in France – Louis de la Bourdonnais, in Germany – Adolf Anderssen, and in the United States – Paul Morphy, who all fought for the unofficial title of world champion (H.J.R. Murray, 1913, pp. 878-887).

The first big international chess tournament took place in 1851 in London, and the winner was Adolf Anderssen. Wilhelm Steinitz was winner of the first official match for the title of world champion in 1886. Over the next 100 years, the rules of selecting the strongest chess player in the world have changed many times (H.J.R. Murray, 1913, pp. 881-889).

The International Chess Federation was established in 1924 and also from that year the Chess Olympiads were played. The Women's World Chess Championships have taken place since 1927 and the world's first women's chess champion was Vera Menchik. In the following years, the world championships of juniors and students and also continental championships, both individually and team-wise, were organized. Moreover, the world championships in correspondence chess were held. The first individual Polish men's chess championships were organized in 1926 (won by Dawid Przepiórka), the first individual Polish women's chess championships in 1935 (won by Regina Gerlecka) and the first Polish team chess championship took place in 1929 (S. Gawlikowski, 1972).

The ability to play chess in the Cold War era was supposed to testify to the intellectual status of a given nation. The peak of chess popularity took place in 1972, when Russian, Boris Spassky and American, Bobby Fischer faced the world championship match (W. Żuchowski, 2009).

Impact of chess game on children development

Almost 200 years ago Benjamin Franklin in his dissertation published in *Dr. Franklin's Essay on the morals of chess* (1841, pp. 7-11) wrote about the many benefits of chess, which he considered to be the oldest and most universal game people play. Among the many advantages he mentioned was the development of abilities of observation, prediction, prudence and precautionary skills. Franklin also claimed that the way we act during the chess game can be translated into other aspects of life.

In a sense, it is possible to get to know a man by analyzing his style of playing chess. In Poland, Krupski described the benefits of chess in the publication *Strategika szachowa; czyli, Praktyczny sposób doskonalenia się w grze szachów* already in 1835.

Modern scientists have analyzed this game very intensely. In the light of this research, the ability to play chess is the source of many benefits, the most important of which are presented in Table 1.

Table 1. The benefits of chess skills

Chess teaches	Chess develops	Chess shapes
– responsibility – respect for yourself and your rival – self–discipline – urgency – regularity – commitment – diligence – determination – perseverance in action – planning (time) – correct assessment of the situation – fair competition – dealing with failures – tolerance	– memory – concentration – communication – creativity – imagination – perceptivity – divisibility of attention – logical thinking – spatial thinking – abstract thinking – strategic thinking – critical thinking – mathematical abilities – ability to read and understand – creative abilities – ability to learn from your mistakes – ability to analyze the problems encountered	– character – intellect – sense of observation – combination sense – cognitive skills – good reasoning skills – ability to make decisions – ability to solve problems – ability to achieve the set goals

Source: prepared by the authors.

The game of chess is above all entertainment and fun, it can become a passion and a way of life for children. Simultaneously, it influences the intellectual, emotional and psychosocial development of players.

The creator of multiple intelligence Howard Gardner confirmed in a study (H.E. Gardner, 2008) **positive influence of chess on intelligence**. This American psychologist said that chess affected two of the eight types of intelligence: mathematical-logical and visual-spatial. The number of challenges faced by a chess player during a chess game and the intellectual effort made during the game are enormous. While playing games, children develop their intellectual potential, as chess sets them with many tasks and problems requiring concentration, consideration of possibilities, forward prediction, visualization, assessment of the situation, abstract thinking and planning (A. Kaczmarek, 2015).

In assessing **the impact of chess on the overall intellectual development** of children and youth it was noticed that the game trains the child's spatial imagina-

tion, teaches logical thinking, analyzing of situations and drawing of conclusions. The chess increases the volume of visual memory and improves the coordination of movements. The greatest benefits of the game occur for children over 7 years of age, which is associated with rapid development at this stage.

Based on the research, scientists described the progressive development of the imagination, the improvement of the ability to concentrate, the ability to organize thoughts, better skills in planning and the improvement of understanding of their actions and their consequences (M. Weteschnik, 2017, pp. 13-14). In Venezuela, a study was conducted among children who took a four and a half month courses in chess. There have been significant increases in intellectual abilities. Similar studies of concentration and logical thinking were carried out in Australia in 2003 among the participants of chess lessons (E. Szymańska, 2018). This confirmed that the game of chess improves intellectual abilities.

In the light of research carried out by Robert Boruch (2011), the chess **influences mathematical abilities**. The students of Italian primary schools performed a mathematical test before entering chess classes and after a thirty-hour chess course. Children who played chess improved the results of their tests by about 17%, and students taking part in other supportive activities improved by about 4.5%, which was in line with the conclusions of other researchers (R.M. Berkman, 2004, pp. 246-250; S. Hong, W. Bart, 2007, pp. 89-96). Students also improved other skills: critical thinking, self-confidence, anticipation of consequences of their actions, logical thinking, development of memory, the ease of solving problems, increased concentration.

James Smith and Robert Cage conducted an experiment among children, which took 120 hours of learning chess. The influence of chess teaching on mathematical achievements among youth was examined. Significantly better results of mathematical tests and the impact of the game on the perception capacity were observed (E. Belanger, 2014). The main driving force behind the development of these abilities is the need to devise strategies and predict a few moves forward (E. Szymańska, 2018). Chess is therefore crucial for the development of a child's mathematical skills, **improve arithmetic skills**.

In the work *Szachy jako specyficzne narzędzie pomocne w rozwoju dziecka* (T. Pintal, D. Sondej, 2012, pp. 1-9), the authors collected the results of research carried out in different countries on groups of children who play chess.

Among children playing chess twice a week their trainer Albert Frank noted a significant improvement in language skills, improvement of mathematical skills and fluent execution of strategic tasks (2011, pp. 3-80). The researcher claims that chess uses and strengthens the child's individual abilities and also affects the linguistic sphere. Chess as a game in which words are not used, **sharpens language skills**.

On the basis of research carried out by Robert Ferguson (1995) and others (N.W. Krogius, 2011; W.M. Bart, 2014; R. Aciego et al., 2012), it can be concluded that chess **develops critical thinking skills**. The game is also a great instrument in shaping the ability to assess the situation. Advantageously, it develops organizational skills, an ability to plan activities and predict consequences, strengthens immunity to distraction, improves reflexes and motor coordination. It favorably develops organizational skills, planning skills and prediction of consequences, enhances immunity to distraction, improves reflex and motor coordination.

Assessing **the impact of chess on the psyche and development of children's personality** it can be seen in them the development of such features as: patience, self-control, perseverance, concentration, determination, imagination, courage, self-confidence. Every chess workout shapes the will to fight and win, just like other sports (M. Dworecki, A. Jusupow, 2005, pp. 13-37). The chess game teaches a healthy competition, a respect for the opponent and the proceedings according to the rules of fair play, it is learning to make and maintain good, friendly contacts with people.

Thanks to chess, the child acquires psychological resistance, learns their own reactions to stressful situations, learns how to deal with stress and tiredness, how to effectively operate under pressure and not give up even in the most difficult situation. At the same time chess teaches the child the responsibility and the consequences of their own decisions. Research shows that in the socio-social dimension chess players, compared to players of other team games such as basketball, etc., are more socially engaged and more willing to cooperate. Teachers assessed people from the chess group as more satisfied with school and teachers, fond of learning, having a greater satisfaction with their own work, more self-confidence, a much greater ability to cooperate and solve problems. Chess training shapes the ability to perceive, control and evaluate emotions. It can therefore be concluded that **chess supports the development of emotional intelligence and psychosocial skills**.

Based on the research conducted on a group of patients, it was noticed that chess helps to train cause-and-effect thinking and relationships between events. It was found that chess is highly effective in protecting against neurodegenerative diseases such as dementia and Alzheimer's disease and, to some extent, **has therapeutic value** regardless of the age of the player (E. Szymańska, 2018).

In the last few years, in many Polish primary schools, additional chess classes have been introduced in early childhood education as a program-methodic innovation (M. Zielińska, 2014). Classes are implemented based on the Regulation of the Ministry of National Education and Sport (*Rozporządzenie...*, 2002) and the Regulation of the Ministry of National Education (*Rozporządzenie...*, 2017). Using the chess didactic means, the goals such as a comprehensive child development, the increasing of their mathematical skills and the shaping of important personality traits are realized.

The development of chess computer programs

Chess is a decision game, and its beauty lies in strategy. A game consisting of 100 movements of both opponents can be played in 10^{155} ways. It is 10^{79} times more than the total number of atoms in the entire Universe. The counting of all the possibilities is not feasible, so the best option is often chosen intuitively. Even a hyper-fast computer cannot analyze a fraction of all variants in a conceivable time. A human makes a decision based on an intuition and an experience, and analyzes only selected options (W. Litmanowicz, J. Giżycki, 1986, pp. 7-9).

The creative imagination of people who played and appreciated the beauty of chess, has contributed to attempts to teach machines, and later computers, to solve chess problems and tasks that require the use of human intelligence. The first machine chess games were created in the nineteenth century, but real computer programs were created only in the twentieth century. The most important events at the stage of evolution of computer programs are presented in Table 2.

Table 2. A brief history of the development of computer chess programs

Year	Creator / inventor	Computer chess program
1	2	3
1846	Charles Babbage	He considered the possibility of teaching chess his unfinished mechanical counting machine called *Analytical Engine*.
1912	Leonardo Torres y Quevedo	He created the oldest mechanism called *El Ajedrecista* dedicated to play chess endgames. The automat moved the figures on the chessboard using electromagnets mounted under the board and was able to solve chess problems correctly.
1950	Claude Shannon	He publishes "Programming a Computer for Playing Chess", one of the first papers on the problem of computer chess and the min-max algorithm.
1951	Alan Turing	He designed a chess program, which, however, due to the lack of access to the appropriate computing machine was not launched.
1952	Dietrich Prinz	He wrote the first chess program that was really launched.
1958	Three programmers from the USA	They wrote the first program which was able to play a chess game in a correct way, although at a low level.
1974	Mikhail Botvinnik and Russian scientists	The Kaissa program became the first winner of the Computer Chess World Chess Championship in Stockholm.
1980	Kenneth Thompson	Belle – the first program which reach the chess master level, launched on specially designed equipment. Belle won the World Computer Chess Championships in 1980.

1	2	3
1983-1986	Firma Cray andRobert Hyatt, Harry Lewis Nelson, Albert Gower	The Cray supercomputer was created and the Cray Blitz program implementation dethroned Belle. Cray Blitz was a two-time winner of the World Computer Chess Championships in 1983 and 1986.
1988	IBM	The Deep Thought chess program defeated the Danish Grand Master Bent Larsen for the first time in the tournament game.
1997	IBM	The Deep Blue computer system won with world champion Garri Kasparov 3½ to 2½ (two wins by Deep Blue, one win by Kasparov, three draws).

Source: prepared by the authors on the basis of D. Heath, A.D. Derek, 1997, pp. 63-68 and E.J. Larson, 2016.

Since 2005, commercial and free chess engines are available, which are run on home PCs or laptops and achieve a game power comparable or superior to the best chess players in the world (A. Jusupov, 2011, pp. 6). There are internet chess servers, such as ICC – Internet Chess Club and FICS – Free Internet Chess Server. Today are about 2250 computer programs of different power and popularity, of which 387 have the ELO chess ranking index (for CCRL 40/40) with a value between 1500 and 3460 points. The best ten of them with the ELO index value > 3200 (for CCRL 40/40 Rating List) are presented in Table 3.

Table 3. The best 10 chess engines

No	Program name	ELO	Kind of source
1	Stockfish 270918 64-bit 4CPU	3460	Open source
2	Komodo 11.3.1 64-bit 4CPU	3403	Commercial
3	Houdini 6 64-bit 4CPU	3400	Commercial
4	Fire 7.1 64-bit 4CPU	3325	Free
5	Deep Shredder 13 64-bit 4CPU	3285	Commercial
6	Fizbo 2 64-bit 4CPU	3283	Free
7	Ethereal 10.55 64-bit 4CPU	3281	Open source
8	Andscacs 0.94 64-bit 4CPU	3273	Open source
9	Booot 6.3.1 64-bit 4CPU	3272	Open source
10	Laser 1.6 64-bit 4CPU	3227	Open source

Source: prepared by the authors on the basis of FIDE Rating.

The dependence of the number of chess programs on the ELO index value is shown in Figure 1. This figure shows that the increase in the chess ranking causes a decrease in the number of programs that are able to achieve this ranking.

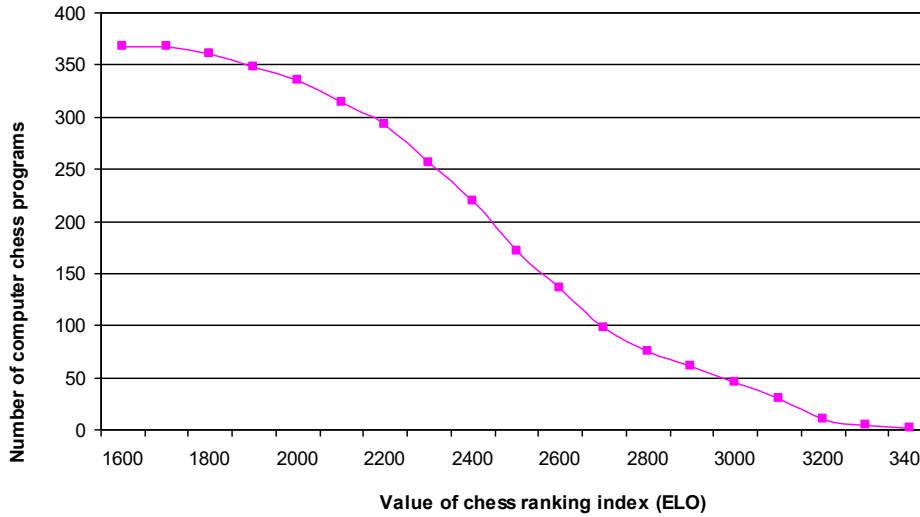

Figure 1. Relationship between the number of computer chess programs and the value of the chess ranking index ELO (for CCRL 40/40)
Source: prepared by the authors on the basis of the CCRL 40/40 rating list.

Competition of people and computers in a game of chess

The game of chess can be covered by mathematical rules, which is why it could be implemented as computer programs. Thus, chess computer programs were implemented, with which players with small or medium skills could lose, while masters and grandmasters did well (D. Levy, M. Newborn, 1982, pp. 24-39). As a result of the development of computer science, methods of artificial intelligence and a sharp increase in speed of computers, a lot of different chess programs were implemented. Among them there are over 70 computer programs, whose ELO chess ranking index exceeds the value of 2800 and reaches the level of up to 3400 points.

Currently, most players in the world have an ELO index below 2000 points, and until now there were only 8 grandmasters (Magnus Carlsen, Garri Kasparov, Fabiano Caruana, Levon Aronian, Viswanathan Anand, Veselin Topalov, Vladimir Kramnik, Alexander Grischuk), who reached the ELO chess ranking index above 2800 points (FIDE Rating). The dependence of the number of players on the ELO index value is shown in Figure 2.

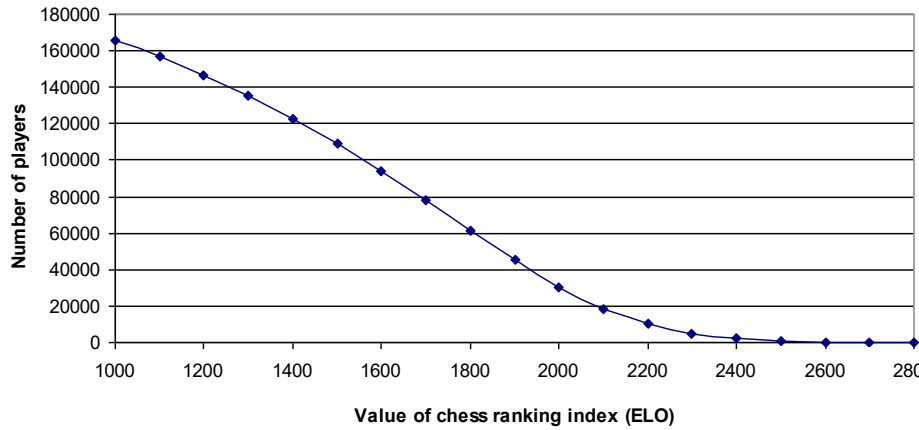

Figure 2. Relationship between the number of players and their ELO index values
Source: prepared by the authors on the basis of the FIDE Rating.

The greatest chess virtuosos include among others: José Raúl Capablanca, Alexander Alekhine, Mikhail Tal, Bobby Fischer, Anatolij Karpov and Garri Kasparov. Magnus Carlsen of Norway is considered the best contemporary chess player, who became grandmaster in 2004 and is the current world champion. He collaborated with the long-time world chess champion, Garri Kasparov, for whom "chess is a fight and sport, and a combination of science and art" and who, as the first grandmaster, was defeated by the computer system Deep Blue in 1997 (J. Konikowski, 2008, pp. 14-15). Carlsen is called the Mozart of Chess and is ranked first in the ranking of the World Chess Federation (ELO=2839 in FIDE Rating). Carlsen became world champion after winning the World Chess Championship in 2013 against Viswanathan Anand. Carlsen defended his world champion title against Anand in the World Chess Championship 2014 and against Sergey Karjakin in the World Chess Championship 2016. Sergey Karjakin won the title of grandmaster in 2002 at the age 12 years and 7 months, becoming the youngest chess player ever to reach this title (F. Friedel, 2011).

There have been several historical matches of human versus machine (W. Żuchowski, 2009). Making a small mistake as a human during a game against a chess computer program usually results in a loss. In a game against a good chess program, after achieving a significant advantage by the chess program the result of the game can almost always be judged in favor of the computer. Computers never get tired and do not get upset. Since 2006, in principle, human cannot compete effectively and win with good chess programs, which may be the cause of human frustration and discouragement.

Playing chess by two humans, the result can be determined not only by the skill of the game, but also by resistance to stress, physical and mental endurance, especially during games that last several hours. Even committing a serious error by one of the players sometimes does not decide on the final result. As the best move is often considered not the perfect move, but the most unpleasant move in a given phase of the game for the opponent. In the game between two humans the result of their chess play can be considered as unresolved till the end. This is due to the fact that at any time one of the players may make a fatal error that will immediately determine the result of the play.

Chess computer programs compete not only with people, but also with each other, constantly improving. The relationship between human chess players and computers is actually more symbiotic than adversarial. Today's chess masters use computer programs as learning aids to improve their own game (K. Finley, 2012). Many chess computer programs have been created (R. Szrubarczyk, 2007), interactive chess textbooks (R. Korpalski, 2014), and websites with chess tasks (P. Mroziński, 2018), which are to support development of young chess players.

Nowadays, people have a choice how to play chess. Two players can compete against each other on a traditional chessboard or remotely using a computer connected to a network. A human can also play against a computer chess program. Additionally, two computer chess programs can play the game with each other. These cases are shown schematically in Figure 3.

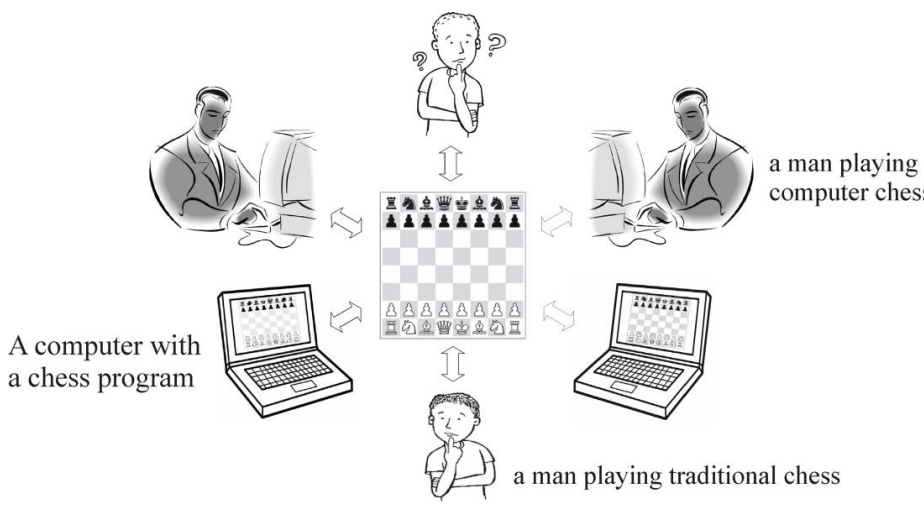

Figure 3. Possibilities of competing in a game of chess:
human-human, human-computer, computer-computer
Source: prepared by the authors.

From Figures 1 and 2, it is visible that times when humans could seriously compete against chess programs are over. Today Carlsen, and in the future the next world chess champions, will not have a realistic chance to beat the best chess programs. However, the computer chess programs can be considered as a good tool for improving humans understanding of the game. Carlsen asked how important computer programs are for his preparation, answered: "Computers are very important for sure. All the analysis I have done has been with the help of the computers. You constantly need them"; and added: "It is a tool to help me analyze and to help me improve at chess". Carlsen's answer to the question of whether he plans to play a match against a computer was: "I personally never wanted that. I find it much more interesting to play humans. And also, of course, now that they have become so strong in a game like that, I wouldn't stand a chance" (K. Prevezanos, 2016).

Conclusions

This work shows the multidimensionality of chess and the benefits of chess regardless of the age of a player. Chess is not only a form of intellectual activity and entertainment, but above all a huge investment in the mind and development process of a young man. Chess games favor the child's versatile development, trains memory and the ability to abstract thinking, develops spatial imagination. This game affects the development of the intellect, increases mental activity, awakens creative abilities. In addition, chess shapes the character, teaches courage, humbleness, respect for the opponent and himself, as well as responsibility for his own decisions. Chess has educational, didactic and upbringing qualities, it has a positive impact not only on mental development, but also on shaping the positive personality traits of every player. Chess excels attention, develops the ability to concentrate and logically think. It affects the development of positive traits and attitudes such as: objectivism, tolerance, persistence in pursuing a goal. Chess can be an element of entertainment and satisfaction throughout a whole life.

In accordance with Garri Kasparov, chess is a tool that improves the ability of children to acquire knowledge. For this reason this game can constitute a good basis to better meet the requirements of a modern education program. Chess as an educational tool has more value and bring more benefits to players in the case of direct human-human rivalry on a traditional chessboard. Chess computer programs are very good didactic help, they allow students independently practice, improvement and raising the skill level of playing, however, they do not develop socially. Contemporary chess has been strongly influenced by research on artificial intelligence, which crystallized in the implementation of chess programs outstripping the ranking of the best chess players. For this reason, it is important to choose the right computer program used for learning and to adjust the level of its game to

suit the player's age and skills, because when the computer is too strong, the losing player can feel frustration and discouragement.

Bibliography

Aciego R., Garcia L., Betancort M. (2012), *The Benefits of Chess for the Intellectual and Social-Emotional Enrichment in Schoolchildren*, The Spanish Journal of Psychology, Vol. 15, No. 2, 551-559, DOI: 10.5209/rev_SJOP.2012.v15.n2.38866.

Bart W.M. (2014), *On the effect of chess training on scholastic achievement*, Frontiers in Psychology, 5: 762, doi: 10.3389/fpsyg.2014.00762.

Belanger E. (2014), *Could chess instruction be the key to academic success in Birmingham classrooms?*, Advance Local Media LLC, Birmingham, https://www.al.com/news/birmingham/index.ssf/2014/07/will_chess_strategy_be_the_key.html [18.10.2018].

Berkman R.M. (2004), *The Chess and Mathematics Connection: More Than Just a Game, Mathematics Teaching in the Middle School*, Vol. 9, Issue 5, pp. 246-250.

Binev S., Attard-Montalto J., Deva N., Mauro M., Takkula H. (2012), *Written declaration on the introduction of the programme 'Chess in School' in the educational systems of the European Union*, No. 0050/2011, 15.03.2012, PE477.301v01-00, eur-lex.europa.eu [16.10.2018].

Boruch R. (2011), *Does Playing Chess Improve Math Learning? Promising (and Inexpensive) Results from Italy*, http://www.europechesspromotion.org/upload/pagine/doc/SAM_research_synthesis.pdf [19.10.2018].

CCRL (2018), *CCRL 40/40 Rating List – All engines*, http://www.computerchess.org.uk/ccrl/4040/index.html [22.10.2018].

Dworecki M., Jusupow A. (2005), *Metody treningu szachowego*, Oficyna Wydawnicza Read Me, Łódź.

Dworecki M., Jusupow A. (2008), *Rozwój twórczego myślenia*, Oficyna Wydawnicza Read Me, Łódź.

Ferguson R. (1995), *Chess in Education. Research Summary. A review of key chess research studies for the BMCC chess in education*, A Wise Move Conference, the Borough of Manhattan Community College.

FIDE Rating (2018), *Chess players by rating*, 365Chess.com – Biggest Chess Games Database Online, https://www.365chess.com/top-chess-players.php [17.10.2018].

Finley K. (2012), *Did a computer bug help Deep Blue beat Kasparov?*, Wired, https://www.wired.com/2012/09/deep-blue-computer-bug/ [14.10.2018].

Frank A. (2011), *Chess And Aptitudes*, Published by Lulu Press, Inc., Morrisville.

Franklin B. (1841), *Dr. Franklin's Essay on the morals of chess* [in:] G. Walker, B. Franklin, W.S. Kenny, *The chess player*, Published by Nathl, Dearborn, Boston, pp. 7-11.

Friedel F. (2011), *Chess prodigies and mini-grandmasters revisited*, ChessBase News, https://en.chessbase.com/post/che-prodigies-and-mini-grandmasters-revisited [22.10.2018].

Gardner H.E. (2008), *Multiple Intelligences: New Horizons in Theory and Practice*, Basic Books, New York.

Gawlikowski S. (1972), *Olimpiady szachowe 1924-1970*, Wydawnictwo Sport i Turystyka, Warszawa.

Giżycki J. (1984), *Z szachami przez wieki i kraje*, Wydawnictwo Sport i Turystyka, Warszawa.

Harazińska A. (2015), *Edukacja przez Szachy w Szkole*, Ogólnopolski Projekt Polskiego Związku Szachowego 2013-2015, WordPress, http://www.szachywszkole.pl/ [17.10.2018].

Heath D., Derek A.D. (1997), The *Historical Development of Computer Chess and its Impact on Artificial Intelligence*, Technical Report WS-97-04, AAAI, pp. 63-68.

Hong S., Bart W. (2007), *Cognitive effects of chess instruction on students at risk for academic failure*, Int. J. Spec. Educ., 22, pp. 89-96.

Jusupov A. (2011), *Chess evolution. The fundamentals*, Vol.1, Quality Chess Press, Glasgow, UK.

Kaczmarek A. (2015), *Naukowcy o szachach*, Akademia szachowa MAT, http://akademia-szachowa-mat.pl/naukowcy-o-szachach/ [16.10.2018].

Konikowski J. (2008), *Zagraj jak Arcymistrz*, Wydawnictwo Penelopa, Warszawa.

Korpalski R. (2014), *Interaktywny Podręcznik szachowy*, http://serwer1311891.home.pl/epodrecznik/ [15.10.2018].

Krogius N.W. (2011), *Szachy – gra i życie*, Feniks, Moskwa.

Krupski K. (1835), *Strategika szachowa; czyli, Praktyczny sposób doskonalenia się w grze szachów*, Drukarnia Gazety Warszawskiej, Warszawa.

Larson E.J. (2016), *A Brief History of Computer Chess*, The Quad Magazine, https://thebestschools.org/magazine/brief-history-of-computer-chess/ [18.10.2018].

Levy D., Newborn M. (1982), *All about chess and computers*, Springer-Verlag Berlin-Heidelberg.

Litmanowicz W., Giżycki J. (1986), *Szachy od A do Z*, Vol. 1 i 2, Wydawnictwo Sport i Turystyka, Warszawa.

Meyers J. (2000), *Why offer chess in schools* [in:] *The benefits of Chess in Education. Examples f Research and Papers on Chess and Education*, Kasparov – Chess Foundation Europe, pp. 3-5, http://www.academiadesah.ro/wp-content/uploads/2016/08/research_kcfe.pdf [22.10.2018].

Mroziński P. (2018), *Zadania szachowe*, http://zadania.szachowe.pl [19.10.2018].

Murray H.J.R. (1913), *A History of chess*, Original Edition, Clarendon Press, Oxford.

Pintal T., Sondej D. (2012), *Szachy jako specyficzne narzędzie pomocne w rozwoju dziecka*, Miejski Dom Kultury, Stalowa Wola, http://sp-siercza.pl/wp-content/uploads/2016/05/EBOOK_ Tomasz_Pintal_Dominik_Sondej_szachy_narzedziem_rozwoju.pdf [21.10.2018].

Prevezanos K. (2016), *World chess champion Magnus Carlsen: The computer never has been an opponent*. Interview, Deutsche Welle, https://www.dw.com/en/world-chess-champion-magnus-carlsen-the-computer-never-has-been-an-opponent/a-19186058 [17.10.2018].

Rozporządzenie Ministra Edukacji Narodowej i Sportu z dnia 9 kwietnia 2002 r. w sprawie warunków prowadzenia działalności innowacyjnej i eksperymentalnej przez publiczne szkoły i placówki, Dz.U. 2002 Nr 56, poz. 506 ze zm.

Rozporządzenie Ministra Edukacji Narodowej z dnia 14 lutego 2017 r. w sprawie podstawy programowej wychowania przedszkolnego oraz podstawy programowej kształcenia ogólnego dla szkoły podstawowej, w tym dla uczniów z niepełnosprawnością intelektualną w stopniu umiarkowanym lub znacznym, kształcenia ogólnego dla branżowej szkoły

I stopnia, kształcenia ogólnego dla szkoły specjalnej przysposabiającej do pracy oraz kształcenia ogólnego dla szkoły policealnej. Dz.U. 2017, poz. 356.
Szrubarczyk R. (2007), *Szachowisko – Szachy dla każdego*, http://www.szachowisko.pl [18.10.2018].
Szymańska E. (2018), *7 powodów, dlaczego gra w szachy jest genialna, (zwłaszcza dla dzieci)*, DSW – Serwis dzieci są ważne, https://dziecisawazne.pl/7-powodow-dlaczego-gra-w-szachy-jest-genialna-zwlaszcza-dla-dzieci/ [18.10.2018].
Weteschnik M. (2007), *Tajemnice taktyki szachowej*, Wydawnictwo Penelopa, Warszawa.
Zielińska M. (2014), *Grajmy w szachy, Materiały szkoleniowe dla najmłodszych*, Warszawa.
Żuchowski W. (2009), *Sławne mecze człowiek kontra maszyna*, Techniki informatyczne w szachach, Szachy i komputery, PCLab.pl, https://pclab.pl/art34801-12.html [20.10.2018].

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BIG DATA AND ITS ROLE IN STREAMLINING THE TEACHING PROCESS

Abstract

Due to the rapid development of ICTs, and in particular the internet, large amounts of digital data (Big Data) is generated on a daily basis, which affects most areas of people's work and personal lives and, of course, the learning process as well. Big Data represents a concept that was created on the basis of a large amount of unstructured data, which is a problem to process with traditional data processing methods. The aim of the article is, in line with the direction of the ICT in Educational Design project, to analyze the current status of the issue of using Big Data in education based on expert and scientific literature. Based on the analysis, we specify the main concepts used in this area, characterize Big Data in the area of education, adaptive learning systems, Big Data processing tools and techniques, as well as the benefits and risks of evaluating educational Big Data and create a theoretical basis for subsequent empirical research. Methodology: the study has a theoretical character, standard methods of scientific work were used, namely analysis, synthesis, comparison, abstraction, induction, deduction, and summary. Results: the result is a literary search of the previously published literature, summary, and explanation of the main terms used in this area, and the outline of the direction of further research.

Keywords: Big Data, analysis of the educational process, the efficiency of the educational process, data-driven education, digital education governance.

Introduction

One of the most frequently addressed topics in the education process is to make it more effective. With the constant evolution of the institution, there is a change in the idea of an ideal education system in which frequent changes occur. These can be minimal but also fundamental changes, which are mainly associated with the

emergence of information and communication technologies. The development of information and communication technologies and their introduction into teaching has positive impact on the education process. It brings new possibilities and areas of teaching methods, simplifies communication between teachers and students, or makes the administrative aspect of education more effective while allowing for more efficient options for collecting different data and their subsequent evaluation.

Using Big Data to streamline the learning process is largely about managing school and education institutions at national levels. In the area of management of education and training institutions, the following terms are used: Big Data in education, educational Big Data, data-driven education a digital educational governance. With respect to their meaning, they can be considered synonymous and the possible differences are precisely specified by individual authors (A. Hargreaes et al., 2013; K.R. Koerdinger et al., 2013; J.A. Marsh et al., 2006; S. Neo, 2016; A.G. Picciano, 2012). Ben Williamson states: "Educational governance today increasingly needs to be understood as digital educational governance. The monitoring and management of educational systems, institutions and individuals are taking place through digital systems that are normally considered part of the backdrop to conventional policy instruments and techniques of government; technical systems that are brought into being and made operational by certain kinds of actors and organizations, and that are imbued with aims to shape the actions of human actors distributed across education systems and institutions" (B. Williamson, 2015).

In terms of the European Union, the issue of Big Data is explored, for example, by the following documents: *Big Data for Monitoring Educational Systems*, which, from the Big Data perspective, focuses on student privacy, educational efficiency and equity, assessment, student tracking and skills forecasting (B. Berendt et al., 2017); then there are international documents adopted by the Government of the Slovak Republic published on the website of the Office of the Deputy Prime Minister of the Slovak Republic for Investments and Informatization (ÚPVII), closely related to the transformation of the labor markets and the modernization of the European education systems. These include also *Declaration on Cooperation in Artificial Intelligence* and *V4 Position on Artificial Intelligence* (ÚVVII, 2018).

Big Data characterization

The term Big Data represents the ever-increasing acceleration of digital data at the current stage in the development of information and communication technologies. The concept of Big Data has been used over the last decade for large volumes of data that have emerged primarily through the onset of new technologies, services, and their combination. Examples include sensor networks or scientific devices exploring natural phenomena, social networks or mobile technologies and related applications. These types of technologies and applications generate every second

a large amount of data that need to be stored efficiently and processed expediently. "Depending on the industry and individual organizations, Big Data is made up of information from internal and external sources such as transactions, social media, business data, sensors, and mobile devices. Businesses and organizations can use this data to better tailor their products and services to customer needs, further optimize operations and infrastructure, and/or find new sources of revenue" (D. Pejčoch, 2014).

A clear definition of Big Data, as with other concepts related to new technologies, does not exist. There are several definitions in literature, each of which is correct and focuses on another aspect. Judith Hurwitz defines Big Data as a combination of old and new technology that allows large amounts of data to be processed at a reasonable rate to provide the desired analyses at a given moment (2013). Frank J. Ohlhorst provides a more general definition: "Big Data is such an extremely large set of data that has caused traditional data processing to be insufficient for the required analysis" (2012). Edd Dumbill defined Big Data more precisely, as follows: "Big Data is data whose processing exceeds the capabilities of conventional database systems. This data is too large, it moves too fast, or its structure does not correspond to the existing database architecture. To acquire a value from such a data file, you need to choose an alternative method of processing" (2012). The analytical company Gartner defines Big Data as a concept under which we understand a set of data the size of which is beyond the ability to capture, manage and process data with commonly used software tools at the desired time. The size is understood not only in terms of data volume but comprehensively in a three dimensional context referred to as 3V (*Gartner*, 2017):

1) Volume – expresses an exponentially growing amount of data within a business field;
2) Variety – information varies in countless types, sources, formats, structures, coding, syntax, etc.;
3) Velocity – the speed at which data are formed and the need for their analysis in real time.

Other authors have extended the 3V to a 5V model, adding two additional features:

1) Veracity – expresses the accuracy and the preciseness of information. In practice, it is ensured by administering and managing data quality, administering and managing metadata along with ensuring the legal requirements of data and privacy protection;
2) Value (Value) – thanks to the ability of current technologies we are able to gather and analyze in real-time large volumes of data from a large number of (dozens, hundreds) diverse resources; we can extract a lot of valuable information from them (G. Bello-Orgaz et al., 2015; I.A.T. Hashem et al., 2015; M. Koseček, 2016).

George Firican and Manu Jeevan more accurately complement the Big Data feature with 5 other features:

1) Variability – in Big Data's context, variability refers to a few different things. The number of inconsistencies in the data is one. These are required to be found by anomaly and outlier detection methods for any meaningful analytics to occur.
2) Validity – quite akin to veracity, validity refers to how accurate and correct the data is for its intended use. According to Forbes, approximately 60 percent of a data scientist's time is expended cleansing the data before being able to do any analysis. The benefit from Big Data analytics is only as good as its underlying data, so one needs to adopt good data governance practices to ensure consistent data quality, common definitions, and metadata.
3) Vulnerability – Big Data has got along with its new security concerns.
4) Volatility – before Big Data came into being, organizations tended to store data indefinitely. A few terabytes of data would not lead to high storage expenditure; it could even be kept in the live database without hindering performance. In a classical data setting, data archival policies may not even be in place. Due to the velocity and volume of big data, however, the volatility of the data needs to be carefully considered. It will be required to establish rules for data currency and availability, as well as ensure rapid retrieval of information whenever it is required. It must be ensured that these are clearly tied to the business needs and processes; with big data, the complexity and costs of a storage and retrieval process are magnified.
5) Visualization – yet another characteristic of Big Data is how challenging it is to visualize. Due to limitations of in-memory technology and poor scalability, functionality, and response time, current big data visualization tools face technical challenges. One cannot rely on traditional graphs when trying to plot a billion data points, so different ways of representing data such as data clustering or using tree maps, sunbursts, parallel coordinates, circular network diagrams, or cone trees are needed (G. Firican, 2017; M. Jeevan, 2018).

Big Data includes structured, partially structured and, in particular, non-structured data. An important feature of large data is the fact that there is a lot of unnecessary data that is stored in the system just because the technology simply allows it. When looking for a meaningful boundary between data volume and relevancy, the basic prerequisite for working with them is the understanding of the problem that business users need to address.

Big Data and education

In the area of education, a number of areas and problems are addressed in the expert and scientific literature related to the use of Big Data, some of which are specified in Table 1.

Table 1. Overview of the application of Big Data in education

Author	Name	Issue
1	2	3
Allen B., 2017	How Big Data Can Improve Public Education	Finding Trends in How Students Learn Identifying the Most Effective Strategies Finding Reasons Behind Behavior Predictive Analytics in Education Guiding Students to Careers
Baker R., 2018	Big Data and Education	Online and software-based learning tools have been used increasingly in education.
Brdička B., 2014	Is Big Data a big potential or a big mistake?	Risks of Big Data analysis
Černý M., 2014	Data controlled the learning process	Adaptable learning systems Risks of using Big Data
Frk B., 2016	Innovations in education? Clearly Big Data and Virtual Reality.	Big Data usage options: 1. Analytics – Big Data offers the opportunity to carry out analyses of educational needs, evaluation, feedback almost instantly and continuously, or in real time. 2. Adaptability of education systems (content and process) – learning content can be changed in connection with analytical outputs. 3. Micro-targeting – Big Data enables effective personalization of education, tracking of individual users and understanding the so-called learning patterns.
Hargreaves A., Braun H., 2013	Data-Driven Improvement and Accountability	The uses of Data: data for improvement, data for public accountability, improvement and accountability together (DDIA), DDIA in education, evaluation of DDIA
Ho A., 2017	Advancing Educational Research and Student Privacy in the "Big Data" Era	Framework for evaluating the benefits of educational research Using modern educational data systems and the risks to student and family privacy
Joshi N., 2017	4 ways big data is transforming the education sector	Big Data in the education sector: 1. Improve student result. 2. Customize programs. 3. Reduce dropouts. 4. Targeted international recruiting.

1	2	3
Kalota F., 2015	Applications of Big Data in Education	Applications of big data: Student Success, E-books and Mobile Devices, Finance and Budgets
Marsh J.A. et al., 2006	Making Sense of Data-Driven Decision Making in Education	Data-Driven Education Research Questions: - What types of data are administrators and teachers using? - How are administrators and teachers using these data? - What kinds of support are available to help with data use? - What factors influence the use of data for decision making?
Ozga J., 2016	Trust in numbers? Digital education governance and the inspection process	Critical study of digital data use in education, in England
Parakh M., 2018	How Is Big Data Influencing the Education Sector?	Importance of Big Data Analytics How Big Data Is Shaping the Education Sector Students' Results Analytics of Educators Career Prediction
Poulovassilis A., 2016	Big Data and Education	Learning Analytics, Educational Data Mining, Potential of Big Data in Education
Tajovský Z., 2018	Big Data and its role in streamlining the learning process	Getting Big Data from MS systems Risks of using Big Data
Vollenbroek W. et al., 2014	Learning Education: An 'Educational Big Data' approach for monitoring, steering, and assessment of the process of continuous improvement of education	Educational Big Data Learning Education Check Framework (LECF)
Williamson B., 2016a	Digital education governance: An introduction	Digitizing education, Digital instruments of governance, Digital code, algorithms, data and infrastructures, Digital education governance
Williamson B., 2016a	Digital education governance: data visualization, predictive analytics, and "real-time" policy instruments	The virtual world of educational data, Digital policy instruments, and data infrastructures, Machine readability, Centres of visualization, Centres of anticipation
Williamson B., 2016b	Digital methodologies of education governance: Pearson plc and the remediation of methods	Software systems in education governance, focusing on digital Methods in the collection, calculation, and circulation of educational data. Socializing methods, The software governing techniques of Pearson plc, Digital methods

1	2	3
Williamson B., 2017	Big Data in Education	The role of learning analytics and educational data science in schools A critical appreciation of code, algorithms, and infrastructures The rise of 'cognitive classrooms', and the practical application of computational algorithms to learning environments Important digital research methods issues for researchers Digital Education Governance The Social Life of Education Data Science

Source: prepared by the authors.

In addition, several authors specifically target the use of Big Data in university education (Table 2), the importance of which is underlined by Oracle's experience (research): "Higher education institutions that focus on better instructional quality and the acquisition and retention of students and faculty historically used data warehouses and business intelligence tools to report on and analyze this data. By deploying Big Data Management Systems that include data reservoirs (featuring Hadoop and/or NoSQL Databases), greater benefits can be achieved in these areas and the institution can become more agile. New kinds of analyses can potentially impact all of the major areas of importance for an institution – student enrollment and retention, operational cost management, integrated information management, reporting and regulatory compliance, and advanced research" (*Oracle*, 2015).

Table 2. Big Data in higher education

Author	Name	Issue
1	2	3
Busato V.V. et al., 1998	The relation between learning styles, the Big Five personality traits and achievement motivation in higher education.	The authors developed a model, in which study success and progress in higher education was predicted.
Gupta B. et al., 2015	Business Intelligence and Big Data in Higher Education: Status of a Multi-Year Model Curriculum Development Effort for Business School Undergraduates, MS Graduates, and MBAs.	Research model includes: BI-specific material, it focuses on the teaching perspective (mainly at universities), it has a long tradition and reflects the BI domain's development over the years, and the spectrum of participating faculty is broad and diverse in terms of number, educational organizations, and internationality.
Chen J. et al., 2013	Big data challenge: a data management perspective.	Big Data platform, data integration, data cleaning, data reduction, data query, and indexing, data analysis, and mining.

1	2	3
Johnson J.A., 2014	The ethics of big data in higher education.	Challenges of using Big Data in Higher Education. Practical Ethics for Ethical Data Mining: institutional researchers must understand data mining as part of a techno social whole that spans the entire policy process. They must ensure the contextual integrity of information flows to protect the actors involved in data mining. In addition, they must ensure both the scientific and the normative validity of the data mining process.
ORACLE, 2015	Improving Higher Education Performance with Big Data.	Student Acquisition Optimization, Student Course Major Selection, Student Performance, Student Retention, Student Progression, Teaching Effectiveness, Research Optimization, IT operational efficiency.
Picciano A.G., 2012	The evolution of big data and learning analytics in American higher education.	Data-driven decision-making. The six important technologies: Mobile Applications, Tablet Computing, Game-Based Learning, Learning Analytics, Gesture-Based Learning, Internet of Things.
Siemens G., Long P., 2011	Penetrating the Fog: Analytics in learning and education.	For educators, the availability of real-time insight into the performance of learners-including students who are at-risk-can be a significant help in the planning of teaching activities. For students, receiving information about their performance in relation to their peers or about their progress in relation to their personal goals can be motivating and encouraging. Administrators and decision-makers are today confronted with tremendous uncertainty in the face of budget cuts and global competition in higher education.
Tulasi B., 2013	The significance of Big Data and analytics in higher education	Phases for analyzing big data: Acquisition and Extraction of data, Integration, and Analysis, Interpretation.
West D.M., 2012	Big Data for Education: Data Mining, Data Analytics, and Web Dashboards	The Value of Systematic, Real-Time Data Predictive Assessments Tracking Performance Through Dashboards and Visual Displays Overcoming Operational and Policy Impediments

Source: prepared by the authors.

"Turning specifically to big data in the Education sector, the field of Learning Analytics is concerned with gathering, analyzing and visualizing data about learners and learning processes so as to increase stakeholders' understanding of these, and hence to improve learning and the environments in which it occurs" (G. Siemens, 2012; H. Drachsler, W. Greller, 2012; R. Ferguson, 2012). This data may be collected from many different sources:

- virtual learning environments that track and support students' activities, interactions, reflections and progress through learning tasks;
- students' assessment activities – both formative and summative;
- students' personal records and records of prior achievement;
- learner profiling and learner modeling software;
- software supporting social networking, peer support, collaboration;
- audio and video recordings; gesture and physiological sensor recordings (e.g. heart rate, galvanic skin response, blood pressure, EEG readings);
- mobile learning apps, gathering large-scale user-centered and context-aware data (A. Poulovassilis, 2016).

This exceptionally broad range of data sources is allowing increasingly individualized, detailed and longitudinal data to be collected and analyzed, bringing with it the potential to derive new insights and to provide more effective support to learners and tutors.

Another important resource is LMS (Learning Management Systems), which are information systems used to plan and manage to teach. Specific options vary according to individual LMSs, but basic elements include students' records, course management, various communication tools, or study materials databases. For data acquisition for analytical needs, the functions of students' knowledge and skill testing and their subsequent evaluation are essential. According to Christopher Pappas (2016), the following data types are suitable for further analyses:

1) Completion Rates – data of students who have completed an online course including the time of the completion of the individual course modules;
2) Online Learner Performance and Progress – online learner performance and progress metrics offer insight into learning behaviors, experience, and proficiency;
3) eLearning Assessment Scores – eLearning assessment scores provide the teacher with measurable data that the teacher can use to improve teacher's eLearning course design;
4) Online Learner Surveys – surveys are one of the most direct and measurable forms of eLearning feedback;
5) Peer-Based Feedback – eLearning forums, social media groups, online group collaboration projects, and learner-generated online content are great sources of peer-based feedback.

The main objective of analyzing data from LMS systems is the success of students in individual courses. The data thus obtained allow the teacher to get an overview of the pupils' abilities, to reveal the areas that pose the greatest difficulties, and on the basis, thereof the teacher can provide a well-targeted feedback or personalize the learning plan. Data can also be obtained from surveys among students, from their interactions within LMS discussion forums or from mutual

evaluation. In these cases, the analysis is more difficult. In general, it is important to evaluate data continuously and to respond operationally by adjusting courses to make them as effective as possible.

These types of data can contribute to the greater effectiveness of the learning process in the following areas (*Allerin*, 2017):

1) Improving learning results – students, through online courses, create a digital footprint which enables to trace the characteristics of their behavior and thereby optimize the educational environment to increase the learning effectiveness.
2) Program adjustment – Big Data analysis allows you to create individual educational plans regardless of the number of students in study groups. The application of the Blended Learning method, a specific form or process of learning that combines the form of teaching with the students being present in person with electronic and web applications (especially e-learning), which helps to reduce their disadvantages and achieve synergies of benefits from both approaches, can contribute to it as well. Using this method, the student is given the opportunity to discuss any questions encountered during online learning at meetings in person with the teacher.
3) Reducing the number of early school leavers – by using predictive data analysis, educational courses can be adjusted before they are implemented into the educational process so that they do not contain unclear parts that may impair the study results. At the same time, this type of analysis can be used to select a suitable school or individual courses.
4) Better targeting when selecting a school – Big Data allow to get more detailed information about educational institutions around the world, so it's easier for students to choose the right school according to their ideas and requirements.

Adaptive learning systems

The use of Big Data in education process a great challenge and a chance to change the learning process. It does not concern the replacement of the teacher with the information system, but rather the improvement of education for each individual (M. Černý, 2014).

In Europe, one of the main problems of education is its massiveness. It does not concern only common complaints concerning the uninteresting approach of teachers, but above all, it is the fact that the teaching has mostly a frontal character (M. Černý, 2014). Such a concept of teaching does not allow to respect the needs of each individual's education, his/her style of learning, the pace at which he/she is accustomed to working, his/her interests or previous and current knowledge and skills. As a result, there are problems with inclusive learning (which are com-

pensated by assistants) as well as, above all, with gifted students, who receive only minimum special attention. The result of massiveness at school is to educate an average student with average knowledge (M. Černý, 2014).

There are four levels of adaptation to the needs of an individual student (P. Hill, 2013):

1) Mass education – it does not adapt to a student's specific needs at all, it perceives the study group as a mass, it pursues summary evaluation, and the goal is an optimal benefit of the whole mass.
2) Differentiated learning respects the existence of different paths leading to a common goal. The student can choose the order of interpretation, the sequence of examples he/she wants to address.
3) Personalized learning is based on the idea that based on the pre-test; a set of learning materials or activities is designed for the student. It is mostly about restricting teaching materials that are unnecessary for the student because he/she is well aware of their content or, on the contrary, restricting advanced materials to students who do not have the necessary knowledge to understand them. It can also work with materials or examples according to the interests or activities of a particular student.
4) Adaptive learning that responds flexibly to student needs and outcomes during the educational process. In this case, any computer processing of emotions that would allow modifying subjects or methods according to actual fatigue or mental state of the student is also considered.

Through adaptive learning, which should be the goal of all innovations in the area of LMSs and educational process reforms in general, learning can be personalized perfectly in such a way that the student has complex knowledge rather than just formal awareness from a given area. By using these systems, a student can change the pace and the style of interpretation according to his/her abilities and interests so that at the end of the process he/she learns what he/she is supposed to. Such a concept naturally leads to better learning outcomes (N. Hamdan et al., 2013).

Big Data processing tools and techniques in education

According to D.M. West, the main techniques and tools for processing Big Data in education include Educational Data Mining (EDM), Learning Analytics (LA) and Web Dashboards (D.M. West, 2012).

Educational Data Mining (EDM)

Educational data mining is emerging as a research area with a suite of computational and psychological methods and research approaches for understanding how students learn (A.R. Anaya, J.G. Boticario, 2009). New computer-supported

interactive learning methods and tools-intelligent tutoring systems, simulations, games have opened up opportunities to collect and analyze student data, to discover patterns and trends in those data, and to make new discoveries and test hypotheses about how students learn. Data collected from online learning systems can be aggregated over large numbers of students and can contain many variables that data mining algorithms can explore for model building (B.R. Prakash, 2014).

Educational data mining researchers view the following as the goals for their research (H. Jeong, G. Biswas, 2008):

1) Predicting students' future learning behavior by creating student models that incorporate such detailed information as students' knowledge, motivation, metacognition, and attitudes;
2) Discovering or improving domain models that characterize the content to be learned and optimal instructional sequences;
3) Studying the effects of different kinds of pedagogical support that can be provided by learning software; and
4) Advancing scientific knowledge about learning and learners through building computational models that incorporate models of the student, the domain, and the software's pedagogy.

To accomplish these four goals, educational data mining research uses the five categories of technical methods (M. Köck, A. Paramythis, 2011) described below:

1) Prediction entails developing a model that can infer a single aspect of the data (predicted variable) from some combination of other aspects of the data (predictor variables).
2) Clustering refers to finding data points that naturally group together and can be used to split a full dataset into categories.
3) Relationship mining involves discovering relationships between variables in a dataset and encoding them as rules for later use. For example, relationship mining can identify the relationships among products purchased in online shopping.
4) Association rule mining can be used for finding student mistakes that co-occur, associating content with user types to build recommendations for content that is likely to be interesting, or for making changes to teaching approaches.

We can use predictive models to capture student behavior, to find out why he/she cannot answer the question if he/she has the necessary skills, to analyze student behavior in the online e-learning system, etc.

According to Doug Clow (2013) predictive modeling can be used, for example, to detect students who may be at risk of dropping out of a course so as to guide them towards resources or people who might help them. Clustering can be used, for example, for grouping students into groups on the basis of the results they achieved in online education with a follow-up supply of events and resources

corresponding to the acquired knowledge. These techniques can be used to associate student activity in a learning management system or discussion forums, with student grades or to investigate such questions as why students' use of practice tests decreases over a semester of study. Other techniques that can be used in the EDM concept mentioned by the authors include, e.g.:

- data modeling: designing the way that data is represented within computing systems so as to facilitate the types of processing that needs be applied to the data (H. Chen et al., 2012);
- data cleansing, transformation, integration: correcting errors and inconsistencies in the data; transforming data so that it can be more easily integrated – including converting it to expected standard formats; and creating integrated data resources that combine data from different data sources (M. Chen et al., 2014);
- semantic modeling and reasoning: representing knowledge domains using specialist ontologies; using ontology-based reasoning to provide personalized information to users (G. Siemens, 2012);
- data mining: including classification, clustering, Bayesian reasoning, rule and pattern extraction (M. Chen et al., 2014).

An exemplary data architecture according to Alex Poulovassilis is shown in Figure 1.

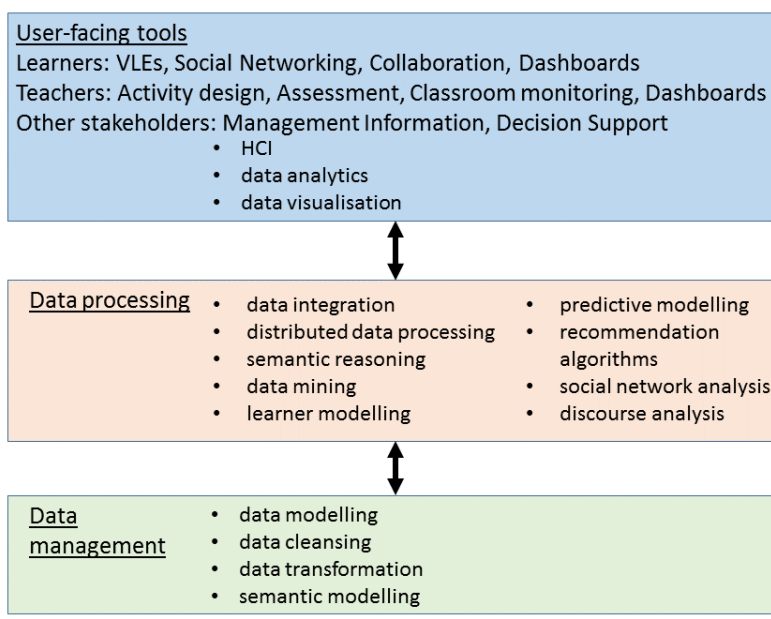

Figure 1. Data architecture and Computational Techniques
Source: A. Poulovassilis, 2016.

Learning Analytics

Learning analytics is the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs. How learning analytics is defined and implemented may vary, including:

- for individual learners to reflect on their achievements and patterns of behavior in relation to others;
- as predictors of students requiring extra support and attention;
- to help teachers and support staff plan supporting interventions with individuals and groups;
- for functional groups such as course teams seeking to improve current courses or develop new curriculum offerings;
- for institutional administrators taking decisions on matters such as marketing and recruitment or efficiency and effectiveness measures (S. Powell, S. MacNeill, 2012).

EDM – technology, tools, and dashboards

Darrell M. West (2012) as well as Mirjam Köck and Alexandros Paramythis (2011) consider EDM Predictive Assessments along with Diagnostic Assessment and Tracking Performance Through Dashboards and Visual Displays as the most important technologies and tools (D.M. West, 2012; M. Köck, A. Paramythis, 2011).

The former seeks to evaluate how students will perform on standardized tests, while the latter emphasizes which instructional techniques work for individual students and the best ways to tailor learning. Tracking Performance Through Dashboards and Visual Displays – dashboards compile key metrics in a simple and easy to interpret interface so that school officials can quickly and visually see how the organization is doing (D.M. West, 2012).

There are many opportunities to advance learning through data mining, data analytics, and web dashboards and visual displays. Technology enables the use of new approaches to formative and predictive assessment. Yet many barriers complicate the achievement of these benefits. In general, too much of contemporary education focuses on education inputs, not outputs (D.M. West, 2012).

Testing and evaluation systems

Wouter Vollenbroek et al. (2014) focused on their research on test and evaluation systems. The Learning Education Check System (LECF) makes use of multiple resources and methods, the more traditional ones like questionnaires and interviews and the more progressive ones like big data.

It is necessary to design a system, which is capable to guide itself and change those directions as well in response to changing ways and trends in education. A system that supports a data-driven decision-making process within education. The so-called Big Data makes it possible to mine learning information for insights regarding performance and learning approaches (D.M. West, 2012). The LECF is a process where individuals learn from each other in order to improve their knowledge, competencies, practices, and experiences. To support the development and distribution of knowledge, Web 2.0 applications are nowadays almost indispensable (J.S. Brown, R.P. Adler, 2008). Learning Education Check Framework is shown in Figure 2.

Benefits of evaluating Big Data in the field of education

According to *ORACLE* (2015), it is possible to increase the performance of universities and other educational institutions by integrating Big Data processing into information architecture. IT departments at universities and educational institutions usually work with academic leaders to create solutions that bring about the following when defining Big Data projects (*ORACLE*, 2015):

1) Student Acquisition Optimization: improved success in recruiting of the most desirable student prospects through better analysis of their sentiment about the institution, better-targeted information provided on the institution's website, and a better understanding of the potential student's background and capabilities.
2) Student Course Major Selection: aligning a student's passions with an appropriate major by analyzing the feelings that they express about their classes on social media and the amount of time they are dedicating to courses.
3) Student Performance: gaining an early understanding of the student's work, social, sleep, and eating habits by measuring them in comparison to successful students can be a key to understanding early if a student is in trouble and needs corrective action.
4) Student Retention: understanding a student's current sentiment about the institution and their instructors can help the institution take corrective action sooner that will enable retention of the student.
5) Student Progression: identifying 'at risk' students who are not progressing towards graduation early in order to get them back on track. The cause of lack of adequate progression can be analyzed and addressed.
6) Teaching Effectiveness: understanding if lack of teaching effectiveness is a widely expressed sentiment about individual instructors can enable the institution to take corrective action faster. The institution can also reward those instructors who have widespread positive sentiment and successful students.

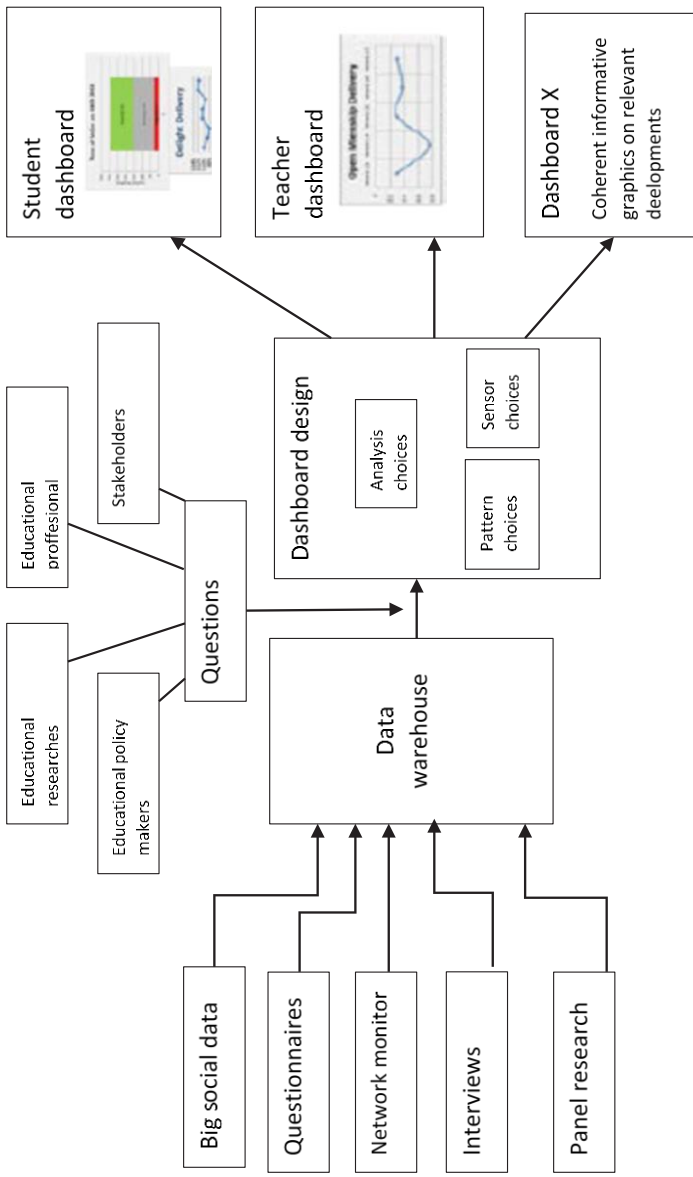

Figure 2. Learning Education Check Framework
Source: W. Vollenbroek et al., 2014.

7) Research Optimization: data critical to research might be gathered directly from sensors in semi-structured form. It can be ingested by NoSQL databases and analyzed using predictive analytics in Hadoop at a lower cost and more effectively.

Here are several benefits of Big Data in e-learning, according to eLearning Industry (S. Neo, 2016):

1) Big data helps to identify specific courses, modules, and sections that best resonate with your audience.
2) Big data points out structural issues with course designs and what strategies succeeded or failed to engage your audience.
3) Big data provides insight on what deployment strategies are effective.
4) Big data provides the opportunity to design better, more effective and engaging courses based on what strategies worked and didn't.
5) Big data provides almost real-time feedback, which allows training professionals to make changes and adjust their strategy to be specifically tailored to the learner.

Appropriate testing and evaluation are also important for the effectiveness of education. The document on the Data-Driven Improvement and Accountability evaluates the benefits of testing and collecting data for the effectiveness and the quality of education (A. Hargreaves, 2013; M. Černý, 2014). It has 12 recommendations for the correct setup of tests and information systems to measure the parameters that are necessary:

1) Measure what is important, and that is just what is easily measurable. Discomfort in the form of more complex tests or integration of modules into the LMSs is definitely worthwhile.
2) Create a metric that reflects the ranges and goals we perceive in the teaching as important, not just those that are easily measurable.
3) Define and integrate the individual elements of innovation so that they do not act as counter-indications.
4) Only work with high quality and valid data.
5) Test sensibly and deliberately. The purpose of the tests is not to get complete information about everything but relevant information about the innovations.
6) Promote and spread the willingness to innovate and measure the effectiveness of education.
7) Systematically perform evolutionary changes that allow for progress and improvement.
8) Try to reduce the gap between the worst and the best students.
9) To support and develop learning communities.
10) Promote the vertical distribution of responsibility for the content taught and education results include students in this process.

11) Identify trends, lead education to its goal, and not be just the executor of the recommendations of statistics and metrics.
12) Create a standard that will result in the codification and transferability of measurement results.

These 12 points, which are based on the idea of action research, need to be accepted in the course of implementation of data managed education. In addition, teachers should have a good knowledge of mathematics, statistics, and methodology to be able to handle the data correctly, to create their own processing and analyses to identify current important facts.

Risks of using Big Data

Big Data is a source of many useful and important information to make education more efficient, but they also contain many personal data that can put students' privacy at risk. Bořivoj Brdička (2014) the greatest possible risks include:

1) Threats to privacy: the activities that we do online reveal a lot of information about us as well. Online application operators that we use for mailing, searching for information, storing documents or photos, communicating, shopping, etc. have access to personal information. Much information can also be obtained from publicly available sources. It is therefore very important to set up who and how it can work with students' private data.
2) Distortion: the result of a big data analysis may be distorted. For example, it is difficult to include in the analysis the conditions under which students carry out their online learning activities. It can affect, for example, the final student profile as well, which is created automatically based on the data obtained by monitoring his/her online activities. There is a risk that this distorted picture may be damaging to the student.
3) Dehumanization: the analysis of the teaching results based on the collection of Big Data leads to the dehumanization of this process. What has always been done exclusively within the teacher's direct contact with the student is accomplished by machines that deal with living people as non-living objects or data.
4) Incorrect data: many countries in the world carry out the so-called high-stakes testing. These practices are criticized by many experts. Big Data allows replacing the "high-stakes tests" by analyzing the student's long-term activity, but these methods, unfortunately, lead to competition among pupils and schools in the area of achieving better results. This creates a bad social climate. In addition, there is a great risk that schools will only learn what is being tested and other learning objectives will be neglected. The worst what may happen is if the process actors decide to directly falsify the results.
5) Correlation/cause: the fact that there are some correlations between some

phenomena (they seem to be interrelated) does not yet cause causal dependence. Wrong dependencies are not obvious and identifiable when analyzing big data at a first glance. Therefore, it is not right to make immediate conclusions. The causes of the phenomena that we investigate need to be verified thoroughly.

6) Conclusions do not match data: sometimes the data may be accurate, but the conclusions of the analysis are incorrect. For example, the ranking of the quality of universities is based primarily on the level of the scientific work of their employees. To assess the level of teaching based on that is misleading, to say the least.

Conclusions

The growing impact of Big Data and Artificial Intelligence on different areas of our company proves that they are not just marketing concepts. The decision made based on the Big Data analysis brings efficiency to the educational process, but also to the management of educational institutions. Data managed education is also a major challenge for scientific research in this area.

Big Data brings great possibilities to education, but it also carries some risks. One of the main sources of the Big Data is the information systems of educational institutions, especially LMS systems, which integrate advanced tools for testing students and evaluating their success and progress in learning. Proper analysis of the data thus obtained can increase the efficiency of the learning process by either individualizing the teaching plans based on the results of the individual courses or, for example, through a targeted immediate feedback.

Risks include, in particular, the risk to students' privacy because the system, by analyzing the results, collects a number of compelling data that can be misused in various ways. This requires to apply the GDPR consistently. Another risk in analyzing Big Data is incorrectly evaluated or misinterpreted data.

Using Big Data in education has great prospects and benefits that can make the learning process prevail over possible risks. Risks need to be known in advance and eliminated as much as possible.

Bibliography

Allen B. (2017), *How Big Data Can Improve Public Education*, https://datafloq.com/read/how-big-data-can-improve-public-education/4112 [28.09.2018].

Allerin (international provider of software solutions) (2017), *4 ways big data is transforming the education sector*, https://www.allerin.com/blog/4-ways-big-data-is-transforming-the-education-sector [10.09.2018].

Anaya A.R., Boticario J.G. (2009), *A Data Mining Approach to Reveal Representative Collaboration Indicators*, [in:] T. Barnes, M. Desmarais, C. Romero, S. Ventura (eds), *Open*

Collaboration Frameworks. In Educational Data Mining 2009: Proceedings of the 2nd International Conference on Educational Data Mining, pp. 210-219.

Bello-Orgaz G., Jung J., Camacho D. (2016), *Social big data: Recent achievements and new challenges*, "Information Fusion", Vol. 28, pp. 45-59.

Berendt B., Littlejohn A., Kern P., Mitros P., Shacklock X., Blakemore M. (2017), *Big data for monitoring educational systems*, Publications Office of the European Union, Luxembourg.

Brdička B. (2014), *Jsou velká data velkým potenciálem nebo velkou chybou?*, https://spomocnik.rvp.cz/clanek/18645/JSOU-VELKA-DATA-VELKYM-POTENCIALEM-NEBO-VELKOU-CHYBOU.html [03.09.2018].

Brown J.S., Adler R.P. (2008), *Open education, the long tail, and learning 2.0*, "Educause Review", Vol. 43, No. 1, pp. 16-20.

Busato V.V., Prins F.J., Elshout J.J., Hamaker C. (1998), *The relation between learning styles, the Big Five personality traits and achievement motivation in higher education*, "Personality and individual differences". No. 26(1), pp. 129-140.

Carver C.S., Scheier M.F. (1982), *Control theory: A useful conceptual framework for personality-social, clinical, and health psychology*, "Psychological bulletin", Vol. 92, No. 1, p. 111.

Černý M. (2014), *Daty řízený proces vzdělávání*, http://itlib.cvtisr.sk/archiv/2014/3/daty-rizeny-proces-vzdelavani.html?page_id=2731 [05.09.2018].

Chen H., Chiang R.H., Storey V.C. (2012), *Business Intelligence and Analytics: From Big Data to Big Impact*, "MIS quarterly", No. 36(4), pp. 1165-1188.

Chen J., Chen Y., Du X., Li C., Lu J., Zhao S., Zhou X. (2013), *Big data challenge: a data management perspective*, "Frontiers of Computer Science", No. 7(2), pp. 157-164.

Chen M., Mao S., Liu Y. (2014), *Big data: a survey*, "Mobile Networks and Applications", No. 19(2), (EMC 2015), pp. 171-209.

Clow D. (2013), *An overview of learning analytics*, "Teaching in Higher Education", No. 18(6), pp. 683-695.

Dawson S. (2008), *A study of the relationship between student social networks and sense of community*, "Educational Technology & Society",No. 11(3), pp. 224-238.

De Liddo A., Shum S.B., Quinto I., Bachler M., Cannavacciuolo L. (2011), *Discourse-centric learning analytics* [in:] *Proceedings of the 1st International Conference on Learning Analytics and Knowledge*, ACM, pp. 23-33.

Drachsler H., Greller W. (2012), *The pulse of learning analytics understandings and expectations from the stakeholders* [in:] *Proceedings of the 2nd international conference on learning analytics and knowledge*, ACM, pp. 120-129.

Dumbill E. (2012), *Planning for big data*, O'Reilly Media, Inc.

Ferguson R. (2012), *Learning analytics: drivers, developments and challenges*, "International Journal of Technology Enhanced Learning", No. 4(5-6), pp. 304-317.

Firican G. (2017), *The 10 Vs of Big Data*, https://tdwi.org/articles/2017/02/08/10-vs-of-big-data.aspx, [05.10.2018].

Frk B. (2016), *Inovácie vo vzdelávaní? Jednoznačne Big Data a Virtuálna realita*, https://www.edunews.cz/a-647/inovacie-vo-vzdelavani-pre-rok-2016-jednoznacne-big-data-a-virtualna-realita [30.09.2018].

Gartner (2017), *IT Glossary. From the Gartner IT Glossary: What is Big Data?*, https://research.gartner.com/definition-whatis-big-data?resId=3002918&srcId=1-8163325102> [10.04.2017].

Gupta B., Goul M., Dinter B. (2015), *Business Intelligence and Big Data in Higher Education: Status of a Multi-Year Model Curriculum Development Effort for Business School Undergraduates, MS Graduates, and MBAs*, CAIS, p. 36, 23.

Hamdan N., McKnight P., McKnight K., Arfstrom K.M. (2013), *The flipped learning model: A white paper based on the literature review titled a review of flipped learning*, Flipped Learning Network/Pearson/George Mason University.

Hargreaves A., Braun H., Gebhardt K. (2013), *Data-driven improvement and accountability*, https://www.education.nh.gov/essa/documents/data-driven-improvement.pdf [06.09.2018].

Hashem I.A.T., Yaqoob I., Anuar N.B., Mokhtar S., Gani A., Khan S.U. (2015), *The rise of "big data" on cloud computing: Review and open research issues*, "Information Systems", Vol. 47, pp. 98-15.

Hill P. (2013), *Differentiated, Personalized & Adaptive Learning: some clarity for EDUCAUSE* [in:] *e-Literate*, http://mfeldstein. com/differentiated-personalized-adaptive-learning-clarity-educause [05.09.2018].

Ho A. (2017), *Advancing educational research and student privacy in the "big data" era* [in:] *Workshop on Big Data in Education: Balancing the Benefits of Educational Research and Student Privacy*, National Academy of Education Washington, DC, pp. 1-18.

Hurwitz J., Nugent A., Halper F., Kaufman M. (2013), *Big data for dummies*, John Wiley & Sons.

Jeevan M. (2018), *10 Vs of big data*, https://www.edvancer.in/10-vs-big-data/ [05.10.2018].

Jeong H., Biswas, G. (2008), *Mining Student Behavior Models in Learning-by-Teaching Environments* [in:] *Proceedings of the 1st International Conference on Educational Data Mining*, Montréal, Québec, Canada, pp. 127-136.

Johnson J.A. (2014), *The ethics of big data in higher education*, "International Review of Information Ethics", No. 21(21), pp. 3-10.

Kalota F. (2015), *Applications of Big Data in education*, "International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering", No. 9(5), pp. 1602-1607.

Köck M., Paramythis A. (2011), *Activity Sequence Modeling and Dynamic Clustering for Personalized E-Learning*, "Journal of User Modeling and User-Adapted Interaction", No. 21(1-2), pp. 51-97.

Koedinger K.R., Baker R. Cunningham K. Skogsholm A., Leber B., Stamper J. (2010), C. Romero, S. Ventura, M. Pechenizkiy, R.S. Baker (eds), *A Data Repository for the EDM Community: The PSLC DataShop* [in:] *Handbook of Educational Data Mining*, CRC Press, Boca Raton, FL, pp. 43-55.

Koedinger K.R., Brunskill E., Baker R.S., McLaughlin E.A., Stamper J. (2013), *New potentials for data-driven intelligent tutoring system development and optimization*, "AI Magazine", No. 34(3), pp. 27-41.

Koseček M. (2016), *Pri big data treba robiť chyby rýchlo. Ako v korporácii začať s big data*, http://www.bigdatablog.sk/ [20.02.2017].

Li N., Cohen W., Koedinger K.R., Matsuda N. (2011), *A machine learning approach for automatic student model discovery*, "Educational Data Mining", 2011, pp. 31-40.

Manouselis N., Drachsler H., Vuorikari R., Hummel H., Koper R. (2011), *Recommender systems in technology enhanced learning* [in:] *Recommender systems handbook*, Springer US, pp. 387-415.

Marsh J.A., Pane J.F., Hamilton L.S. (2006), *Making Sense of Data-Driven Decision Making in Education: Evidence from Recent RAND Research*, RAND Corporation, Santa Monica, CA, https://www.rand.org/pubs/occasional_papers/OP170.html [30.09.2018].

Marsh J.A., Pane J.F., Hamilton L.S. (2006), *Making sense of data-driven decision making in education*, https://www.rand.org/pubs/occasional_papers/OP170.html [15.09.2018].

Neo S. (2016), *Data-Driven Learning: Benefits of Big Data in E-Learning*, http://blog.contentraven.com/learning/data-driven-learning-benefits-of-big-data-in-elearning [05.09.2018].

Ohlhorst F.J. (2012), *Big Data Analytics: Turning Big Data into Big Money*, John Wiley & Sons, Hoboken.

Oracle (2015), *Improving Higher Education Performance with Big Data Architect's Guide and Reference Architecture Introduction*, Oracle Enterprise Architecture White Paper, http://www.oracle.com/us/technologies/big-data/big-data-education-2511586.pdf [05.09.2018].

Ozga J. (2016), *Trust in numbers? Digital education governance and the inspection process*, "European educational research journal", No. 15(1), pp. 69-81.

Pappas Ch. (2016), *5 Types Of Big Data To Extract From Your LMS And How To Use It. eLearning Industry*, https://elearningindustry.com/types-big-data-extract-lms-how-use [27.08.2018].

Parakh M. (2018), *How Is Big Data Influencing the Education Sector?*, https://dzone.com/articles/how-is-big-data-influencing-the-education-sector [28.09.2018].

Pejčoch D. (2014), *CADAQUES: Metodika pro komplexní řízení kvality dat a informací*, "Acta Informatica Pragensia", Vol. 3, No. 1, pp. 44-56.

Picciano A.G. (2012), *The evolution of big data and learning analytics in American higher education*, "Journal of Asynchronous Learning Networks", No. 16(3), pp. 9-20.

Poulovassilis A. (2016), *Big Data and education*, Technical Report BBKCS-16-01, Birkbeck, December 2016, http://www. dcs. bbk. ac. uk/research/techreps/2016/bbkcs-16-01.pdf [02.09.2018].

Powell S., MacNeill S. (2012), *Institutional Readiness for Analytics A Briefing Paper*, CETIS Analytics Series, JISC CETIS, December 2012.

Prakash B.R., Hanumanthappa M., Kavitha V. (2014), *Big data in educational data mining and learning analytics*, "Int. J. Innov. Res. Comput. Commun. Eng", No. 2(12), pp. 7515-7520.

Siemens G. (2012), *Learning analytics: envisioning a research discipline and a domain of practice* [in:] *Proceedings of the 2nd International Conference on Learning Analytics and Knowledge*, ACM, pp. 4-8.

Siemens G., Long P. (2011), *Penetrating the fog: Analytics in learning and education*, "EDUCAUSE review", No. 46(5), p. 30.

Tajovský Z. (2018), *Big data a jejich role v zefektivnění vzdělávacího procesu*, Educational Technology, KISK Masaryk University, https://medium.com/edtech-kisk/big-data-a-

jejich-role-v-zefektivn%C4%9Bn%C3%AD-vzd%C4%9Bl%C3%A1vac%C3%ADho-procesu-9383407d7e44 [05.09.2018].
Tulasi B. (2013), *Significance of Big Data and analytics in higher education*, "International Journal of Computer Applications", No. 68(14).
Úrad podpredsedu vlády SR pre investície a informatizáciu (ÚPVII) (2018), *Umelá inteligencia*, https://www.vicepremier.gov.sk/index.php/informatizacia/jednotny-digitalny-trh/umela-inteligencia/index.html [03.10.2018].
Vollenbroek W., Jagersberg K., de Vries S.A., Constantinides E. (2014), *Learning Education: An 'Educational Big Data' approach for monitoring, steering and assessment of the process of continuous improvement of education*, Paper presented at 2014 European Conference in the Applications of Enabling Technologies, ECAET 2014, Glasgow, United Kingdom, https://research.utwente.nl/en/publications/learning-education-an-educational-big-data-approach-for-monitorin [10.09.2018].
West D.M. (2012), *Big data for education: Data mining, data analytics, and web dashboards*, "Governance studies at Brookings", No. 4(1), http://www. brookings. edu/~/media/research/files/papers/2012/9/04% 20education% 20tec hnology% 20west/04% 20education% 20technology% 20west.pdf [12.09.2018].
Williamson B. (2016a), *Digital education governance: data visualization, predictive analytics, and 'real-time' policy instruments*, "Journal of Education Policy",No. 31(2), pp. 123-141.
Williamson B. (2016b), *Digital methodologies of education governance: Pearson plc and the remediation of methods*, "European Educational Research Journal", No. 15(1), pp. 34-53.
Williamson B. (2017), *Big data in education: The digital future of learning, policy and practice*, Sage.

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